Semiconductor Equipment, Manufacturing, and Materials

Source: Dataquest

Dataquest

Welcome to Dataquest

Semiconductor Equipment, Manufacturing, and Materials

You are in the *Source: Dataquest* binder

An annually updated collection of reference documents for the Semiconductor Equipment, Manufacturing, and Materials service. Worldwide and regional market statistics; *Company Backgrounders;* and several guides such as *How to Use Dataquest, Dataquest Research Methodology, Dataquest High-Technology Guide—Segmentation and Glossary* are contained in this binder.

Other Semiconductor Equipment, Manufacturing, and Materials service binders:

Dataquest Perspective
A series of multitopic publications that provide analysis on worldwide semiconductor equipment, manufacturing, and materials issues and semiconductor news and views.

Semiconductor Equipment, Manufacturing, and Materials

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01/11/93

SEMICONDUCTOR EQUIPMENT, MANUFACTURING, AND MATERIALS
SOURCE: DATAQUEST
Binder Checklist

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North American Fab Database	10/27/92	______
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Market Trends:		
SEMM-SVC-MT-9202 (Semi. Equipment Manufacturing , and Materials Forecast)	12/28/92	______
SEMM-SVC-MT-9201 (Semi. Equipment Manufacturing , and Materials Forecast)	08/17/92	______
Vendor Profiles:		
SEMM-SVC-VP-9202 (Texas Instruments)	12/21/92	______
SEMM-SVC-VP-9201 (Silicon Valley Group Inc.)	09/28/92	______

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Dataquest

How to Use Dataquest

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How to Use Dataquest

Dataquest

A worldwide network of information-gathering resources

Source: Dataquest

Published by Dataquest Incorporated

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Chapter 1

A Guide to Help You Get the Most Out of Your Dataquest Information Resources

Introduction

As a Dataquest client, we want you to obtain the greatest possible value from your subscription. This guide will acquaint you with the available information resources and will help you establish a "user strategy" that ensures that Dataquest's products and services contribute to your success.

This guide is divided into the following sections:

- Your Industry Service: What's in It for You?
- How to Use Your Industry Service
- Customizing Your Industry Service
- Whom Do You Call at Dataquest?
- About Dataquest
- Subscription Terms
- Appendixes
  - Appendix A: Dataquest Information Resource Center CD-ROMS and Computer Databases
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Chapter 2

Your Industry Service: What's in It for You?

Clients can tap into Dataquest's extensive knowledge base to support their decision-making process in the industries and markets that we track. The information and analysis that you receive from Dataquest can help you to better:

- Evaluate markets
- Position new products
- Develop marketing strategies
- Perform competitive analysis
- Understand end-user trends
- Verify critical market assumptions
- Assess emerging technologies
- Implement and execute tactical plans
- Support your ongoing research activities

As a Dataquest client you will receive much of this information automatically through the regular publication of database documents and industry analysis. Your industry service also provides information, available at your initiation, that is specific to your company's needs. You will receive Dataquest information through a variety of forms, including:

- *Source: Dataquest*
- *Dataquest Perspectives*
- Inquiry support
  - Industry Analysts
  - Client Inquiry Centers
- Dataquest Information Resource Center

Source: Dataquest

The *Source: Dataquest* binder is an annually updated collection of reference documents. The binder contains worldwide and regional market statistics, *Company Backgrounders*, and several guides.

Guides

- *How to Use Dataquest*: Describes your industry service subscription, publications, inquiry privileges, phone contacts, library use, and other services.
- *High-Technology Guide—Segmentation and Glossary*: Lists key terms and defines the market segments, products, applications, regions, distribution channels, and environments tracked by Dataquest.
- *Dataquest Research Methodology*: Details the research methodology used by Dataquest to gather data and information and provides the general assumptions used to generate industry forecasts.

Market Statistics

Market Statistics documents provide clients with detailed tables consisting of product shipments, average selling prices, industry revenue, forecasts, and market share data.

Company Backgrounders

Each service provides its clients with a set of *Company Backgrounders by Dataquest*, made up of companies that represent 80 percent of the revenue of that industry. *Company Backgrounders* are produced by the Strategic Company Analysis group in Research Operations. The documents contain useful information on a company's finances, product lines, sales and manufacturing locations, and joint ventures, mergers, and acquisitions.

Dataquest Perspective

This multitopic publication, delivered on average twice a month, contains timely analysis of markets, products, technologies, companies, and industry events, and provides detailed discussions of our market projections and market share statistics. These publications are filed chronologically, and include a quarterly index that cross-references articles by company name and major topic. They may be supplemented as needed by the timely delivery of faxes that provide information and analysis of current significant events.

Please note that all of Dataquest's written material is copyrighted and therefore may not be copied without our permission.

Inquiry Support

Inquiry—via phone, fax or letter—is an integral part of the service Dataquest provides. Through inquiry you can:

- Clarify or interpret information.
- Explore Dataquest information in more depth.
- Discuss the application of this information to a particular situation.
- Access information that is not available in Dataquest publications, but is available in Dataquest's extensive files.

Each Dataquest client has a designated binderholder. In addition to receiving all the Dataquest published materials, the binderholder serves as the liaison between Dataquest and your company.

The binderholder has access to Dataquest's inquiry privilege and may designate up to two people to serve as alternates for inquiry privileges. Dataquest account managers need to be aware of any designated alternates.

If someone calls who is not a binderholder or alternate, Dataquest will refer that person to the account manager for your company. We have a commitment to our clients to provide them with timely, high-value information. In order to do that, services must be restricted to authorized contacts.

Call Your Industry Analyst

Industry analysts have significant industry expertise. Directly or through the assistance of Client Inquiry Center (CIC) personnel, you have access to the industry analysts associated with your service. This access is on an as-required basis relative to those markets, products, and technologies within the scope of your service. Analysts may be called directly when you know exactly what you need and who at Dataquest can provide the information.

Call the Client Inquiry Center

Many of Dataquest's services provide a Client Inquiry Center (Enquiry Desks for European customers). These centers are responsible solely for the quick turnaround of your fact-based questions. CIC personnel have access to industry service publications and database information, and they are trained to help you locate information within your Dataquest service. CIC personnel will also put you in touch with appropriate industry analysts when you require in-depth analysis of issues and trends, or opinion about the implications of recent industry events. The CIC may be called when you need an answer to a fact- or data-related question, when you need a backup to your regular analysts should they not be available, or when you need direction to new areas as your questions develop.

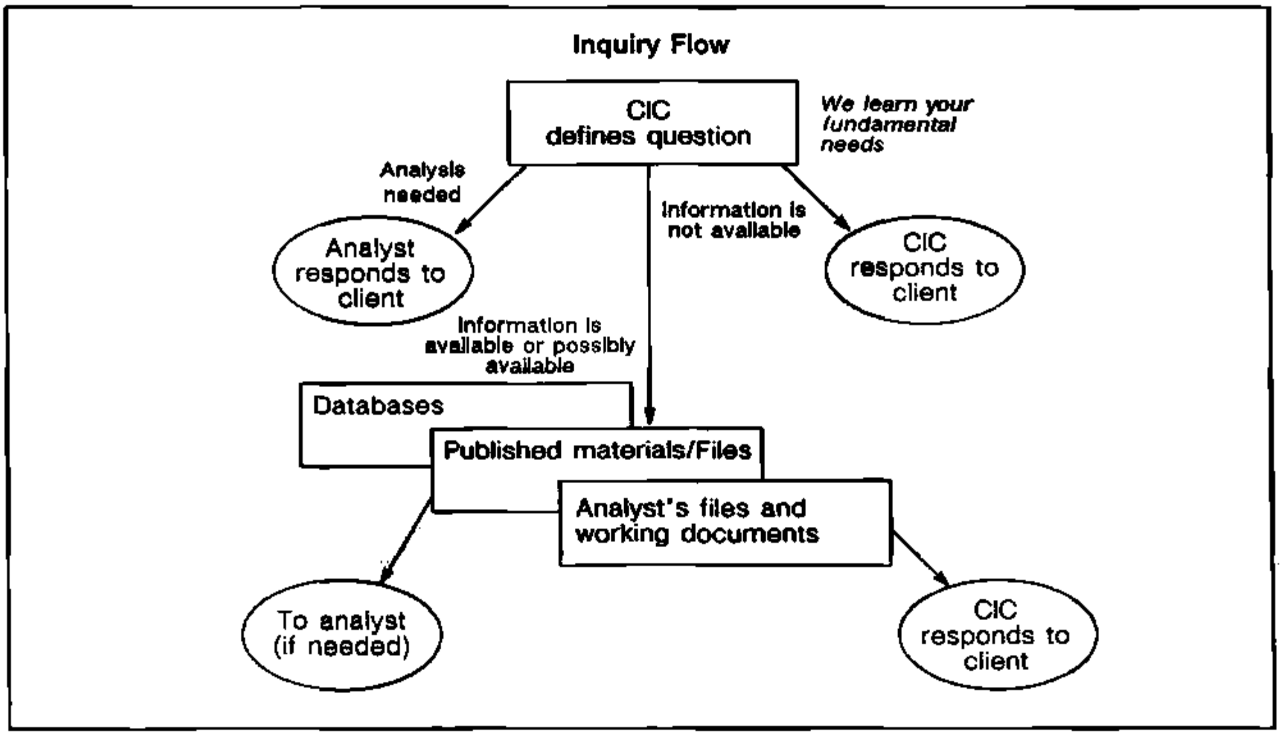
Dataquest is committed to personally handling each of your calls. Figure 2-1 illustrates how inquiries in the CIC are handled. We will ensure that you are put in touch with the right individual, or if you wish, you may choose to leave a voice-mail message when a particular analyst is not immediately available.

The more Dataquest knows about your inquiry, the better we will be able to help you. When you call with a question, the CIC will want to know:

- What information you already have on the subject
- What related information you are gathering
- How you plan to use the information
- What you are trying to demonstrate

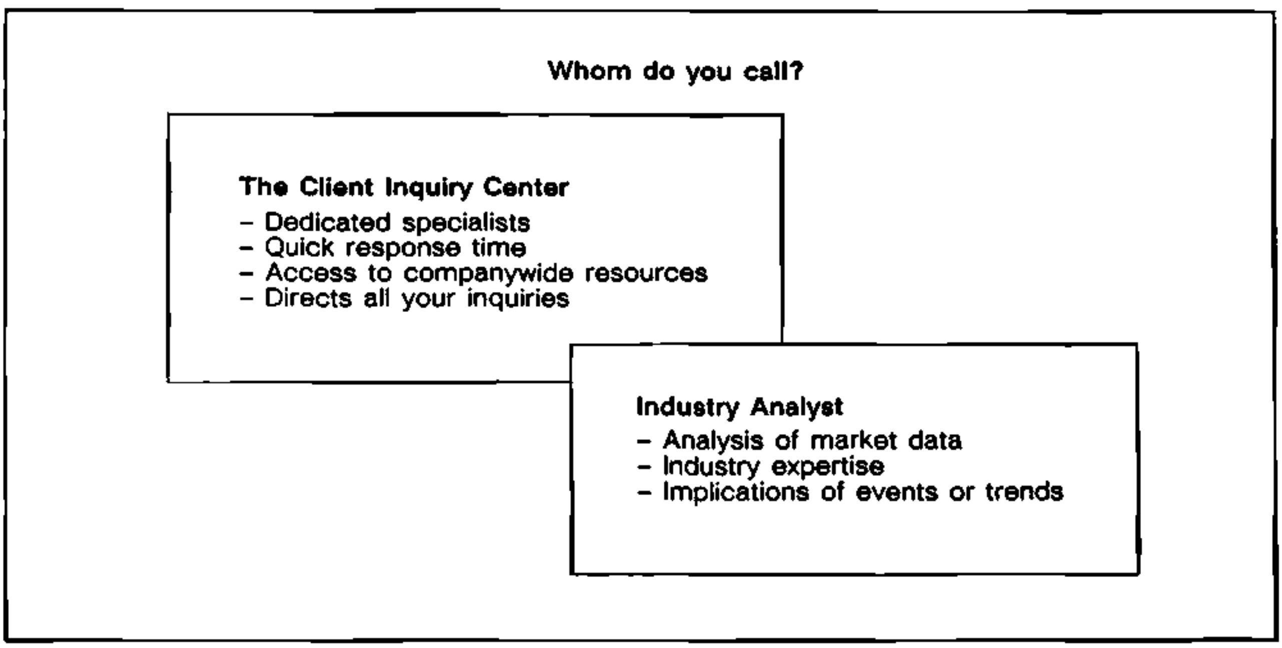
It will also help us to know what stage of the market research process you are in, as well as the depth of information you require. The more we know, the better we will be able to offer additional or related information, or offer insights into different ways to approach the question. Of course, tell us only what you are comfortable with—we don't need or want to know proprietary information. Figure 2-2 shows the mix of people available to respond to your inquiries.

Figure 2-1
Client Inquiry Center Flow



Source: Dataquest (April 1991)

Figure 2-2
Whom to Call for Your Inquiry



Source: Dataquest (April 1991)

Information Resource Center

Dataquest's Information Resource Center (IRC) is a valuable supplement to the information delivered through your industry service. It consists of a 1,200-square-foot corporate library in San Jose, plus two major satellite libraries located in Boston and the United Kingdom. The IRC maintains a wide selection of industry directories, trade press periodicals, financial reports from most of the publicly held companies followed by Dataquest industry services, government reports, and CD-ROM-based and on-line information services.

The European Corporate Library maintains more than 300 titles and reference works concerning the European Community, including approximately 30 files and 100 reference works on the 1992 single European market objective. The U.K. library collection includes basic reference works produced by Her Majesty's Government, the Department of Trade and Industry, and other governmental agencies. Special reports have also been collected from a variety of sources, including the U.K. government, trade associations, the Financial Times, and other research organizations.

Appendix A lists the CD-ROMs and computer databases available to clients at the San Jose IRC. The San Jose IRC is staffed by three degreed professionals (Master of Library Science), as well as assistants who specialize in managing the corporation's secondary research resources.

Clients typically use the IRC in the following ways:

- To obtain financial information on the leading companies within their industry
- To collect recent publications on new areas of the market
- To research a market or topic not covered by a Dataquest industry service

You are encouraged to use the IRC. If it is not convenient to visit an IRC, your Client Inquiry Center staff can often make many of the center's resources available to you through your inquiry privilege.

Policies and Procedures

Because the IRC is a private company library, our collections are limited to the following individuals:

- All permanent Dataquest employees
- Current clients—Binderholders and designated alternates from within the client company
- Consultants/contractors working on specific Dataquest projects (only for duration of contract)
- Prospective clients escorted by a Dataquest salesperson

Non-Dataquest Consultants

It is Dataquest policy to deal directly with Dataquest clients in answering their information needs. The Information Resource Center does not authorize the use of library facilities by consultants working for clients.

Chapter 3

How to Use Your Industry Service

Receiving value from your industry service requires knowing where to find the information you need and how to use that information. The following guidelines will help you get the most out of the many elements of your service.

What Written Materials Will You Receive?

You will receive written material at least twice a month. Some industry services are segmented into key market areas (product or geographic) to allow you to choose the coverage that is most relevant to the markets in which you participate. You will receive written material covering both the broad-based issues of the industry as a whole, as well as the more focused issues of the particular market segment. All written material will be labeled as belonging to one of the following:

- The *Source: Dataquest* binder
- The *Dataquest Perspective* binder
- The segment binder

Source: Dataquest

Source: Dataquest is a regularly updated reference binder in which you'll find the following:

- *How to Use Dataquest:* You are currently in this document.
- *Dataquest High-Technology Guide—Segmentation and Glossary:* This document describes in detail the segmentation and terms used by all Dataquest services to define the markets they track. This guide should be used whenever you are looking for definitions of products, applications, regions, technologies, and environments referred to by your industry service. This document also provides you with standard definitions of research terms that appear in your industry service publications, such as retirements, average selling price, and compound annual growth rate.
- *Dataquest Methodology:* This document will help you understand the research methodology Dataquest uses to gather information on the industries covered by our industry services. It also describes the general assumptions used to generate industry forecasts.
- *Market Statistics:* Each Dataquest industry service provides its clients with documents that contain detailed tables consisting of history, market forecasts, and market share data. We encourage you to use these tables as an opportunity to review your business outlook with Dataquest analysts. Updates and detailed discussions of these data are provided in the *Dataquest Perspective* on an ongoing basis. For segmented services, top-level market statistics are provided in the *Source: Dataquest* binder, and the more detailed statistics for each segment can be found in each segment binder.
- *Company Backgrounders:* You will receive a set of *Company Backgrounders*—profiles on the top players in your industry. These documents are published annually. You should refer to them for corporate overview information, such as financial reports, product line descriptions and analysis, sales and manufacturing locations, and joint ventures, mergers, and acquisitions.

With the exception of the *Company Backgrounders,* these documents will be individually bound and delivered annually or twice yearly, as required. Each *Company Backgrounder* will be updated once a year and will be shipped shortly after the close of the fiscal year for that company. At the time of arrival, the earlier version of the document should be removed from the binder and archived as desired so that the most recent information will be easily accessible to you.

Dataquest Perspectives

Dataquest Perspectives are designed to deliver analysis and Dataquest's view of important issues in your industry. This is a multitopic publication delivered twice a month that contains articles under the following major topic headings:

- Market Analysis: These articles may cover either a product market, regional market, application market, or a distribution channel. Industry service forecast updates are presented and discussed in this section of the *Dataquest Perspective.*
- Product Analysis: These articles analyze the impact of new products on the industry.
- Company Analysis: This section highlights new activities or organizational changes within companies. The articles provide more in-depth analysis of a company's product strategy, financial performance, or marketing performance and strategy than is contained in the *Company Backgrounders*. Articles may also be written about companies for which there is no *Company Backgrounder.*
- Technology Analysis: This section analyzes the impact of key or emerging technologies on your industry. These articles are designed to assist you in strategic and competitive evaluations.
- Conferences and Exhibitions: These articles will identify important industry trends and analyze key events at the conferences and exhibitions attended by Dataquest analysts.
- News and Views: These shorter articles provide Dataquest's perspectives on major industry events.

Dataquest Perspective offers a twice-monthly opportunity to engage your industry service analysts in discussion of the issues and events contained in each publication. For this reason, we provide the name of the author of each article along with a brief synopsis. Clients are encouraged to call the appropriate analyst with questions or a request for more information.

How Do You File Your Written Materials?

Your *Source: Dataquest* binder holds a collection of reference and statistical material. Each document that belongs in this binder will be clearly marked as such and should be filed behind the appropriate tab as indicated in the Table of Contents. Outdated sections should be either discarded or filed separately for archival purposes.

Clients will receive at least 24 *Dataquest Perspectives* each year. These should be filed in the *Dataquest Perspective* binder in chronological order. If you subscribe to a segmented service, at least 4 of your 24 annual *Dataquest Perspectives* will focus on issues specifically related to the markets covered under that industry segment. The industrywide *Dataquest Perspectives* are filed in the core *Dataquest Perspective* binder, and the segment-specific editions are filed in the segment binder.

Each *Dataquest Perspective* will be identified by the name of the service and the name of the segment, if appropriate. It will also have the date, volume, and number on the first page. For example, a subscriber to the Telecommunications—North America service may receive the following two *Dataquest Perspectives:*

- Telecommunications—North America
Vol. 1, No. 1
- Telecommunications—North America
Image Communications
Vol. 1, No. 1

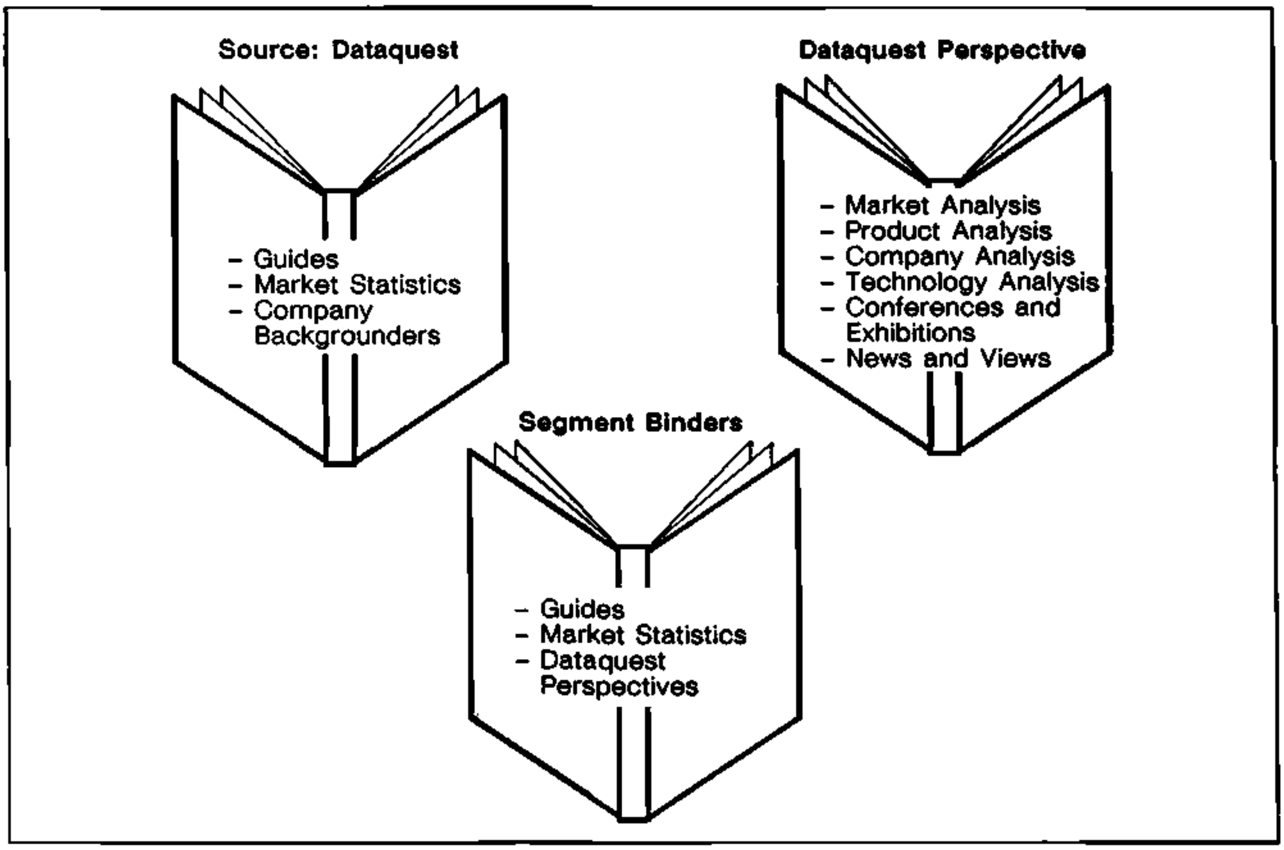
The first document would be filed in the core Telecommunications—North America *Dataquest Perspective* binder. The second would be filed in the Image Communications segment binder.

The contents of your binders are illustrated in Figure 3-1. Subscribers to a standalone European country segment will receive detailed market statistics for that particular country, top-level European statistics, and the pan-European Perspectives. The binder contents are illustrated in Figure 3-2.

How Do You Find the Written Material?

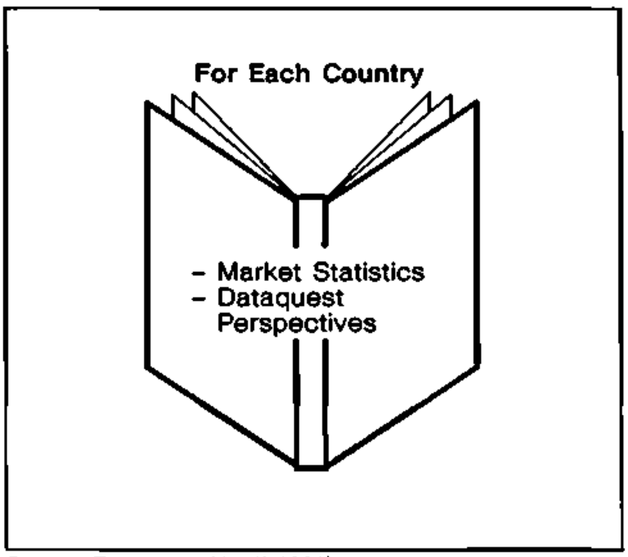
Dataquest is committed to not only providing you with the highest quality research, but also

Figure 3-1
Contents of Your Binder



Source: Dataquest (April 1991)

Figure 3-2
Standalone European Country Binder Contents



Source: Dataquest (April 1991)

making it easy for you to access the information. Clients are provided with the following tools:

- The spines of all binders list the types of information you will find in that binder.
- "What's in This Binder?", appearing immediately following the title page, summarizes the documents in that binder and highlights what can be found in other binders of that service.
- A detailed Table of Contents is contained in the *Source: Dataquest* and segment binders.
- Each bound document in the *Source: Dataquest* and segment binders has its own Table of Contents, including a list of tables where appropriate.
- To help you access the articles you need in a timely manner, Dataquest provides you with a comprehensive index which is delivered quarterly and provides a year-to-date

cross-reference by company name and major topic. The index lists the titles of all articles and of all tables and figures that appear in issues of the publication. Listings include the title, date, and page number for each entry. The first page of each quarterly index provides an explanation of how the index can best be used, along with an example. Segment Perspectives are indexed separately and incorporated into the year-end index provided for the entire service.

Chapter 4

Customizing Your Industry Service

As a subscriber to a Dataquest syndicated market research service, clients receive significant tactical and strategic information. Dataquest also offers a variety of individualized and proprietary programs to clients to help them solve their specialized information and analysis needs. Each project is treated with the strictest confidence.

We carefully review each project with the client prior to beginning the actual research. Dataquest's consulting staff designs a research plan that most effectively meets each client's unique requirements. This includes determining the appropriate information to be gathered, the proper sample size, appropriate collection techniques, and the best analytic methods to be used.

Custom Consulting

Dataquest's custom consulting helps clients in any of the following ways:

- Analyzing specific markets and competitive environments
- Developing strategies for increased market penetration
- Evaluating new business, product, and distribution plans
- Verifying critical market assumptions
- Assessing the impact of emerging technologies on existing products and markets
- Assisting in developing international business strategies, including:
  - Identifying strategic partners, both domestic and international
  - Defining technology "fits"

Custom consulting is structured to provide assistance across all TID services beyond the scope of each service. In areas where new, original work is needed, consulting provides value not only through its own individualized proprietary efforts, but also through its integration of TID information and analysis resources.

Among the elements that consulting can bring to a project are specialized planning assistance, proprietary analyses, in-person interviews, mail surveys, telephone surveys, focus groups, and custom database cuts.

Multiclient Studies

Custom Consulting engages not only in full-custom research projects, but also in the generation of multiclient studies. These studies allow Dataquest to offer clients in-depth information on emerging and/or niche markets at an amortized cost for consulting.

Retainer Consulting

Dataquest also offers its clients retainer consulting. Dataquest analysts and consultants provide consulting advice on an ongoing basis and with quick turnaround to address a variety of client management and marketing needs.

Primary Research

Dataquest's Primary Research services offer a comprehensive range of survey research capabilities that can provide vital information tailored to each client's specific needs. This is important when survey work, but not analysis, is needed. Studies of any type, size, or aspect can be performed as a supplement to existing market research efforts, when nonbiased third-party research is required, or to provide complete primary research capabilities when company resources are not available. Primary Research assumes total responsibility for a project at any stage, from questionnaire development through sample selection, data collection, and final tabulation. The following are examples of the broad range of business applications addressed by Primary Research:

- Market penetration surveys
- Customer needs and satisfaction surveys
- New product research
- Product pricing and positioning surveys
- Annual trend surveys
- Installed base surveys
- Sales trend identification

End-User-Based Services

Score Reports

Customer satisfaction surveys track the level of satisfaction by users of PCs, copiers, electronic printers, PBXs, and public key systems. Key indicators measured include value for price, quality, commitment to customer, features, product delivery, technical documentation, and service. The Score Report is conducted four times a year so that manufacturers can monitor trends in end-user satisfaction levels over an extended period of time.

Score Reports are based on telephone interviews with an annual sample of over 5,000 respondents. A stratified sampling plan is used, with users selected randomly by vendor from a database of U.S. business establishments. No manufacturers' lists are used.

The Score Report survey meets the requirements for measuring customer satisfaction as defined by the Malcolm Baldrige National Quality Award. The Baldrige Award is granted annually by the U.S. Department of Commerce in recognition of U.S. companies that excel in quality achievements and management.

CPE Market Dynamics

This end-user information service provides quarterly data on PBX, Centrex services, and key systems users' purchases by manufacturer, system model, RHC region, state, and vertical market. There are two proprietary custom options, as follows:

- Product-Presence-Hit Rate (PPH) Analysis: Assesses a company's position in the marketplace as a function of product acceptance, distribution, or sales effectiveness.
- Win-Loss Analysis: This option takes PPH analysis one step further, delving into why systems sales are being won or lost by you and your competitors. A customized direct mail, telephone, or personal interview program is established to contact the appropriate end users.

Chapter 5

Whom Do You Call at Dataquest?

Clients who have questions or need assistance in any way are encouraged to call Dataquest at their earliest convenience. Table 5-1 is an overview of who to contact at Dataquest.

Table 5-1

Who to Contact at Dataquest

Question/Concern	Who to Contact
My subscription (e.g., billing, renewal)	My customer service representative
Subscribing to another service	My sales account manager
Data or facts about my industry	Client Inquiry Center
Opinion or analysis about my industry	Analyst in the service
Other services/products offered by Dataquest	My sales account manager
New services/products I would like Dataquest to offer or feedback on current offerings	Product Marketing
	Components: (408) 437-8624
	Systems: (408) 437-8517
	Telecommunications: (408) 437-8602
	Peripherals: (408) 437-8308
	Ledgeway: (617) 862-8500
An upcoming conference	Conference Department
	U.S.—(408) 437-8245
	Europe—(44) 895-835050
	Japan/Asia—(81) 3-5566-0416
A possible proprietary consulting project	Consulting Department, sales account manager, or service analyst
Library visits	Client Inquiry Center, service analyst, or corporate librarian in the U.K.
The new Dataquest format for research delivery	(408) 437-8215, or dedicated Voice Mail Hot Line: (408) 437-7878
Reprints of selected articles	Sales Department—Technology Products: (800) 624-3282

Source: Dataquest (April 1991)

Chapter 6

About Dataquest...

Dataquest was formed in 1971 with the sole purpose of delivering timely and accurate information on critical issues in the high-technology arena. Quoting from the Dataquest mission statement:

> "Our goal is to be the acknowledged worldwide leader in market intelligence for the industries we serve by providing indispensable information and analysis to our clients."

As a member of The Dun & Bradstreet family of companies, Dataquest has access to supplemental information from Dun & Bradstreet and its subsidiaries. Together with our own primary and secondary research capabilities and analyst expertise, this relationship offers the most comprehensive information available on topics pertinent to your industry.

Dataquest comprises two basic business units. Dataquest's Technology Information Division (TID) provides data and analysis on the high-technology electronics industry, encompassing semiconductors, systems, peripherals, application markets, software, and service and support. A cross-industry financial program supported by TID analysts and assigned account managers is tailored to the needs of the financial community. The Machinery Information Division (MID) offers a full range of marketing research and consulting services for professionals in all areas of the heavy equipment and material-handling industries.

The Technology Information Division

The information service you have purchased from Dataquest is part of our Technology Information Division (TID) family of products. TID provides information services that are both tactical and strategic in nature, and include syndicated industry services, custom consulting, multiclient studies, primary research, specialized information services for the financial community, product specification directories, and standalone reports on technology markets. These services are described in more detail in the following paragraphs.

There are five research groups within TID. Each provides data and analysis covering the global electronics industry from semiconductors to systems, from hardware to software, and from applications to service.

Semiconductor Group

This group covers the entire semiconductor "food chain," including manufacturing equipment and materials, device technologies and markets, and end-use applications and procurement issues. Its information services are worldwide in scope and include targeted North American, European, Japanese, and Asian services. The Semiconductor Group is divided into the following 9 services:

- Semiconductors—Worldwide
  - Segments:
    - Semiconductor Memories
    - ASICs
    - Analog and Mixed Signal ICs
    - Microcomponents
    - Gallium Arsenide Semiconductors
- Semiconductors—Europe
- Semiconductors—Japan
- Semiconductors—Asia
- Semiconductor Application Markets—Worldwide
- Semiconductor Application Markets—Europe
- Semiconductor Application Markets—Japan
- Semiconductor Procurement
- Semiconductor Equipment, Manufacturing, and Materials

Systems Group

This group covers business and technical computer systems and applications, both hardware and software, ranging from palmtops to PCs to supercomputers.

Computer Systems Services

The computer systems services cover the following six segments:

- Business Computers
- Servers
- Supercomputers
- Technical Computers
- Unix Systems
- Workstations

European Computer Systems

This service covers the same product areas for 14 European regions.

Microcomputer Systems Group

This worldwide service tracks and analyzes PCs by packaging type, microprocessor, operating system, price point, environment, and region of the world. It includes the following segments:

- Personal Computers—North America
- Personal Computers—Europe
- Personal Computers—Asia
- Personal Computers—European Quarterly Statistics
- Personal Computers—European Price Tracking

Business Applications

This service covers electronic equipment environments in the office that are primarily software driven and looks at the ways in which these environments drive their associated hardware markets. Business Applications is divided into two services:

- Office Software
- Personal Computer Software

Technical Applications

The CAD/CAM/CAE service provides information on four key applications: Mechanical, AEC, GIS/Mapping, and Electronic Design Automation. Its geographic coverage extends to North America, Europe, and Asia. The service is segmented as follows:

- Electronic Design Automation
- Mechanical Applications
- Architecture, Engineering, and Construction, and Geographic Information Systems
- Personal CAD
- CAD/CAM—Europe
- CAD/CAM—Asia

In addition, CASE is covered through consulting.

Telecommunications Group

The Telecommunications Group is divided into two services, the Telecommunications North America service and the Telecommunications Europe service.

These worldwide services divide their coverage of the industry into five major product segments, as follows:

- Image Communications
- Networking
- Personal Communications
- Public Network Equipment and Services
- Voice Communications

Regional market options include country-specific coverage of any of the following European countries: France, Germany, Italy, Netherlands, Spain, Sweden, and the United Kingdom.

Peripherals Group

This group covers markets for devices that are typically attached to multiuser host systems or serve an output function.

Computer Storage Service

The Computer Storage service covers the following four segments:

- Rigid Disk Drives
- Tape Drives
- Optical Disk Drives
- Flexible Disk Drives

Graphics and Displays Service

The Graphics and Displays service covers the following four segments:

- Graphics Processors
- Monitors
- Display Terminals
- Network Stations

Document Management Group

The Document Management group is made up of the following four services:

- Copying and Duplicating (including fax coverage)
- Electronic Printers—North America
- Electronic Printers—Europe
- Electronic Publishing

Ledgeway/Dataquest

Ledgeway/Dataquest is the group that provides strategic and tactical information on the fast-growing services industry. Computer systems vendors typically obtain 25 to 30 percent of their revenue from pre- and postsale services. In addition to services provided by manufacturers, there is a very large and fast-growing industry for professional and systems integration services. Ledgeway/Dataquest covers both of these market sectors.

Ledgeway/Dataquest offers 10 different subscription programs. All programs include access to Ledgeway/Dataquest analysts for inquiry support, periodic bulletins on key events in the service industry, and attendance at Ledgeway/Dataquest's annual ServiceTrends conference.

The ServiceTrends Program

The most widely subscribed service, now in its eighth year, is Ledgeway/Dataquest's ServiceTrends program. In addition to the cornerstone of the program, Ledgeway/Dataquest's annual two-volume *Trends and Forecast* report, which provides in-depth market size and forecast information and analysis of market trends, four topical reports are provided. In 1991, these topical reports are:

- *Global Support Strategies*
- *Measuring and Managing Customer Satisfaction*
- *Japan and the Pacific Rim: Customers or Competitors*
- *Self-Service: Opportunity or Threat*

The Professional ServiceTrends program features analysis of customer wants and needs for systems integration and professional services, in addition to a market trends report, which forecasts market size, growth rates, and analyzes trends. In addition, there are six profiles provided on leading participants in the industry.

Sector Market Programs

Sector market programs are focused on narrow segments of the service market and feature an annual market trends and forecast report, user wants and needs analysis, a pricing trends and data study (for all but the European ServiceTrends program), and six profiles of leading service vendors in each sector. Ledgeway/Dataquest's sector market programs are as follows:

- European ServiceTrends
- Independent/Multivendor Services

- Network/Communications Support
- Mini/Mainframe Software Support
- PC/Workstation Software Support
- Technical Workstation Service and Support
- PC/End-User Computing Services
- Channel Support Strategies

In addition to its subscription services, Ledgeway/Dataquest has a very professional and active custom consulting group that conducts custom projects focused on the following areas:

- Customer satisfaction and service quality audits
- Key competitor analysis and positioning
- New service product market analysis and strategy formation

Subscription services and custom consulting are provided covering worldwide markets.

The Executive and Financial Group

Dataquest's Executive and Financial Group (EFG) offers a number of cross-industry services that are designed primarily for clients in the financial and executive communities. These services offer clients the following benefits:

- Access to all Dataquest research professionals
- Access to TID *Dataquest Perspectives*
- Access to TID conferences
- A personal account manager

EFG includes the following services, which are differentiated largely in terms of the type of clients they serve.

Financial Services Program

The Financial Services Program (FSP) is designed to serve the needs of clients who evaluate loans and investments, monitor portfolios, identify markets and prospects, and develop strategies for penetration of new markets. FSP clients include banks, venture capital firms, CPAs, leasing companies, and development agencies. The program benefits these clients by helping them develop financial strategies in high-technology areas, identify financial opportunities, evaluate proposed client investments and relationships, and monitor companies and markets.

Strategic Executive Service

The Strategic Executive Service (SES) is a networking and technology advisory program specifically designed for CEOs or senior executives. The service is open by invitation only to the presidents of technology companies. Dataquest senior staff from all high-technology industry service groups provide decision support to each president. SES also hosts an annual Presidents' Summit Conference, bringing together subscribers to focus on future trends in high technology products and markets. It is a highly customized service for executive decision makers.

Equipment Leasing Service

At the core of Equipment Leasing Service (ELS) is a portfolio of more than 300 individual future value projections for specific products from more than 45 leading computer, peripherals, and telecommunications vendors. These projections are calculated through a proprietary model and are delivered to clients along with relevant research newsletters. Clients also receive inquiry access to specialized leasing analysts. ELS is designed for companies that lease high-technology equipment. The service assists clients in the areas of lease origination sales, vendor sales, equity sales, asset management and remarketing, and new business development and marketing.

Technology Investment Program

The Technology Investment Program (TIP) is designed to serve the needs of clients in the securities industry, investment banking industry, equity research markets, and institutional investment fields. The service provides clients with company evaluations, product and technology assessments, and other forms of information that help identify target companies for merger/acquisition, joint venture, initial public offerings, and equity investment.

Other Dataquest Services

Conferences

Technology Information Division Conferences

Dataquest hosts a number of conferences each year to present industry forecasts and discuss critical issues and trends. Clients obtain a number of benefits from attending these conferences, including:

- Receiving Dataquest updates on key markets
- Meeting with industry leaders and users
- Discussing market events and their significance to your organization with Dataquest analysts

As an industry service client, you may purchase tickets to any Dataquest conference you wish to attend. Each ticket entitles you, or someone you designate, to attend one Dataquest conference. A complete list of conferences is included in Appendix B of this document. To purchase a conference ticket, or to obtain more information about Dataquest's conferences, contact Dataquest's conference department at any of the following locations:

- North America
  (408) 437-8245
- Europe
  (44) 895-835050
- Japan/Asia
  (81) 3-5566-0416

Invitational Computer Conferences

Dataquest's Invitational Computer Conferences (ICCs) bring major computer manufacturers together with buyers in 41 regional markets around the world. The one-day ICC format combines hands-on product displays with technology seminars designed to educate prequalified regional buyers throughout the United States, Europe, and Asia/Pacific. Each SalesEvent ensures a focused conference, whereby the manufacturers have a selectively targeted audience of buyers and the buyers can learn about new technology, receive a hands-on view of products and solutions, and discuss their application needs with exhibiting regional sales and technical managers. Three ICC series are held as follows:

- *OEM Peripherals* (in various U.S. and European locations), serving OEMs, systems integrators, volume end users, and government buyers/integrators who are all looking to buy computer peripherals.
- *Computer Connectivity* (in various U.S. and European locations), serving MIS/DP managers, systems integrators, network managers, and value-added resellers/dealers who are all looking to buy connectivity/networking solutions.
- *Asia Pacific* (in various Asian locations), serving OEMs, systems integrators, volume end users, and government purchasers who are all looking to buy computer peripherals.

Technology Products

Dataquest also provides standalone products, including specification guides in both hard copy and electronic format (disk), reports, and monthly newsletters that are marketed and sold individually to broad customer audiences. These products are designed to be complementary to the TID syndicated market research services and include highly tactical information on product specifications and pricing, as well as in-depth analyses of specific markets and technology trends. See Appendix C for a current list of products.

Chapter 7

Subscription Terms

Basic Terms of Syndicated Industry Services

The service begins on the date of the first billing. At that time, the subscriber receives the *Source: Dataquest* binder with the current documents and a *Dataquest Perspectives* binder complete with documents covering the last six months. Clients also receive the current year-to-date index as well as the previous year's annual index.

Subscribers to a segment of a service receive a segment binder containing recent segment-specific *Dataquest Perspectives* and the current version of the detailed, segment-specific market statistics. For the duration of the subscription, subscribers receive a copy of each *Dataquest Perspective* published and any annual updates to *Source: Dataquest* documents as they are produced. The inquiry privilege may be used to supplement the material in the binders.

Add-On Subscriptions

Subsidiaries, divisions, regional offices, majority-owned affiliates, and parent companies of a subscribing organization within the same region are eligible for add-on subscriptions at a percentage of the base subscription price. Add-on subscriptions include complete copies of all published material, inquiry privileges specific to the markets subscribed to, and conference attendance at discounted prices. Regions are defined as North America, Europe, and Japan.

Payment Terms

Dataquest's terms, including the applicable sales or value-added tax, are net 30 days.

Base Price

Dataquest reserves the right to change its subscription prices to reflect broadened scope or increased costs. Subscribers will be notified in advance of any such price increase.

A Reminder

Your agreement specifies the individuals in your company who have access to Dataquest information. You will need to obtain written consent from Dataquest to disclose data, analysis, and written materials to any other person or entity beyond those specified by the terms of the agreement.

Dataquest also asks that you not use any data obtained through your industry service in any legal proceedings, or as the basis for advertising copy, press releases, collateral material, or any other promotional material. For further information on the conditions pertaining to your industry service, please refer to your industry service agreement, or contact your sales representative.

Your industry service agreement provides you with a license to use your industry service for the length of time designated in the agreement. If you decide not to renew your industry service at the end of this time, it is your obligation to return these materials to your nearest local Dataquest office.

We Thank You for Choosing Dataquest as Your Marketing Research Partner.

We hope this guide has helped you. Please take advantage of the services we have described. Dataquest's goal is total satisfaction. If you have any questions or comments about this guide or the services it describes, please let us know.

Dataquest Information Resource Center CD-ROMS and Computer Databases

PATENTS

Micropatent

This CD-ROM is a basic search and current awareness tool for U.S. patents, containing abstracts and selected front-page information from patents published by the U.S. Patent and Trademark Office. It covers 1975 to date, with limited information 1969 to 1974. Patent number, inventor, title, and assignee are just a few of the ways to search this CD. It is updated monthly. Book version not available.

FINANCIAL INFORMATION

Compact d Sec—USA

This CD-ROM contains financial and management information on 11,000 public companies filing with the SEC. The current and historical financial information is culled from annual reports and 10-Ks. It is updated monthly. Book version not available; however, the library files have annual reports, 10-Ks, quarterly reports, and 10-Qs. Please check the lateral files and the listing on top of the files.

Compact d Sec—Canada

This CD-ROM provides financial information on 6,000 Canadian companies and is updated quarterly. Book version not available; however, the library files have annual reports. Please check the lateral files and the listing on top of the files.

Compact d Sec—Europe

This CD-ROM provides financial and factual information on 2,000 publicly held European companies and is updated quarterly. Book version not available; however, the library files have annual reports. Please check the lateral files and the listing on top of the files.

COMPANY DIRECTORIES

Corptech

This database contains information on developers and manufacturers of high-technology products in the United States. It is searchable by product, location, size, status, and name and is updated quarterly. Book version available.

Thomas Register

This CD-ROM provides product and directory information for manufacturing companies in the United States and Canada. It is updated monthly. Book version available.

ARTICLE SEARCH

Computer Select (formerly Computer Library)

This CD-ROM is a major upgrade to Computer Library. In addition to the ever-growing list of periodicals included in Computer Select, the full contents of Data Sources, the most comprehensive computer industry directory available, have been added. You'll be able to retrieve specifications on over 67,000 hardware, software, and data communications products, as well as profiles of the over 1,000 companies that make them. New searching capabilities include locating articles by choosing lists of publications, article types, date ranges, topics, and other fields. It is updated monthly. Book version of Data Sources available.

COMPUTER DIRECTORIES

ICP Software Information Database

This CD-ROM provides information on micro, mini, and mainframe software products offered by over 4,000 vendors and is updated quarterly. Book version available.

Dataquest 1991 Conference Schedule

North America		
Forecast '91-Technology Briefing	March 5	San Jose
Ledgeway Service & Support	April 8-9	San Francisco
Semicon/West	May 22	Redwood City
Document Management	June 27-28	San Francisco
Personal & Wireless Communications	August 12-13	Monterey
Portable Computing	September 11-12	San Jose
Semiconductor	October 14-16	Monterey
Europe		
Computer Industry	February 14-15	London
	February 19-20	Milano
	February 25-26	Frankfurt
	March 6-7	Paris
Semicon/Europa '91	March 6	Zurich
Semiconductor	May 29-31	Marbella
Printer	June 11-12	Amsterdam
Colour Market	June 12-13	Amsterdam
Copying & Duplicating	June 13-14	Amsterdam
Telecommunications	November 7-8	London
Japan and Asia		
Semiconductor	April 22-23	Tokyo
Computer & Telecommunications	June 25-26	Tokyo
Strategic Industry	September 24-25	Taipei
Peripherals	October 1-3	Tokyo

For reservations or further information call: U.K. 895-835050 San Jose (408) 437-8245 Tokyo 3-5566-0411
January 1991—Subject to revision

Appendix C

Technology Products

SpecCheck Guides

Copier SpecCheck-On-Disk Disk version of the Copier SpecCheck Guide. Allows custom sorts on 500 models and 24 vendors. Six annual updates on either 3.5-inch or 5.25-inch format.

Copier SpecCheck Guide Detailed specifications and pricing information on 500 copier models. Two full books, two updates per year.

Fax SpecCheck-On-Disk Disk version of Fax SpecCheck Guide. Allows custom sorts on 600 models and 47 vendors. Six annual updates on either 3.5-inch or 5.25-inch format.

Fax SpecCheck Guide Detailed specifications and pricing information on 600 fax models. Two full books, two updates per year.

PC SpecCheck-On-Disk Disk version of PC SpecCheck Guide. Allows custom sorts on 400 models and 47 vendors. Six annual updates on either 3.5-inch or 5.25-inch format.

PC SpecCheck Guide Detailed specifications and pricing information on 400 PC models. Four full books per year.

Personal Page Printer SpecCheck-On-Disk Disk version of Personal Page Printer SpecCheck Guide. Allows custom sorts on 400 models and 100 vendors. Four annual updates on either 3.5-inch or 5.25-inch format.

Personal Page and Ink Jet Printers SpecCheck Guide Detailed specifications and pricing information on 275 personal page and ink jet printer models. Two full books per year.

Dot Matrix Printer SpecCheck Guide Detailed specifications and pricing information on 300 dot matrix printers. Two full books per year.

High-Speed Page and Line Printers SpecCheck Guide Detailed specifications and pricing on 300 high-speed page and line printers. Two full books per year.

Reports

Imaging Materials Series

Series of reports on key areas of the imaging materials industry. Reports currently available or planned are:

Toner in the '90s: The Shape of Things to Come Detailed analysis of the liquid and dry toner and developer industry. The report looks at market size, structure and growth, U.S. and foreign producers, and trends in materials manufacturing and distribution. Includes directory of suppliers. Available now.

Specialty Papers and Films: New Technology, Media, and Markets In-depth report on the hard-copy media field for paper and film products. The report looks at imaging processes, imaging hardware, end-use applications for hard-copy output, and market size and forecast. Includes directory of suppliers. Available June 1991.

The Photoreceptor Industry: A Marketing and Technical Analysis Detailed analysis of photoreceptor technology and the industry. Volume I chronicles the evolution of the industry in terms of equipment, manufacturing, and distribution, providing market size and forecasts. Volume II is a complete reproduction of U.S. patent abstracts from 1979-1990. Includes directory of manufacturers. Available Fall 1991.

Other Reports

Fax On Demand—Marketing Tool for the '90s A useful report to help end users evaluate and select voice/fax systems and implement fax-on-demand services for their business. Includes applications, technology, and economic considerations for fax-on-demand, as well as a directory of product vendors and service providers. Available June 1991.

Color Scanner User Survey for U.S. Publishing Markets Extensive survey of key end-user markets in publishing, advertising, printing services, graphic design, PostScript output services, and Fortune 1000 companies to ascertain purchase intentions and installed base of color and monochrome scanners. Available May 1991.

Semiconductor Industry Insights—from Silicon to Systems Analysis of the global semiconductor industry containing market forecasts, key drivers, product demand, semiconductor production, equipment, and materials.

Voice Processing Opportunities in the U.S.—A Market Assessment and End-User Survey Extensive end-user survey providing networking information, applications, satisfaction level, purchase decision making, and selection criteria by key vertical markets. Also includes market shares, technology, standardization, revenue, and pricing forecasts through 1994.

High-Speed Printing Applications in Banking A vertical market study comprising two reports and videotapes/transcripts of three focus sessions. Study focuses on high-speed printing applications in the banking industry and examines the applications that banks print internally and externally, as well as special printing capability needs of the banking industry.

Portable Computing in the 1990s Three-part series on the latest products, features, and options for transportables, laptops, notebooks, palmtops, and electronic daybooks.

PC LAN Markets in Europe 1990 Analysis of all the major PC LAN vendors in 13 European countries. Market shares, forecasts, distribution channels, and shipments segmented by end-user types.

Computer Usage in European Banks 1990 In-depth, two-volume study on the demand for hardware, applications, LANs, and operating systems in European banks, segmented by bank size. A widespread survey of banks in nine European countries was supplemented by personal interviews with key decision makers at the largest banks.

Monthly Newsletters

Copier FAXts A look at new products, distribution, organizational news, and trade show highlights for the copier and fax industries.

IC Europe All the latest local intelligence and analysis of new products, alliances, technology impacts, and forecasts for the European semiconductor industry.

European Monitor Monthly newsletter with all the latest news on vendor, product, and distribution developments in the European personal computer market.

Price Tracking Flash Monthly newsletter on PC product announcements and changes in price, configuration, and distribution for PC products by 16 manufacturers in 14 European countries.

Other Technology Products

Company Backgrounders by Dataquest Detailed vendor profiles on almost 300 leading worldwide high-technology companies highlighting company strategic direction, business direction, detailed product line summaries, information on joint ventures, mergers and acquisitions, and licensing agreements.

DQ Monday On-Line News, analysis, and current prices for 25 leading semiconductor product groups for all the major markets: United States, Europe, Japan, Hong Kong, Taiwan, and Korea.

DQ Test Target Package of ten 8.5 x 11-inch copier/fax test patterns: gray scale, black and white, and color.

International Test Target Package of ten standard European-size test targets.

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Dataquest Research Methodology

Source: Dataquest

Dataquest

Dataquest Research Methodology

Source: Dataquest

Published by Dataquest Incorporated

Dataquest's Research Philosophy—Methodology for Value

From semiconductors to systems, office to factory automation, Dataquest provides quality research on more than 25 separate high-technology industries and their markets.

Fundamental to the way Dataquest conducts its research is an underlying philosophy that says the best data and analysis come from a well-balanced program. Such a program includes a balance between primary and secondary data collection techniques; between supply-side and demand-side analysis; between focused, industry-specific research and coordinated, "big picture" analysis; and between the informed, insightful perspectives of experienced industry professionals and the rigorous, disciplined techniques of seasoned market researchers. Ultimately, this leads to a balance between data and analysis—the combination of which provides unique insight and ultimate value to our clients.

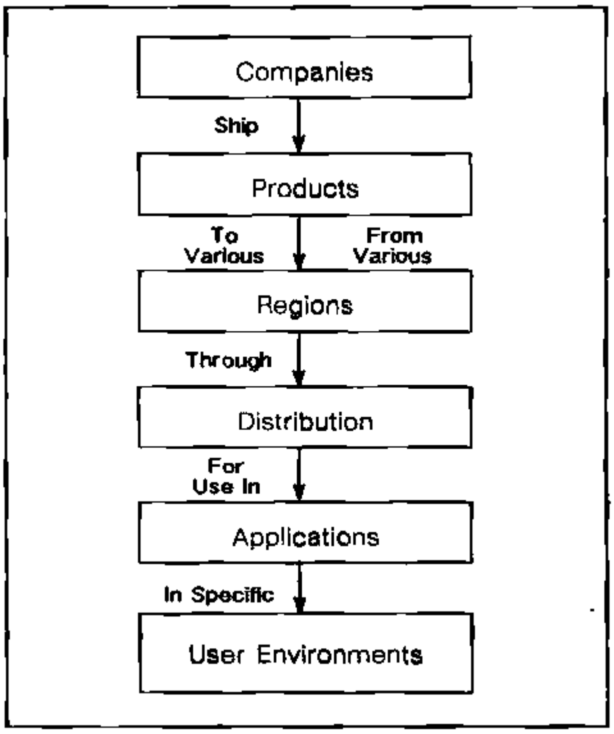
Market Segmentation—Setting the Standards

The design of market segmentation and data standards is a critical issue at Dataquest. Much effort is devoted to choosing and defining the way products, industries, and markets are segmented. Dataquest's objective is to provide data and analysis along lines of segmentation that are logical, appropriate to the industry in question, and immediately useful to clients.

Over the years, Dataquest has consistently established industry-accepted standard segmentations for the way we follow products and their movement. Figure 1 reflects the way we track products. Further, we spend a great deal of time and effort in defining *how* we track these products and determining what *our* definitions are for the market metrics we use—for example, shipments, installed base, retirements, factory revenue versus end-user revenue, market share, and so on.

We follow several dimensions. Sometimes there are one-to-one, or dedicated, relationships between dimensions—for example, between software products and their applications. We believe that all major high-technology industries mirror this scheme. Note that we do not use the term vertical markets. This term is often used to refer to either applications or environments because both terms describe the use of a product. Application describes what the product is used for, and environment describes where the product is used. The term vertical market often is used for either of these terms and thereby can cause confusion.

Figure 1
How Dataquest Tracks High Technology



Source: Dataquest (March 1991)

We have therefore standardized on the following terminology, which distinguishes between application and environment, for each dimension we follow:

- Major product categories:
  - Materials
  - Components
  - Boards and subsystems
  - Equipment
  - Software
  - Consumables
  - Services
  - Others
- Product—A good or service
- Product category—A group of similar products
- Region—Geographic areas of both shipments and consumption
- Distribution—The path by which a product moves from manufacturer to ultimate user
- Application—The use to which a product is put; the function it performs
- Environment—Where a product is ultimately used

The Dataquest Staff

Dataquest believes that in order for an analyst to understand and analyze an industry, the analyst must have competed in it. To that end, our staff is heavily populated with professionals who have extensive experience in the industries they analyze. These analysts have held high-level positions in engineering, marketing, product development, and other related areas.

These industry veterans are complemented by a staff of professional market researchers who understand the principles of market research and who direct Dataquest's programs in primary and secondary research, demographics, economics research, statistical analysis, forecasting, and modeling. Figure 2 illustrates our staffing philosophy. This blend of experience and training is unique in the research industry and allows Dataquest to provide its clients with market research of unequaled value.

To develop industry analysis and data, Dataquest collects a wide spectrum of information from a carefully selected portfolio of sources. Data are collected directly by our researchers in the United States, Europe, Japan, and Asia.

Primary Research

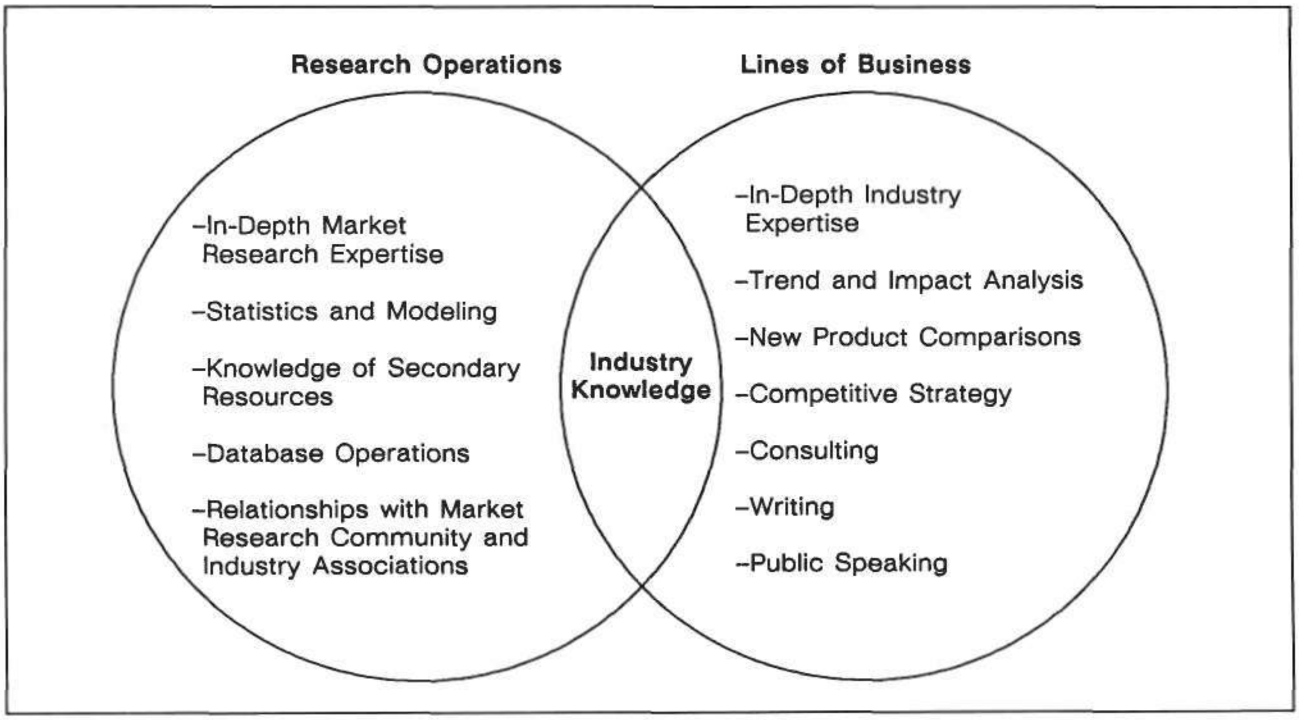
The principal data collection methodology at Dataquest is primary research—firsthand data collection by Dataquest researchers. Primary research is conducted with businesses, households, government, and schools; manufacturers, suppliers, and distributors; and product end users. Dataquest's in-house Primary Research Group (located in San Jose and Paris) processes more than 10,000 interviews each month, through both mail and telephone interviews, as well as using focus groups and personal interviews. Questionnaires are developed by the Primary Research Group in conjunction with Dataquest industry analysts.

All surveys have been designed and demographic samples selected to answer specific inquiries. These samples conform with Dataquest's standard demographic profiles so that results will comply with existing data structures.

The samples are drawn from a variety of sources, frequently from the databases of our parent company, The Dun & Bradstreet Corporation, including the Dun's Market Identifier File of 6 million U.S. businesses. We also draw samples from the databases of Computer Intelligence and Focus Research. The number of interviews conducted is usually specified to produce data with a reliability of ± 5 percent at a 95 percent confidence level.

Following questionnaire development and sample selection, each survey undergoes a rigorous pretesting to make sure the interview captures the desired information. Once adjustments have been made, the telephone surveys are conducted on-line by Dataquest's in-house team of professional interviewers. Call monitoring allows us to provide quality control throughout the process. All data entry and tabulation are done in-house.

Figure 2
Research Organization



Source: Dataquest (March 1991)

Firsthand Observation

On a daily basis, Dataquest watches and measures high technology around the world, using yet another technique of primary research: firsthand observation. Dataquest analysts regularly visit the laboratories, R&D facilities, and manufacturing plants of the companies they follow. They view the technologies and new products; study the manufacturing yields and levels of automation; and meet the people behind the products and companies, from start-up companies to industry leaders.

Secondary Sources

Primary research is supplemented with a review of secondary-source materials. Dataquest's Information Resource Centers throughout the world maintain an extensive collection of information including technical, trade, and general business periodicals; reports; economic data; technical papers; patents; government data; directories; financial literature; product literature; press releases; and many on-line databases. These sources provide specific data points and qualitative input to Dataquest analysis. They cover trends in technology, pricing, manufacturing capacity, competition, product features, demand, buyer behavior, and macroenvironmental forces such as demographics, the economy, and the regulatory arena. The following steps reflect the overall research process at Dataquest:

- Initiate and clarify research request
- Develop methodological approach
- Develop questionnaire
- Select sample
- Load questionnaire (on-line interviewing)
- Prepare estimates (if appropriate)
- Conduct interviewer briefing
- Pretest
- Interview

- Perform quality check and call monitoring
- Merge data
- Perform scrubbing, tabulation, and statistical analysis
- Approve data
- Report on and deliver results
- Maintain database (as required)

The following is a typical cadre of sources:

- Industry contacts
- Industry associations and user groups
- Trade shows and conferences
- Demographics
- D&B economic research
- D&B credit services
- Computer intelligence
- Document management systems
- Focus Research
- Government and regulatory agencies
- Industry and trade publications
- Public databases and libraries
- Annual reports and Forms 10-K
- Product specifications and press releases
- Patent activity

Market Sizing and Market Share

Dataquest conducts surveys of manufacturers and distributors in their respective industries monthly, quarterly, or annually. These surveys collect information on shipment and inventory levels, pricing, and short-term market expectations. Data are checked and cross-checked across data collection points at the supplier, manufacturer, distributor, and end-user levels.

This data collection effort resides at the core of our standard syndicated industry services. We use demand-based surveys for many of our newer products and custom consulting. However, the balance of this discussion focuses on our standard, syndicated industry service product line.

We first develop a company universe for each industry. The sources reflected in Figure 2 are checked to make sure that we have a full census of industry participants.

Next, Dataquest analysts and researchers derive estimates for each product or product category for which we collect shipment and revenue data. The estimates are then provided to vendor representatives for correction or substantiation.

The data collected in our vendor surveys are always considered public information. The data are used to allow bottom-up analysis defining market revenue, market size, and market share. The names of respondents are always kept confidential, and all data are published as Dataquest estimates. All respondents are notified of our policies when our market estimates are initially sent.

Following is a list of steps we go through to derive estimates and reconcile the responses for final approval and reporting:

- We establish product category or model-level detail.
- We establish estimates and check against the following:
  - Aggregate data
  - Industry forecast
  - Historical performance
  - Growth rate of competition
  - Growth rate of related products
- We use the following sources:
  - Vendor verification
  - Quarterly financials
  - Industry associations
  - Distribution channel data
  - Manufacturing capacity
  - Life-cycle analysis
  - Components and peripherals purchases
  - Consumables production
  - Ongoing dialog with industry sources

- Industry analysts' qualitative insight
- Government statistics
- Other secondary sources

- We reconcile responses against Dataquest segmentation standards.

Market Forecasts

We believe that complex interrelationships among the various products, markets, and high-technology industries that we follow should be understood and accounted for in the assumptions underlying each forecast. Forecasts must reconcile the complementary nature of systems, peripherals, and components.

Our forecast methodology begins with the completion of our vendor-based data acquisition, which is used to establish market size for the given year of data collection. These data are used to measure the accuracy of our previous year's projection for the current year. This infrastructure creates a critical foundation that is the starting point for our forecasts.

No single forecast model applies at Dataquest because of the large scope of products and industries that we follow. We have a basic forecasting framework in place that incorporates both quantitative and qualitative data to derive forecasts. Analysts take the following factors into consideration when deriving and cross-checking forecasts and their assumptions:

- Macroeconomics
- Emerging technologies
- Life-cycle analysis
- Retirements
- Environmental trends
- Demographic trends
- Product availability
- Buying intentions
- Captive production
- Historical growth
- Historical pricing
- Installed base
- Saturation
- Obsolescence
- Import and export
- Most likely constraints
- Total available market

Finally, we regularly hold research forums that provide an open exchange of opinions for our analysts.

Throughout Dataquest, each variable must be defined and measured in the same way. Analysts may vary the relationships between variables but not the values themselves. Not all variable relationships hold true for all industries; therefore, analysts may specify which sets of variables to use. Data must be reported according to Dataquest standard segmentation, and all final data must be approved before they are reported. *All* preliminary data are clearly stated as such. All final data are reported as Dataquest estimates. Our information is sourced appropriately with the phrase "Source: Dataquest," and the data are stamped with a date so that users have a clear understanding of what iteration they are using and the assumptions behind those data.

Dataquest Market Research—What's behind the Numbers?

When Dataquest clients receive forecast data with the familiar line "Source: Dataquest," they receive the end result of a rigorous process of primary and secondary data collection; supply-side, demand-side, and macroenvironmental analysis; and the cross-industry perspective afforded by Dataquest's uniquely broad and in-depth worldwide coverage of high technology.

Behind the numbers is a thorough discussion, involving industry professionals and research experts, and testing of the assumptions used to develop Dataquest's forecasts. In this way, clients get more than simply a single point of data for planning and decision making. Behind the numbers is a commitment to quality—a worldwide organization of people committed to supplying the highest-quality *information* and *analysis* to Dataquest's clients.

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Dataquest High-Technology Guide

Segmentation and Glossary

1991

Source: Dataquest

Dataquest

Dataquest High-Technology Guide

Segmentation and Glossary

1991

Source: Dataquest

Dataquest

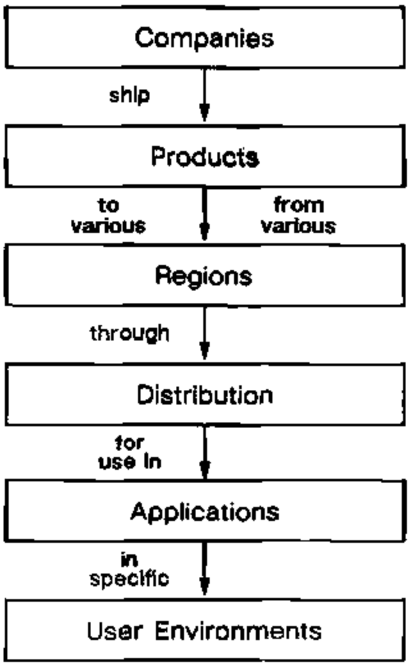
Published by Dataquest Incorporated

High–Technology Guide

The *High–Technology Guide* provides a reference for Dataquest research, analysis, and publications. The segments and terms found in this guide are used consistently in our research and methodology and throughout Dataquest products.

The *High–Technology Guide* is divided into two parts: segmentation and glossary. The segmentation section provides a comprehensive listing of the classifications used in our research. This segmentation is broken into different dimensions including companies, products, regions, distribution, applications, and user environments. These dimensions are illustrated below (see Figure 1). The glossary is an alphabetical list defining the terms found in the segmentation section.

Figure 1
Research Dimensions



Source: Dataquest (January 1991)

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Segmentation

Companies

The companies section contains more than 3,500 companies on which Dataquest conducts research. These companies are studied because of their concentration or emphasis in technology markets and industries. The company segmentation shows the breadth and depth of collective coverage that Dataquest maintains. Because of the extensive nature of the company list, it is not published in this guide but can be provided upon request.

Products

The products section lists high-technology products. This section presents the segmentation of the technology as defined by Dataquest.

The major categories of products are as follows:

- Materials
- Components
- Boards and Subsystems
- Equipment
- Software
- Consumables
- Services
- Other Products

The segmentation represents Dataquest's view of the high-technology marketplace and is not intended to represent the availability of data.

Products

MATERIALS

- Wafer
  - Silicon Wafer
  - Epitaxial Wafer
- Gas
  - Bulk Gas
    - Nitrogen
    - Oxygen
    - Hydrogen
    - Argon
  - Specialty Gas
    - Silicon Precursor
    - Dopant
    - Plasma Etchant
    - Reactant Gas
    - Atmospheric/Purge Cylinder Gas and Other
  - Plastics

COMPONENTS

- Semiconductor
  - Integrated Circuit
    - Bipolar Digital (by Technology)
      - TTL/Others
      - ECL
    - Bipolar Digital (by Function)
      - Bipolar Digital Memory
        - Bipolar RAM
        - Bipolar Nonvolatile Memory
        - Other Bipolar Memory
      - Bipolar Digital Microcomponents
      - Bipolar Digital Logic
        - Bipolar ASIC
          - Bipolar Gate Array
          - Bipolar PLD
            - Bipolar PLA
            - Bipolar PMD
            - Bipolar FPGA

The segmentation represents Dataquest's view of the high-technology marketplace and is not intended to represent the availability of data.

COMPONENTS

- Bipolar ASIC (Continued)
  - Bipolar Cell-Based IC
- Bipolar Custom IC
- Bipolar Standard Logic
- Other Bipolar Logic

MOS Digital (by Technology)
- NMOS/PMOS
- CMOS
- BiCMOS

MOS Digital (by Function)
- MOS Memory
  - DRAM
    - 16K DRAM
    - 32K DRAM
    - 64K DRAM
    - 128K DRAM
    - 256K DRAM
    - 1Mb DRAM
    - 4Mb DRAM
    - 16Mb DRAM
  - SRAM
    - Slow SRAM
      - 1K SRAM
      - 4K SRAM
      - 8K SRAM
      - 16K SRAM
      - 64K SRAM
      - 256K SRAM
      - 1Mb SRAM
      - 4Mb SRAM
    - Fast SRAM
      - 1K SRAM
      - 4K SRAM
      - 8K SRAM
      - 16K SRAM
      - 64K SRAM
      - 256K SRAM
      - 1Mb SRAM
      - 4Mb SRAM

The segmentation represents Dataquest's view of the high-technology marketplace and is not intended to represent the availability of data.

COMPONENTS

- Nonvolatile Memory IC
  - ROM
    - 4K ROM
    - 8K ROM
    - 16K ROM
    - 32K ROM
    - 64K ROM
    - 128K ROM
    - 256K ROM
    - 1Mb ROM
    - 2Mb ROM
    - 4Mb ROM
    - 8Mb ROM
    - 16Mb ROM
  - EPROM
    - 16K EPROM
    - 32K EPROM
    - 64K EPROM
    - 128K EPROM
    - 256K EPROM
    - 1Mb EPROM
    - 2Mb EPROM
    - 4Mb EPROM
    - 8Mb EPROM
  - EEPROM
    - 1K EEPROM
    - 2K EEPROM
    - 4K EEPROM
    - 8K EEPROM
    - 16K EEPROM
    - 32K EEPROM
    - 64K EEPROM
    - 128K EEPROM
    - 256K EEPROM
    - 512K EEPROM
    - 1Mb EEPROM
  - Other MOS Memory
- MOS Microcomponents
  - MOS Microprocessor (by Word Length)
    - 8-bit MOS MPU

The segmentation represents Dataquest's view of the high-technology marketplace and is not intended to represent the availability of data.

COMPONENTS

- MOS Microprocessor (by Word Length) (Continued)
  - 16-bit MOS MPU
  - 16/32-bit MOS MPU
  - 32-bit MOS MPU
  - 32/64-bit MOS MPU
  - 64-bit MOS MPU
- MOS Microprocessor (by Technology)
  - CISC MOS MPU
  - RISC MOS MPU
- MOS Microcontroller
  - 4-bit MOS MCU
  - 8-bit MOS MCU
  - 16-bit MOS MCU
  - 32-bit MOS MCU
  - Digital Signal Processor
    - DSP Microprocessor (DSMPU)
    - Microprogrammable DSP (MPDSP)
    - Special-Function DSP (SFDSP)
- MOS Microperipheral
  - System Support Peripheral
    - Traditional Peripheral
      - Counter/Timer
      - DMA
      - Interrupt Controller
      - Memory Management
      - Real-Time Clock
      - Others
    - General-Purpose I/O
    - DRAM Controller
    - Cache Controller
    - PC Logic Chip Set
  - Display Peripheral
    - Alphanumeric CRT Controller
    - Graphics Controller
    - Keyboard Controller
    - Printer Controller
    - Others
  - Mass Storage Peripheral
    - Floppy Disk Controller
    - Hard-Disk Controller
    - Optical Disk Controller
    - Others

The segmentation represents Dataquest's view of the high-technology marketplace and is not intended to represent the availability of data.

COMPONENTS

- Communications Peripheral
  - LAN
  - ISDN
  - Modem
  - Serial I/O
  - UART/USART
  - Others
- Floating-Point Coprocessor
  - 16-bit
  - 32-bit

MOS Logic
- MOS ASIC
  - MOS Gate Array
  - MOS PLD
    - MOS PLA
    - MOS PMD
    - MOS FPGA
  - MOS Cell-Based IC
- MOS Custom IC
- MOS Standard Logic
- Other MOS Logic

Analog Integrated Circuit
- Monolithic Analog IC
  - Linear IC
    - Amplifier IC
    - Voltage Regulator
    - Voltage Reference IC
    - Comparator IC
    - Special-Function IC
    - Special Consumer IC
    - Special Automotive IC
    - Linear Array/ASIC
  - Mixed Signal IC
    - Data Converter IC
    - Telecommunication IC
    - Interface IC
    - Switch/Multiplexer IC
    - Disk Drive IC
    - Mixed Signal ASIC
- Hybrid Analog IC

The segmentation represents Dataquest's view of the high-technology marketplace and is not intended to represent the availability of data.

COMPONENTS

- Discrete Semiconductor
  - Transistor
    - Small Signal Transistor
    - Power Transistor
      - Bipolar Power Transistor
      - MOS Power Transistor
      - Insulated Gate Bipolar Transistor
  - Diode
    - Small Signal Diode
    - Power Diode/Rectifier
  - Thyristor
  - Other Discrete Semiconductor
- Optoelectronic Semiconductor
  - Light-Emitting Diode/Display
  - Optocoupler
  - CCD
  - Laser Diode
  - Photosensor
  - Solar Cell
- III-V Semiconductor
  - GaAs Digital IC
  - GaAs Analog IC
  - III-V Discrete Transistor
  - Optoelectronic IC

Passive Component

- Cable
- Capacitor
- Cathode Ray Tube (CRT)
- Connector
- Inductor
- Potentiometer
- Relay
- Resistor
- Socket
- Splice (Optical)
- Transducer
- Liquid Crystal Display
- Switch

The segmentation represents Dataquest's view of the high-technology marketplace and is not intended to represent the availability of data.

BOARDS AND SUBSYSTEMS

Graphic Board
- Mac-Type Add-On Graphic Board
- IBM-Type Add-On Graphic Board

Imaging Subsystem
- Add-On Memory Board
- Controller Board
  - Storage Controller Board
  - Printer Controller Board
- Magnetic Recording Head
- Board-Level Computer

Storage Subsystem

EQUIPMENT

Data Processing Equipment
- Computer Systems by Product Segment
  - General-Purpose Computer System
    - Supercomputer
      - Corporate Supercomputer
      - Departmental Supercomputer
      - Research Supercomputer
    - Mainframe Computer
    - Midrange Computer
      - Superminicomputer
      - Minicomputer
      - Microcomputer
    - Workstation Computer
      - Graphic/Project Supercomputer
      - Superworkstation
      - Traditional Workstation
      - Entry-Level Workstation
    - Personal Computer
      - Desktop Personal Computer
      - Desk-Side Personal Computer
      - Transportable Personal Computer
      - Laptop A/C Personal Computer
      - Laptop D/C Personal Computer
      - Notebook D/C Personal Computer
      - Pen-Based Personal Computer

The segmentation represents Dataquest's view of the high-technology marketplace and is not intended to represent the availability of data.

EQUIPMENT

Hand-Held Personal Computer

Special-Purpose Computer System

Data Storage Device
- Flexible Disk Drive
  - Fixed Media
    - Sub-3.5-Inch Disk Drive
      - 0 to 30MB
      - 31 to 60MB
      - 61 to 100MB
      - 101 to 200MB
      - 201 to 500MB
      - 501+MB
    - 3.5-Inch Disk Drive
      - 0 to 30MB
      - 31 to 60MB
      - 61 to 100MB
      - 101 to 200MB
      - 201 to 500MB
      - 501 to 1,000MB
      - 1,001+MB
    - 5.25-Inch Disk Drive
      - 0 to 30MB
      - 31 to 60MB
      - 61 to 100MB
      - 101 to 200MB
      - 201 to 500MB
      - 501 to 1,000MB
      - 1,001+MB
    - 8 to 10.5-Inch Disk Drive
      - 0 to 30MB
      - 31 to 60MB
      - 61 to 100MB
      - 101 to 200MB
      - 201 to 500MB
      - 501 to 1,000MB
      - 1,001+MB
    - 14-Inch Disk Drive
      - 0 to 30MB
      - 31 to 60MB

The segmentation represents Dataquest's view of the high-technology marketplace and is not intended to represent the availability of data.

EQUIPMENT

14-Inch Disk Drive (Continued)
- 61 to 100MB
- 101 to 200MB
- 201 to 500MB
- 501 to 1,000MB
- 1,001+MB

Rigid Disk Drive
- Fixed Media
  - Sub-3.5-Inch Disk Drive
    - 0 to 30MB
    - 31 to 60MB
    - 61 to 100MB
    - 101 to 200MB
    - 201 to 500MB
    - 501+MB
  - 3.5-Inch Disk Drive
    - 0 to 30MB
    - 31 to 60MB
    - 61 to 100MB
    - 101 to 200MB
    - 201 to 500MB
    - 501 to 1,000MB
    - 1,001+MB
  - 5.25-Inch Disk Drive
    - 0 to 30MB
    - 31 to 60MB
    - 61 to 100MB
    - 101 to 200MB
    - 201 to 500MB
    - 501 to 1,000MB
    - 1,001+MB
  - 8 to 10.5-Inch Disk Drive
    - 0 to 30MB
    - 31 to 60MB
    - 61 to 100MB
    - 101 to 200MB
    - 201 to 500MB
    - 501 to 1,000MB
    - 1,001+MB

The segmentation represents Dataquest's view of the high-technology marketplace and is not intended to represent the availability of data.

EQUIPMENT

- 14-Inch Disk Drive
  - 0 to 30MB
  - 31 to 60MB
  - 61 to 100MB
  - 101 to 200MB
  - 201 to 500MB
  - 501 to 1,000MB
  - 1,001+MB

Removable Media

- Sub-3.5-Inch Disk Drive
  - 0 to 30MB
  - 31 to 60MB
  - 61 to 100MB
  - 101 to 200MB
  - 201 to 500MB
  - 501+MB
- 3.5-Inch Disk Drive
  - 0 to 30MB
  - 31 to 60MB
  - 61 to 100MB
  - 101 to 200MB
  - 201 to 500MB
  - 501 to 1,000MB
  - 1,001+MB
- 5.25-Inch Disk Drive
  - 0 to 30MB
  - 31 to 60MB
  - 61 to 100MB
  - 101 to 200MB
  - 201 to 500MB
  - 501 to 1,000MB
  - 1,001+MB
- 8 to 10.5-Inch Disk Drive
  - 0 to 30MB
  - 31 to 60MB
  - 61 to 100MB
  - 101 to 200MB
  - 201 to 500MB
  - 501 to 1,000MB
  - 1,001+MB

The segmentation represents Dataquest's view of the high-technology marketplace and is not intended to represent the availability of data.

EQUIPMENT

- 14-Inch Disk Drive
  - 0 to 30MB
  - 31 to 60MB
  - 61 to 100MB
  - 101 to 200MB
  - 201 to 500MB
  - 501 to 1,000MB
  - 1,001+MB

Dual Media

- Sub-3.5-Inch Disk Drive
  - 0 to 30MB
  - 31 to 60MB
  - 61 to 100MB
  - 101 to 200MB
  - 201 to 500MB
  - 501+MB
- 3.5-Inch Disk Drive
  - 0 to 30MB
  - 31 to 60MB
  - 61 to 100MB
  - 101 to 200MB
  - 201 to 500MB
  - 501 to 1,000MB
  - 1,001+MB
- 5.25-Inch Disk Drive
  - 0 to 30MB
  - 31 to 60MB
  - 61 to 100MB
  - 101 to 200MB
  - 201 to 500MB
  - 501 to 1,000MB
  - 1,001+MB
- 8 to 10.5-Inch Disk Drive
  - 0 to 30MB
  - 31 to 60MB
  - 61 to 100MB
  - 101 to 200MB
  - 201 to 500MB
  - 501 to 1,000MB
  - 1,001+MB

The segmentation represents Dataquest's view of the high-technology marketplace and is not intended to represent the availability of data.

EQUIPMENT

- 14-Inch Disk Drive
  - 0 to 30MB
  - 31 to 60MB
  - 61 to 100MB
  - 101 to 200MB
  - 201 to 500MB
  - 501 to 1,000MB
  - 1,001+MB
- Optical Disk Drive
  - CD-ROM
  - WORM Optical Disk Drive
    - 5.25 Inch
    - 8 to 12 Inch
    - 14 Inch
  - Rewritable Optical Disk Drive
    - 2 to 5.25 Inch
    - 8 to 12 Inch
  - Optical Jukebox
- Tape Drive
  - 1/4-Inch Tape Drive
    - Start-Stop
    - Streamer
      - 8 Inch
      - 5.25 Inch
      - 3.5 Inch
  - 1/8-Inch Tape Drive
    - Cassette
    - Cartridge
  - 1/2-Inch Tape Drive
    - 1/2-Inch Vacuum Column
    - 1/2-Inch Tension Arm
    - 1/2-Inch Streaming
    - 1/2-Inch Cartridge
  - Reel-to-Reel Tape Drive Recap
  - Helical Scan Tape Drive
    - VHS
    - DAT
    - 8mm
    - Others
- Input/Output Device
  - Terminal
    - Alphanumeric (CRT) Terminal
      - Minicomputer-Based Terminal

The segmentation represents Dataquest's view of the high-technology marketplace and is not intended to represent the availability of data.

EQUIPMENT

- Alphanumeric (CRT) Terminal (Continued)
  - Non-IBM, Protocol-Specific Terminal
  - IBM 3270 Protocol Terminal
  - Host/Vendor-Independent Terminal
  - Processing Terminal
- Graphics Terminal
- Point-of-Sale Terminal
- Funds Transfer Terminal (ATMs)
- Smart Card
- Other Specialized Terminal

Electronic Printer
- Serial Printer
  - Serial, Impact, Dot Matrix Printer
    - Dot Matrix Printer by Speed
      - 0 to 180 cps
      - 181 to 250 cps
      - 251 to 399 cps
      - 400+ cps
    - Dot Matrix Printer by Size
      - Total < 9 Wire (Pin)
      - Total 9 Wire (Pin)
      - Total 18 Wire (Pin)
      - Total 24 Wire (Pin)
  - Serial, Impact, Fully Formed Printer
    - 0 to 30 cps
    - 31+ cps
  - Serial, Nonimpact, Direct Thermal Printer
  - Serial, Nonimpact, Thermal Transfer Printer
    - Wax-Based
    - Sublimation
    - Dry Silver
  - Serial, Nonimpact, Ink Jet Printer
- Line Printer
  - Line, Impact, Dot Matrix Printer
    - 0 to 450 lpm
    - 451 to 650 lpm
    - 651+ lpm
  - Line, Impact, Fully Formed Printer
    - 0 to 450 lpm
    - 451 to 650 lpm
    - 651 to 1,050 lpm

The segmentation represents Dataquest's view of the high-technology marketplace and is not intended to represent the availability of data.

EQUIPMENT

Line, Impact, Fully Formed Printer (Continued)
1,051 to 1,250 lpm
1,251+ lpm

Line, Nonimpact, Direct Thermal Printer
Line, Nonimpact, Thermal Transfer Printer

Page Printer
0 to 6 ppm
7 to 10 ppm
11 to 15 ppm
16 to 20 ppm
21 to 30 ppm
31 to 50 ppm
51 to 80 ppm
81 to 150 ppm
151+ ppm

Other Input/Output Devices
Monitor
Remote Batch, Job-Entry, and Output
Key Entry Equipment
Media-to-Media Data Conversion
Magnetic Ink Character Recognition (MICR)
Optical Scanning Equipment
Computer Plotters
Small Format Pen Plotter
Large Format Pen Plotter
Small Format Electrostatic Plotter
Large Format Electrostatic Plotter
Ink Jet Plotter
Thermal Plotter
Photosensitive Plotter
Laser Plotter
Voice Recognition Computer Device
Voice Synthesizer
Mouse
Keyboard
Digitizer

Office Equipment
Copier and Duplicator
Personal Copier (Up to 12 cpm)
Segment 1 (Up to 20 cpm)

The segmentation represents Dataquest's view of the high-technology marketplace and is not intended to represent the availability of data.

EQUIPMENT

- Copier and Duplicator (Continued)
  - Segment 2 (21 to 30 cpm)
  - Segment 3 (31 to 44 cpm)
  - Segment 4 (45 to 69 cpm)
  - Segment 5 (70 to 90 cpm)
  - Segment 6 (91+ cpm)
- Full-Color Copiers
- Electronic Calculator (without Alpha Keyboard)
- Dictating, Transcribing Machine
- Electronic Typewriter
- Word Processor
- Banking System
  - Check-Handling System
- Cash Register
- Mailing, Letter-Handling, Addressing Equipment
- Other Office Equipment

- Communications
  - Telecommunicatons
    - Image Communications
      - Facsimile
        - Classification by Type
          - Standalone Systems
          - PC Facsimile Cards
          - LAN to Fax Gateways
        - Classification by Technology
          - Group I
          - Group II
          - Group III
          - Group III Bis
          - Group IV
        - Classification by Feature
          - Ultra Low End
          - Low End
          - Midrange
          - High End
        - Classification by Price
          - <$1,000
          - $1,000 to $1,499
          - $1,500 to $1,999
          - $2,000 to $2,499
          - $2,500 to $2,999
          - $3,000 or More

The segmentation represents Dataquest's view of the high-technology marketplace and is not intended to represent the availability of data.

EQUIPMENT

- Classification by Printing Technology
  - Thermal
  - Thermal Transfer
  - Plain Paper (Laser, LED, etc.)
- ISDN Terminals
- Servers
- Teleconferencing
  - Audio
  - Video
    - Captured Image
    - Near-Full Motion
    - Codecs
    - PX64
  - Telex
    - Machines
    - Black Boxes
    - Gateways
    - Message Switches
  - Videotex
    - Terminals

Personal Communications

- Mobile Radio
  - Cellular Handsets
    - Classification by Type
      - Car-Mounted
      - Transportable
      - Portable
    - Classification by Technology
      - Analog
        - C450
        - NMT450
        - NMT900
        - TACS
        - ETACS
        - Radiocom 2000
        - AMPS
        - RTMS-Italy
      - Digital
        - GSM
        - Others

The segmentation represents Dataquest's view of the high-technology marketplace and is not intended to represent the availability of data.

EQUIPMENT

- Cordless Handsets
  - CT0
  - CT1
  - CT2
  - CT3
  - DECT
  - GSM
  - Base Stations
- Global Positioning Systems
- Mobile Infrastructure
  - Base Stations
- Personal Communications Networks (PCN)
  - Mininetworks
- Public Mobile Radio (PMR)
- Paging Systems

Networking

- Cable (Private)
- Data PBX
- Encryption Units
- Front-End Processors
  - IBM and IBM-Compatible
  - Proprietary
- ISDN
- Local Area Networks (LANs)
  - Terminal Servers
    - Ethernet
    - Token Ring
    - Others
  - PC Network Operating Software
  - PC LANs
  - Classification by Type
    - IBM PC/Compatible
    - Apple Macintosh
  - Classification by Technology
    - 802.3
    - 802.5
    - Arcnet
    - FDDI
    - Others
  - Classification by Media
    - Coaxial
    - Unshielded Twisted Pair (UTP)
    - Fiber-Optic
    - Datagrade

The segmentation represents Dataquest's view of the high-technology marketplace and is not intended to represent the availability of data.

EQUIPMENT

- Local Operating Network Systems (LONs)
- Modems
  - Classification by Standards
    - U.S. Standards
      - 212 A
      - V.22 Bis
      - 201 B/C
      - 208 A/B
      - V.29
      - V.32
      - V.33
      - 16.8 Kbps
      - 19.2 Kbps
      - V.35
      - V.36
        - Proprietary Dial-Up 9.6 Kbps
    - European Standards
      - V.21/23
      - V.21/23 PC
      - V.22
      - V.22 PC
      - V.22 Bis
      - V.22 Bis PC
      - V.26
      - V.27
      - V.29 Basic
      - V.29 Premium
      - V.32
      - V.32 PC
      - Proprietary Dial-Up 9.6 Kbps
      - V.33
      - 16.8 Kbps
      - 19.2 Kbps
      - Proprietary Baseband
      - Proprietary DOVE
- Multiplexers
  - Classification by Technology
    - Time Division (TDM)
      - Low-End Point-to-Point/Dual Trunk
      - Low-End Networking
      - Channels Banks/Primary MUX
      - T1/E1 Point-to-Point/Dual Trunk

The segmentation represents Dataquest's view of the high-technology marketplace and is not intended to represent the availability of data.

EQUIPMENT

- Time Division (TDM) (Continued)
  - T1/E1 Network Access
  - High-End Networking
  - Greater than T1/E1
- Statistical Time Division (STDM)
  - Classification by Size
    - Low End (Up to 16 Channels)
    - Midrange (Up to 48 Channels)
    - High End (More than 48 Channels)

Network Management Systems
- Public
  - Carrier
  - Local
  - Long Distance
- Private
  - LANs
  - T1/E1
  - X.25
  - Modems
  - Voice (Call Accounting)
  - Switch and Patch
  - Matrix
  - Mini/Mainframe-Based
  - Test Equipment
    - Analyzers
  - Operator Support Systems

Network-Terminating Devices

Operator Support Systems

Other Datacom Equipment
- Fiber-Optic Multiplexers

Public Data Network Systems (Equipment)
- X.21 Switches

Servers

Value-Added Networks (Equipment)

X.25
- Classification by Type
  - Packet Assemblers/Disassemblers (PADs)
    - Asynchronous Only
    - Synchronous Only
    - Multiprotocol
  - Packet Switches (Nodes)

The segmentation represents Dataquest's view of the high-technology marketplace and is not intended to represent the availability of data.

EQUIPMENT

Classification by Capacity
- Low End (Up to 100 Packets per Second)
- Midrange (Up to 1,000 pps)
- High End (More than 1,000 pps)

Public Network Equipment

- Cable
  - Coaxial
  - Fiber-Optics
    - Monomode
    - Multimode
  - Multipair

- Cable TV
- Carrier Equipment
- Central Office
  - Classification by Type
    - Local
    - Trunk
    - Gateway
  - Classification by Technology
    - Analog
    - Digital
      - ISDN
        - Basic Rate Interface (BRI)
        - Primary Rate Interface (PRI)
    - Others
  - Classification By Size
    - Less than 2K Lines
    - 2K to 10K Lines
    - More than 10K Lines

- Digital Access Crossconnect Systems (DACS)
  - Classification by Type
    - 1/0 DCS
    - 1/1 DCS
    - 3/1 DCS
    - 3/1/0 DCS
    - 3/3 DCS
    - 4/1 DCS
    - 4/3 DCS
    - 4/4 DCS
    - OCN/OCN

The segmentation represents Dataquest's view of the high-technology marketplace and is not intended to represent the availability of data.

EQUIPMENT

- Classification by Capacity
  - Low End
  - Midrange
  - High End
- Fiber-Optic Terminal (FOTs)
- Line Conditioners
- Main Distribution Frame (MDF)
- Connectors
- Microwave
  - Classification by Type
    - Systems
    - Antenna
    - Accessories
    - Electronics
  - Classification by Usage
    - Short Haul
    - Long Haul
  - Classification by Technology
    - Analog
    - Digital
- Multiplexers
  - Classification by Type
    - Multiplexers
    - Fiber-Optic Terminals
  - Classification by Technology
    - Analog
    - Digital
  - Classification by Standards
    - European/CEPT Standard
      - 2 Mbps
      - 8 Mbps
      - 34 Mbps
      - 140 Mbps
      - 565 Mbps
      - 2.4 Gbps
    - U.S. Standard
      - 1.5 Mbps
      - 6 Mbps
      - 45 Mbps
      - 90 Mbps
      - 135 Mbps
      - 1.2 Gbps

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EQUIPMENT

- SONET
- Synchronous Digital Hierarchy (SDH)
- Asynchronous Transfer Mode (ATM)
- Fast Packet Switching
- Frame Relay

- Network Termination Units
  - ISDN
  - DSU/CSU
  - NTU
- Operating Support Systems
- Pay Phones
- Public Paging Systems
- Local Loop Equipment
  - Analog
    - PCM Repeaters
    - Digital
  - Twisted Pair
  - SLC-96 and Compatibles
  - Others
  - Fiber Optics
    - Universal Digital Line Carrier (UDLC)
    - Integrated Digital Line Carrier (IDLC)
    - Flexible Access System (FAS)
    - SONET
    - 802.6 Metropolitan Area Network (MAN)
    - Others
  - Wireless
    - Basic Exchange Telephone Radio Service (BETRS)
    - Cordless
- Satellite Communications
  - Space Stations
  - Earth Stations
    - VSAT
    - Master—Hub
    - Remote
      - Receive Only—Data Broadcast
      - Interactive
  - Direct Broadcast
  - Teleport
  - Television Receive Only
  - Video Distribution

The segmentation represents Dataquest's view of the high-technology marketplace and is not intended to represent the availability of data.

EQUIPMENT

- Satellite Communications (Continued)
  - Home
  - Intelsat
  - Eutelsat
  - Others
- Signaling
- Telex
  - Low End (Less than 20 Ports)
  - Midrange(20 to 80 Ports)
  - High End (More than 80 Ports)
- X.25
  - Classification by Size
    - Low End
    - Midrange
    - High End

Voice Communication
- Answering Machines
- Attendant Consoles
- Automatic Call Distributors (ACDs)
  - Classification by Type
    - Standalone
    - Integrated
    - Analog
    - Digital
  - Classification by Capacity
    - 1 to 8 Agent Positions
    - 9 to 24 Agent Positions
    - 25 to 48 Agent Positions
    - 49 to 100 Agent Positions
    - More than 100 Agent Positions
- Business Communications Systems
  - Classification by Type
    - Private Branch Exchange (PBX)
    - Key Telephone System (KTS)
  - Classification by Technology
    - Analog
    - Digital
    - ISDN
      - Terminals
      - ISDN
      - Proprietary
      - Servers
    - Network
      - BRI

The segmentation represents Dataquest's view of the high-technology marketplace and is not intended to represent the availability of data.

EQUIPMENT

- Network (Continued)
  - PRI
  - Proprietary
  - Gateways
- Basic
- Classification by Capacity
  - 1 to 8 Lines
  - 9 to 24 Lines
  - 25 to 48 Lines
  - 49 to 100 Lines
  - 101 to 400 Lines
  - 401 to 1,000 Lines
  - More than 1,000 Lines
- Cable (Private)
- Call Management Systems
  - Centrex
  - KTS
  - PBX
- Integrated Voice/Data Workstations (IVDT)
- Intercom Systems
- ISDN Terminals
  - Voice
  - Data
  - Video
  - Integrated
- Private Paging Systems
- Trading Turrets/Dealer Boards
- Voice-Messaging Systems
  - Classification by Capacity
    - 1 to 4 Ports
    - 5 to 8 Ports
    - 9 to 16 Ports
    - 17 to 32 Ports
    - 33 to 64 Ports
    - 65 to 128 Ports
    - More than 128 Ports
- Voice Response Units (VRUs)
  - Classification by Capacity
    - 1 to 4 Ports
    - 5 to 8 Ports
    - 9 to 16 Ports
    - 17 to 32 Ports
    - 33 to 64 Ports
    - 65 to 128 Ports
    - More than 128 Ports

The segmentation represents Dataquest's view of the high-technology marketplace and is not intended to represent the availability of data.

EQUIPMENT

- Voice Terminals
  - Classification by Type
    - Corded
    - Cordless
  - Classification by Technology
    - Analog
    - Digital
      - Pulse Dial
      - Tone Dial (DTMF)

- Industrial Electronic Equipment
  - Security/Energy Management
    - Alarm System
      - Intrusion Detection Alarm System
      - Fire Detection Alarm System
        - Discrete Device, Security/Energy Management
  - MPU Load Programmer
  - Computerized Energy Control System

  - Manufacturing System
    - Wafer Fabrication Equipment
      - Lithography Equipment
        - Proximity/Contact Aligners
        - Projection Aligner
        - Steppers
        - Direct-Write E-Beam
        - Maskmaking E-Beam
        - X Ray

      - Automatic Photoresist Processing Equipment
      - Etch-and-Clean Equipment
        - Wet Process
        - Dry Strip
        - Dry Etch
        - Ion Milling

      - Deposition Equipment
        - Chemical Vapor Deposition
        - Physical Vapor Deposition
        - Silicon Epitaxy Deposition
        - Metalorganic CVD Deposition
        - Molecular Beam Epitaxy Deposition
        - Diffusion
        - Rapid Thermal Processing

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EQUIPMENT

Ion Implantation
Medium Current Ion Implantation
High-Current Ion Implantation
High-Voltage Ion Implantation
Optical CD/Wafer Inspection
Other Process Control Equipment
Factory Automation Equipment
Other Water Fabrication Equipment

Test Equipment
ATE (Automatic Test Equipment)
Discrete Component Tester
Semiconductor Tester
Interconnect/Bare PCB Tester
In-Circuit PCB Tester
Functional PCB Tester
Combined PCB Tester
Manufacturing EATE N/A
General Test Equipment

Process Control System
Process Control System, Controller
Process Control System, Recorder
Process Control System, Indicator
Process Control System, Auxiliary Station
Process Control System, Nonunified System
Process Control System, Industrial Process

Programmable Machine Tool
Boring Programmable Machine Tool
Drilling Programmable Machine Tool
Grinding Programmable Machine Tool
Horizontal Turning Programmable Machine Tool
Vertical Turning Programmable Machine Tool
Milling Programmable Machine Tool
Machining Center Programmable Machine Tool
Other Cutting Programmable Machine Tool
Punch/Shear/Bend Programmable Machine Tool
Flexible Manufacturing System Programmable Machine Tool

Mechanical Assembly Equipment
Plastic Processing Machinery

Robot System
Robotic Electronic Assembly
Robotic Nonelectronic Assembly

The segmentation represents Dataquest's view of the high-technology marketplace and is not intended to represent the availability of data.

EQUIPMENT

Robot System (Continued)
- Material-Handling/Loading Robot System
- Painting Robot System
- Spot-Welding Robot System
- Arc-Welding Robot System
- Machining Robot System
- Other Robot System

Automated Material Handling
- Guided Vehicle
- Programmable Conveyor
- Storage/Retrieval Automatic Material-Handling System
- Programmable Monorail
- Warehousing
- Programmable Overhead Crane
- Other Automated Material-Handling Equipment

Instrumentation
- Integrating and Totalizing Meter for Gas
- Counting Device
- Digital Panel Meter
- Analog Panel Meter
- Panel Type Instrument
- Elapsed-Time Meter
- Portable Electronic Measuring Instrument
- Electronic Recording Instrument
- Physical Property Test, Inspection, and Measurement
- Commercial Meteorological and General-Purpose Instrument
- Nuclear Radiation Detection and Monitoring
- Surveying and Drafting Instrument
- Ultrasonic Cleaners, Drill
- Meteorological Instrument
- Geophysical Instrument
- Analytical and Scientific Instrument

Medical Equipment
- Diagnostic Medical Equipment
  - Automatic Blood Analyzer
  - CAT Scanner
  - Digital Radiography
  - Electrocardiograph
  - Electroencephalograph
  - Magnetic Resonance Imaging

The segmentation represents Dataquest's view of the high-technology marketplace and is not intended to represent the availability of data.

EQUIPMENT

- Medical Equipment (Continued)
  - Respiratory Analysis
  - Ultrasonic Scanner, Medical
  - X Ray, Medical
  - Other Diagnostic Medical Equipment
- Patient-Monitoring
- Prosthetic Medical Equipment
  - Hearing Aid
- Surgical Support
- Therapeutic
  - Defibrillator
  - Dialysis, Diathermy
  - Electrosurgical
  - Pacemaker
  - Ultrasonic Generator
  - Other Therapeutic Medical Equipment

Other Industrial Electronic Equipment
- Vending Machine
- Laser System (Excluding Communication)
- Power Supply
- Traffic Control
- Particle Accelerator
- Industrial and Scientific X Ray
- Laboratory and Scientific Apparatus
- Teaching Machine and Aid
- Scientific Not Elsewhere Classified

Consumer Electronic Equipment
- Audio Consumer
  - Audio Amplifier
  - Compact (Disc) Player, Music
  - Consumer Radio
  - Stereo (Hi-Fi) Component
  - Stereo Headphone
  - Electronic Musical Instrument
  - Tape Recorder, Consumer
- Video, Consumer
  - Video Camera, Consumer
  - VTRs (VCRs)
  - Videodisc Player

The segmentation represents Dataquest's view of the high-technology marketplace and is not intended to represent the availability of data.

EQUIPMENT

- Video, Consumer (Continued)
  - Color Television
  - Black-and-White Television
  - HDTV
  - Remote Control
  - LCD Television
- Personal Electronic
  - Game
  - Camera
  - Watch
  - Clock
  - Toy
  - Sewing Machine
  - Other Personal Electronic
- Appliance
  - Air Conditioner
  - Microwave Oven
  - Washer and Dryer
  - Refrigerator
  - Dishwasher, Disposal
  - Range and Oven, Consumer
  - Rice Cookers
  - Fans
  - Heaters
  - Vacuum Cleaners
  - Food Processors
  - Other Consumer Appliance
- Other Consumer Electronic
  - Automatic Garage Door Opener
  - Residential Smoke Alarm
  - Consumer Electronic Equipment Not Elsewhere Classified

Military/Aerospace Electronic Equipment

- Military Electronic Equipment
  - Radar, Military
  - Sonar, Military
  - Missile-Weapon
  - Space Military Equipment
  - Navigation, Military
  - Communication, Military
  - Electronic Warfare

The segmentation represents Dataquest's view of the high-technology marketplace and is not intended to represent the availability of data.

EQUIPMENT

- Military Electronic Equipment (Continued)
  - Reconnaissance
  - Aircraft System
  - Military Computer System
  - Simulation and Training, Military
  - Miscellaneous Military Equipment
- Civil Aerospace
  - Radar, Civilian
  - Civilian Space
  - Civil Navigation/Communication
  - Civil Aircraft Flight System
  - Civil Simulation and Training

- Transportation Electronic Equipment
  - Entertainment, Transportation
  - Body Controls
  - Driver Information
  - Powertrain
  - Safety and Convenience
- Other Electronic Equipment

SOFTWARE

- Application Software (See Applications Segmentation)
- System Software
  - Operating System Software
    - Database
      - Document Management
      - Data Acquisition and Control
      - Storage Management
      - Database Administration
      - On-Line Transaction Processing
    - Development Tools
    - Editors
    - Language
      - Compilers
      - Assemblers
      - Translators
      - Data Translator
      - Query Languages

The segmentation represents Dataquest's view of the high-technology marketplace and is not intended to represent the availability of data.

SOFTWARE

- Interactive Languages
  - Fourth-Generation Languages
  - Visual Programming Languages
- Graphic
- Communication Management
  - User Interface
  - Device Interface
- Protocol
- Security

Operating Environment

Operating System

- Proprietary
  - IBM/VM/MVS
  - DEC VMS
  - Others
- Open
  - UNIX
    - OSF1
    - Sun OS
    - System V/BSD
    - Mach
    - XENIX
    - Others
      - Pick
      - Theos
      - Others
  - Real-Time
- PC
  - DOS
  - OS/2
  - Macintosh
  - Others
- Operating Utilities
  - Peripheral I/O Management
  - System Subroutine Libraries
  - Data Center and System Management
  - Information Resource Management
  - Information Center
  - System Utilities

The segmentation represents Dataquest's view of the high-technology marketplace and is not intended to represent the availability of data.

CONSUMABLES

- Paper
  - Cut Sheet
  - Form
  - Label
- Toner and Developer
- Print Ribbon
- Photoreceptor
- Print Element
  - Printwheel
  - Golf Ball
  - Thimble
- Computer Storage Media
  - Flexible Disk
  - Rigid Disk
  - Computer Storage Tape
  - Optical Media
- Transparency
- Other Consumable

SERVICES

- Telecommunications Services
  - Core Services
    - Classification by Type
      - Local Telephone Services
      - Long Distance Services
      - International Services
    - Classification by Technology
      - Analog
      - Digital
        - ISDN
          - HO
          - BRI
          - PRI
        - Others
    - Classification by Product
      - Toll Revenue
      - WATS Outgoing
      - WATS Incoming (800 Service)
      - 900 Service
      - Switched Digital Services
        - Switched 56 Kbps
        - X.21

The segmentation represents Dataquest's view of the high-technology marketplace and is not intended to represent the availability of data.

SERVICES

- Classification by Product (Continued)
  - Analog Private Lines
    - Conditioned
    - Unconditioned
  - Digital Private Lines
    - Classification by Capacity
      - 0 to 19.2 Kbps
      - 19.2 Kbps to 64 Kbps
      - 64 Kbps to H11
      - H11 to 772 Kbps
      - T1
      - E1
      - 8 Mbps
      - T3
      - 34 Mbps
      - More than T3
  - Centrex
    - Classification by Type
      - ETN
      - ACD
      - CLASS
      - Routing
      - Billing
      - Network Management
    - Classification by Size
      - 1 to 8 Lines
      - 9 to 24 Lines
      - 25 to 48 Lines
      - 49 to 100 Lines
      - 101 to 400 Lines
      - 401 to 1,000 Lines
      - More than 1,000 Lines
  - B-ISDN
  - Operator Services
- Enhanced Services
  - Audiotex Access Services
  - Voice Mail
  - Cable TV
  - Directory Inquiry
  - Electronic Messaging
    - X400
    - EDI
    - Others

The segmentation represents Dataquest's view of the high-technology marketplace and is not intended to represent the availability of data.

SERVICES

- ISDN
- Public Data
- Satellite
  - VSAT
  - Others
- Teleconferencing
- Teleport Services
- Telex Services
- Facsimile Services
- Value-Added Networks (VANs)
- VideoConferencing
  - Ad Hoc
  - Carrier Provided
- Virtual Private Network Services
- Videotex Access Services
- X.25
- Voice Messaging

Mobile Services
- Cellular
  - Classification by Technology
    - Analog
      - C450
      - NMT450
      - NMT900
      - TACS
      - ETACS
      - Radiocom 2000
      - AMPS
      - RTMS-Italy
    - Digital
      - GSM
      - Others
- Cordless
  - Portable
    - CT2
    - CT3
    - DECT
  - Mobile
    - GSM
- Global-Positioning Systems
  - Location Identification Systems

The segmentation represents Dataquest's view of the high-technology marketplace and is not intended to represent the availability of data.

SERVICES

- Personal Communications Networks (PCN)
  - SubGSM
- Public Mobile Radio (PMR)
  - Data Services
- Public Paging Systems
- Messaging Services

Hardware Maintenance
- Contract Maintenance
- Time and Materials

Parts
Software Support
Customer Training/Education
Network Support
Professional
- Systems Integration
- Facilities Management

OTHER PRODUCTS

The segmentation represents Dataquest's view of the high-technology marketplace and is not intended to represent the availability of data.

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Geographic Regions

The geographic regions segmentation shows the classification scheme used by Dataquest to define the regions of the world. Dataquest classifies the world into the following regions:

- North America
- Europe
- Japan
- Rest of Asia—Rest of World

The segmentation represents Dataquest's view of the high-technology marketplace and is not intended to represent the availability of data.

Geographic Regions

Worldwide

North America
Europe
Japan
Rest of Asia—Rest of World

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North America

North America

United States

East North Central Division

- Illinois
- Indiana
- Michigan
- Ohio
- Wisconsin
- East North Central Other

East South Central Division

- Alabama
- Kentucky
- Mississippi
- Tennessee
- East South Central Other

Mountain Division

- Arizona
- Colorado
- Idaho

Mountain Division (Continued)

- Montana
- Nevada
- New Mexico
- Utah
- Wyoming
- Mountain Other

Middle Atlantic Division

- New Jersey
- New York
- Pennsylvania
- Middle Atlantic Other

New England Division

- Connecticut
- Maine
- Massachusetts
- New Hampshire
- Rhode Island
- Vermont
- New England Other

The segmentation represents Dataquest's view of the high-technology marketplace and is not intended to represent the availability of data.

United States (Continued)

Pacific Division
- Alaska
- California
- Hawaii
- Oregon
- Washington
- Pacific Other

South Atlantic Division
- Delaware
- District of Columbia
- Florida
- Georgia
- Maryland
- North Carolina
- South Carolina
- Virginia
- West Virginia
- South Atlantic Other

West North Central Division
- Iowa
- Kansas
- Minnesota
- Missouri
- Nebraska
- North Dakota
- South Dakota
- West North Central Other

West South Central Division
- Arkansas
- Louisiana
- Oklahoma
- Texas
- West South Central Other

Puerto Rico Division
- Puerto Rico

United States Other

Canada

North America Other

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Europe

Western Europe

Western Europe Major

- France
- Germany
- Italy
- Netherlands
- Spain
- Sweden
- United Kingdom

Western Europe Other

- Austria
- Belgium
- Cyprus
- Denmark
- Finland
- Gibraltar
- Greece
- Iceland
- Ireland
- Liechtenstein
- Luxembourg
- Malta
- Monaco
- Norway
- Portugal
- San Marino
- Switzerland

European Community (EC)

- Belgium
- Denmark
- France
- Germany
- Greece
- Ireland
- Italy
- Luxembourg

The segmentation represents Dataquest's view of the high-technology marketplace and is not intended to represent the availability of data.

European Community (EC) (Continued)
- Netherlands
- Portugal
- Spain
- United Kingdom

European Free Trade Association (EFTA)
- Austria
- Finland
- Iceland
- Norway
- Sweden
- Switzerland

Eastern Europe
- Albania
- Bulgaria
- Czechoslovakia
- Hungary
- Poland
- Romania
- Union of Soviet Socialist Republics
- Yugoslavia

The segmentation represents Dataquest's view of the high-technology marketplace and is not intended to represent the availability of data.

Japan

Japan

The segmentation represents Dataquest's view of the high-technology marketplace and is not intended to represent the availability of data.

Rest of Asia—Rest of World

Rest of Asia—Rest of World

- **Four Tigers**
  - Hong Kong
  - Korea
  - Singapore
  - Taiwan
- **Other Asia**
  - Bangladesh
  - Brunei
  - Burma
  - Cambodia
  - China
  - East Timor
  - India
  - Indonesia
  - Laos
  - Macau
  - Malaysia
  - Maldives
  - Nepal
  - Pakistan
  - Philippines
  - Sri Lanka
  - Thailand
  - Vietnam

Rest of World

- Australia/New Zealand
  - Australia
  - Christmas Island
  - Cocos Islands
  - New Zealand
  - Norfolk Island
- Oceania
  - American Samoa
  - Canton and Enderbury Islands
  - Cook Islands
  - Fiji
  - French Polynesia

The segmentation represents Dataquest's view of the high-technology marketplace and is not intended to represent the availability of data.

Oceania (Continued)
- Guam
- Johnson Island
- Kiribati
- Midway Islands
- Nauru
- New Caledonia
- Niue
- Pacific Islands
- Papua New Guinea
- Pitcairn
- Samoa
- Solomon Islands
- Tokelau
- Tonga
- Tuvalu
- Vanuatu
- Wake Island
- Wallis and Futuna Islands

Africa
Central America
Caribbean
Middle East
South America
Atlantic
Inner Asia

The segmentation represents Dataquest's view of the high-technology marketplace and is not intended to represent the availability of data.

Distribution

The distribution segmentation outlines the path by which a product moves from the manufacturer to the ultimate end user. This segmentation is used by Dataquest to analyze markups, discounts, and buyer behavior.

Dataquest defines the major distribution classifications as follows:

- Distribution channel
- Distribution method

The segmentation represents Dataquest's view of the high-technology marketplace and is not intended to represent the availability of data.

Distribution

DISTRIBUTION CHANNEL

- Direct
- Indirect
  - Value-Added Reseller/Systems Integrator
  - Original Equipment Manufacturer
  - Distributor
    - Regional Bell Operating Company (RBOC)
      - Independent Telephone Company
      - Telephone Interconnect Supplier
  - Dealer
  - Mass Merchandiser
  - Manufacturers' Representatives/Agents

DISTRIBUTION METHOD

- Direct Sales Force
- Telemarketing
- Mail Order
- Company-Owned Store

The segmentation represents Dataquest's view of the high-technology marketplace and is not intended to represent the availability of data.

Applications

The applications segmentation describes the use to which a product is put or the function it performs. Sometimes there are one-to-one relationships between products and their applications and the actual functions that a product performs.

The major applications as defined by Dataquest are as follows:

- General productivity
- Organizational
- Entertainment
- Industry specific

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Applications

GENERAL PRODUCTIVITY

- Document/Media Creation and Editing
  - Computer-Aided Printing and Publishing
    - Electronic Publishing
    - Technical Publishing
  - Graphics
    - Chart and Map Generation
    - Image Generation
    - Graphic Design Art
      - Image Editing
      - Draw/Paint
      - Image Capture
      - Clip Art
      - Illustration
    - Presentation Graphics
    - Color Prepress
      - Input
      - Image Processing
        - Image Manipulation
        - Color Correction
        - Color Pagination
      - Composition and Translation
      - Color Separation
    - Page Composition and Page Makeup
      - Page Description
      - Page Imaging
      - Document Architecture
      - Desktop Publishing
      - Scientific Visualization/Simulation
    - Multimedia
      - Animation
      - Desktop
        - Video
          - Compression
          - Digitizer
          - Full-Motion
          - Real-Time
        - Videodisc

The segmentation represents Dataquest's view of the high-technology marketplace and is not intended to represent the availability of data.

GENERAL PRODUCTIVITY

- Holography
- Photo Realism
- Information Retrieval

Forms

Publishing Utilities
- Tagging
- PostScript Printing
- Compression/Decompression
- File Translation/Data Conversion

Document Management
- Author/Editor
- Image Processing
- Scanning
  - Text
  - Image
- Word Processing
- Typography

Communication
- Electronic Mail

Spreadsheet/Decision Support/Executive Information Systems
- Spreadsheet
- General-Purpose Simulation
- Modeling
- Forecasting

Learning/Education/Training
- Instructional
  - Computer Training/Assisted Instruction
- Educational Simulation
- Learning

Project Management
- Calendaring
- Scheduling
- Ticketing
- Library Management

Time Management
- Application Utilities
- Integrated Applications
- Relational Database Management System

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ORGANIZATIONAL

- Management and Administration
  - Accounting
    - Accounts Payable
      - Checkbook Management
    - Accounts Receivable
      - Billing/Invoicing
    - General Ledger
    - Payroll
    - Tax Accounting
    - Personal Finance
  - Capital Assets
    - Fixed Assets
    - Lease Accounting
  - Human Resource/Personnel Management
    - Benefits Administration
    - Employment Administration
  - Finance
    - Financial Planning
    - Budgeting
    - Cost Accounting
    - Investment/Portfolio Management
    - Cash/Money Management
    - Deposit/Loan Management
    - Treasury/Stocks/Bonds
  - Purchasing
    - Contract Administration
    - Vendor Management
  - Planning
    - Business Planning
    - Strategic Planning
    - Command, Control, Communications, and Intelligence
  - Facilities Management
    - Facility Planning
    - Facility Simulation
    - Equipment/Maintenance Management
    - Property/Real Estate Management
    - Facility Security Management

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ORGANIZATIONAL

- Sales and Marketing
  - Marketing Research
  - Advertising and Promotional
  - Public Relations
  - Order Entry/Processing
    - Customer/Prospect Management
      - Credit Management
    - Sales Support/Administration
- Research, Engineering, and Development
  - Industrial Automation
    - Shop Floor Plan and Control
    - CAM/Automated Assembly
    - Manufacturing Engineering Tools
    - Other Planning and Control
    - Test and Measurement
    - Others
  - Design Automation
    - CAD/CAM/CAE
      - Modeling
        - Two-Dimensional
        - Three-Dimensional
        - Solid
      - Mechanical
        - Documentation/Drafting
          - Detail Drafting
          - Document Management
          - Schematics
          - Technical Illustration
          - Charts
        - Conceptual Design
          - Industrial Design
          - Design Layout
          - Styling
        - Functional Design
          - Component
          - Assembly Verification
          - Linkage/Mechanism
        - Analysis
          - Fatigue
          - Structural

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ORGANIZATIONAL

- Analysis (Continued)
  - Thermal
  - Vibrational
  - Magnetic
  - Composite
  - Mass Property
- Manufacturing Engineering
  - Tool Design
  - Fixture Design
  - Part-Processing Design
- Manufacturing Process Simulation
  - NC Part Programming
  - Coordinate Measuring Machines
  - Off-Line Robotics
  - QC Analysis

AEC (Architectural, Engineering, and Construction)
- Architectural
- Civil
- Facility Design
- Process Plant Design

Geographical Information Systems
- GIS/Mapping
- Raster-Based GIS Systems

Electronic Design Automation
- Electronic Computer-Aided Engineering
  - Digital Design
    - Design Entry
      - Schematic Entry
      - Libraries
    - Design Verification
      - Simulation
      - Simulation Acceleration
      - Hardware Modeling
      - Static Timing Analysis
    - Logic Synthesis
    - Test Automation
      - Automatic Test Vector Generation
      - Design for Testability/Test Synthesis
      - Fault Simulation

The segmentation represents Dataquest's view of the high-technology marketplace and is not intended to represent the availability of data.

ORGANIZATIONAL

- Analog Design
  - Design Entry
    - Schematic Capture
    - Libraries
  - Design Verification
    - Circuit Simulation
    - Mixed Signal Simulation
- IC Layout and Verification
  - Editing
  - Layout
  - Verification
  - Module Generation
- PCB Layout

Software Development
- Computer-Aided Software Engineering
- Artificial Intelligence
- General Software Development

Earth Resources
- Seismic Analysis
  - Geophysical Seismic Imaging
- Oil Field Services
- Remote Sensing

Technical Data Analysis
- General Scientific
  - Scientific Research/Analysis
  - Scientific Visualization
  - Scientific Simulation
- Chemistry
  - Crystallography
  - Modeling
  - Analysis
- Simulation
- Laboratory
- Analytical Instruments
- Instrument Automation
- Quality Control/Assurance
- Research and Laboratory Analysis
- Others

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ORGANIZATIONAL

- Medical
  - Body Scanning
  - Patient Monitoring
  - Others
- Diagnostic
- Therapeutic

Manufacturing and Distribution
- Distribution Planning and Control
  - Transportation/Fleet Management
    - Route Planning
    - Dispatching
  - Warehouse Management
    - Automated Warehousing and Materials Handling
  - Inventory and Distribution Management and Control

Manufacturing Planning and Control
- Material/Process Requirements Planning, Production and Process Management
- Shop Floor Planning and Control
- CAM/Automated Assembly
- Manufacturing Engineering Tools
- Other Planning and Control
  - Simulation
    - Robot Programming and Simulation
  - Quality Assurance
    - Detection and Tracking
  - Fault Management/Adaptive Control
- Test and Measurement
- Inspection
  - Machine Vision

Others
- Real-Time Data Acquisition and Control
  - Simulation
  - C^3i
  - Others
- Building Automation

The segmentation represents Dataquest's view of the high-technology marketplace and is not intended to represent the availability of data.

ORGANIZATIONAL

Others (Continued)
- Traffic Control
- Railroad Control
- Power Grid Control
- Water Quality and Sewage Control
- Atmospheric Monitoring

ENTERTAINMENT

INDUSTRY SPECIFIC

The segmentation represents Dataquest's view of the high-technology marketplace and is not intended to represent the availability of data.

User Environment

The user environment segmentation is based on industry classifications derived from a format that reflects the United States Department of Commerce's Standard Industrial Classification (SIC) code scheme and the International Standard Industrial Classification of all economic activities used by the United Nations.

Environments are a description of where a product is used ultimately. The major user environments as defined by Dataquest are as follows:

- Home
- Business
- Education
- Government

Dataquest has a classification scheme available at the two-, three-, and four-digit SIC levels, which can be provided on request.

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User Environment

HOME

BUSINESS

Natural Resources and Construction

- Agricultural Production—Crops
- Agricultural Production—Livestock
- Agricultural Services
- Forestry
- Fishing, Hunting, and Trapping
- Metal Mining
- Coal Mining
- Oil and Gas Extraction
- Nonmetallic Minerals, except Fuels
- General Building Contractors
- Heavy Construction, except Building
- Special Trade Contractors

Process Manufacturing

- Food and Kindred Products
- Tobacco Products
- Textile Mill Products
- Lumber Wood Products
- Paper and Allied Products
- Printing and Publishing
- Chemicals Allied Products
- Petroleum and Coal Products
- Rubber and Miscellaneous Plastics Products
- Leather and Leather Products
- Stone, Clay, and Glass Products
- Primary Metal Industries

Discrete Manufacturing

- Apparel and Other Textile Products
- Furniture and Fixtures
- Fabricated Metal Products
- Industrial Machinery and Equipment
- Electronic and Other Electric Equipment
- Instruments and Related Products

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BUSINESS

Discrete Manufacturing (Continued)
- Miscellaneous Manufacturing Industries
- Transportation Equipment

Transportation
- Railroad Transportation
- Local and Interurban Passenger Transit
- Trucking and Warehousing
- Water Transportation
- Transportation by Air
- Pipelines, except Natural Gas
- Transportation Services

Communication
- Communication

Utilities
- Electric, Gas, and Sanitary Services

Wholesale Trade, Durable Goods
- Wholesale Trade—Durable Goods

Wholesale Trade, Nondurable Goods
- Wholesale Trade—Nondurable Goods

Retail Trade
- Building Materials and Garden Supplies
- General Merchandise Stores
- Food Stores
- Automotive Dealers and Service Stations
- Apparel and Accessory Stores
- Furniture and Home Furnishings Stores
- Eating and Drinking Places
- Miscellaneous Retail

Finance
- Depository Institutions
- Nondepository Institutions
- Security and Commodity Brokers

Insurance
- Insurance Carriers
- Insurance Agents, Brokers, and Service

Real Estate
- Real Estate
- Holding and Other Investment Offices

Hotels And Other Lodging
- Hotels and Other Lodging

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BUSINESS

Business Services
- Business Services
- Legal Services

Health Care
- Health Services

Other Services
- Personal Services
- Auto Repair, Services, and Parking
- Miscellaneous Repair Services
- Motion Pictures
- Amusement And Recreation Services
- Social Services
- Museums, Botanical, Zoological Gardens
- Membership Organizations
- Engineering and Management Services
- Services, NEC

EDUCATION

Elementary
Secondary
Higher Education
Four-Year Institution
Two-Year Institution
Public
Private

GOVERNMENT

Government by Function
- Executive, Legislative, and General
- Justice, Public Order, and Safety
- Finance, Taxation, And Monetary Policy
- Administration of Human Resources
- Environmental Quality and Housing
- Administration of Economic Programs
- National Security and International Affairs

Government
- Federal
- State
- Local

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SIZE (BUSINESS, EDUCATION, GOVERNMENT)

Revenue (Millions of U.S. dollars)
- 0 to 99.9
- 100 to 499.9
- 500 to 999.9
- 1 to 4.9
- 5 to 9.9
- 10 to 49.9
- 50+

Employees
- Small
  - 0 to 9
  - 10 to 19
  - 20 to 49
- Medium
  - 50 to 99
  - 100 to 249
- Large
  - 250 to 499
  - 500 to 999
  - 1,000+

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Research Items

The research items segmentation is a listing of general terms used by Dataquest to organize, describe, and analyze data for technology markets and industries. A typical use of research items is to describe market data in terms of shipments, retirements, and installed base.

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Research Items

Application
Assembler
Average Selling Price
Average Usage
Average Volume
Balance of Trade
Bit
Byte
Capital Spending
Captive Production
Compound Growth Rate
Consumption
Conversion Revenue
Cost
End User
End-User Average Selling Price
End-User Revenue
Environment
Export
Factory Average Selling Price
Factory Revenue
Gross Lease Additions
If-Sold Value
Import
Industry
Input/Output (I/O) Ratio
Installed Base
Internal Transfer
Inventory
Joint Venture
Lease
Lease/Rental Conversions
List Price
Manufacturer
Manufacturer's Suggested Retail Price
Market
Market Share
Markup
Merchant Production
Net Additions
New Placement Demand
Placement
Product
Product Category
Production
Replacement Demand
Research and Development
Residual Value
Retirement
Return
Revenue
Shipment
Subsidiary
Tie Ratio
Unit
Useful Life
Users per System
Year-Average Population

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The segmentation represents Dataquest's view of the high-technology marketplace and is not intended to represent the availability of data.

Glossary

This glossary includes definitions of the major terms associated with Dataquest's segmentation of the high-technology marketplace.

III-V discrete semiconductor. 1: A semiconductor device with low noise, low power, and high power in the range of one-half watt to one watt. 2: A device of gate structures based on D-MESFET and E/D MESFET devices.

A

academic support. College expenditures that include expenditures for support services that are an integral part of the institution's primary missions of instruction, research, or public service. Includes expenditures for libraries, galleries, audio/visual services, academic computing support, auxiliary support, academic administration, personnel development, and course and curriculum development.

accounting software. 1: A software application that supports a system of recording and summarizing business and financial transactions and analyzing, verifying, and reporting results. 2: A software application used to manage an organization's money and/or assets. This type of software includes general ledger, accounts payable/receivable, and inventory control.

accounts payable (AP). An application that supports the accounts payable function, which is the amount owed by a business to its suppliers and other regular trading partners.

accounts receivable (AR). An application that supports the accounts receivable function, which is the amount owed to a business by its customers.

ACD. See **automatic call distributor.**

adaptive control. 1: The property of a control system that allows it autonomously to maintain a manufacturing or process environment within predetermined control limits. 2: A device with parameters that adjust automatically to compensate for changes in the dynamics of the process to be controlled.

add-on graphics board. A graphics board that is added to a basic computer to enhance the computer's current graphic capability.

add-on graphics board, Mac-type. Personal computers that were designed to run applications exclusively through a graphical user interface (i.e., windows, menus, and icons). Mac-type systems include Apple's Macintosh series (512E, Plus, SE, and II), Atari's ST series (524 and 1024), and Commodore's Amiga. This term also refers to peripherals intended for use in Mac-type systems.

add-on memory board. A printed circuit board populated with memory integrated circuits (IC), usually DRAMs or SRAMs, that plugs into personal computers via connectors on the central processing unit bus. These boards are used to increase central processing unit storage capacity.

AEC. See **architecture, engineering, and construction.**

aerial. See **antenna.**

AGVS. See **automatic guided vehicle system.**

AI. See **artificial intelligence.**

air conditioner. 1: An apparatus for controlling the temperature and humidity of air. 2: A broad field including numerous processes, among which are refrigeration, heating, ventilation and humidification, and electronic air filtering.

aircraft system (military). Electronic power devices used in airplanes to perform functions like flight control, communication and navigation, lighting computer system (including air data, mission and fire control), engine control, instrumentation, integral targeting system, associated test system, and integrated system.

alarm system. A system designed to warn of an intrusion, a fire, or other undesired occurrence. Alarm systems have three functions in common: detection, control, and annunciation signaling.

alphanumeric CRT controller. A character set of both letters and numbers that is used to control electron beams, which are used to present data in a visual form.

alphanumeric CRT terminal. A display terminal that provides character information to the operator.

amateur radio. A radio used for two-way radio communications by private individuals. It is not used for enterprise activity.

AMH. See **automated materials handling.**

amplifier IC. A linear IC that provides a voltage or power gain to an applied signal.

analog. 1: Representation of data by means of continuously variable physical quantities, such as voltage, current, or frequency. 2: A circuit or system in which the output signals bear a continuous relationship to the input signals. 3: A representation of an event in another form, e.g., the representation of voice sounds as continuously variable electrical signals.

analog design verification. A software application that includes analog simulation, analog synthesis, monte carlo analysis, worst-case analysis, and parametric plotting.

analog loop. A nondigital portion of the telecommunications network.

analog panel meter. 1: An electrical switchboard or instrument board with continuously variable electrical signals known as analog signals. 2: A mounting plate for the controls and/or other parts of equipment, utilizing analog signals.

analysis. Separation of a whole into its parts; proof of a mathematical proposition by assuming the result and deducing a valid statement by a series of reversible steps. Includes mass properties, kinematic and dynamic mechanism analysis, structural, thermal, composite, fluids, and vibration analysis. Finite element and finite difference are common analysis technologies used.

analytical and scientific instrument. Instruments used to measure, access, control, and monitor objects and systems.

animation. A software application to present either continuous pictures or images or to present them in rapid succession.

answering machine. A device, hooked to a telephone, that can record and play messages as they pass through a phone when a user is unable to pick up the telephone.

antenna. 1: A conductor or system of conductors that serves to radiate or intercept energy in the form of electromagnetic waves. 2: A device for transmitting or receiving radio waves. Also called aerial.

AP. See **accounts payable.**

appliance. 1: An instrument or device designed for a specific household or office purpose. 2: A piece of equipment for adapting a tool or machine to a special purpose.

application. The use to which a product is put; the function it performs.

application software. A software program or set of programs designed for a specific application, such as inventory control or linear programming.

application-specific integrated circuit (ASIC). A single-user IC that is manufactured using vendor-supplied tools and/or libraries. (May be sold by an ASIC or standard-product group.)

application utilities. A software application that enhances the operation of other standalone applications; Typically operates concurrently with these standalone applications.

AR. See **accounts receivable.**

architectural. Computer-aided tools intended for use in design and drafting of facilities' architectural aspects.

architecture, engineering, and construction (AEC). The use of computer-aided tools by architects, contractors, plant engineers, civil engineers, and others associated with these disciplines to aid in designing and managing buildings, industrial plants, ships, and other types of nondiscrete entities.

arc-welding robot systems. A system in which a robot carries an arc-welding torch to produce welds.

argon. An inert gas extensively used in discharge tubes.

artificial intelligence (AI). The ability of a machine to perform functions normally associated with human intelligence, such as learning, adapting, reasoning, self-correcting, and improving automatically.

ASCII. Standardized coding for alphanumeric and other standard keyboard characters.

ASIC. See **application-specific integrated circuit.**

ASP. See **average selling price.**

AS/RS. See **automated storage/retrieval system.**

assembler. A company that adds manufacturing value to a product.

assembly. 1: A group of subassemblies and/or parts that, when put together, create a major subdivision of the final product. When two or more components or subassemblies are put together by the application of labor and machine hours, it is called an assembly. An assembly may be an end product or a component for a higher-level assembly. 2: The semiconductor manufacturing steps of mounting a die in a package, bonding the pads to the package leads, and sealing the package.

assembly verification. The integration of various component designs into an assembly to test size/shape and functional characteristics.

asynchronous telecommunications software. A software application that emulates a standard computer terminal (e.g., DEC VT-100) and performs file transfer between asynchronously connected computers and/or provides remote operation of another computer.

ATE. See **automatic test equipment.**

ATM. See **automated teller machine.**

atmospheric monitoring. A real-time software application that monitors weather-related data from satellites and other monitoring sites around the world.

atmospheric/purge cylinder gas. A specialty gas; a cylinder gas for purging certain processing systems and equipment when manufacturers are concerned about possible back contamination of the house lines.

attendant console. A specialized telephone instrument that allows fast and efficient answering and routing of telephone calls.

audio amplifier. A device that uses transistors or vacuum tubes to obtain voltage, current, or power to amplify sound.

audio conferencing. The ability to communicate among more than two people at one time via a speakerphone or the telephone system/network.

audio equipment. Amplifiers, preamplifiers, control consoles, and other equipment used in studio, broadcast, and home environments. Equipment interprets frequencies corresponding to audible sound waves.

automated assembly system. The assembly of parts into subassemblies and/or complete assemblies using programmable equipment that may include robots. In discrete piece manufacturing, this system includes spot- and arc-welding and adhesives. In electronics, this system includes component placement and printed board component insertion. Usually, these automated assembly systems include sensors.

automated guided vehicle system (AGVS). An unmanned mobile transporter under programmable control that moves materials and tooling throughout a factory and/or warehouse. Includes towing vehicles, pallet trucks, light-load transporters, unit-load transporters, and self-loading and unloading vehicles.

automated materials handling (AMH). The automated handling of discrete or bulk materials in manufacturing systems. Materials handling includes the movement, storage, identification, and controlling of materials.

automated storage/retrieval system (AS/RS). All computer hardware, software, and equipment that are used together for mechanical hoists and carriages and that interface with racks and bins for automatic storage and retrieval of unit loads, pallets, and individual parts. An AS/RS moves materials from inventory to operations and back to inventory, frequently for work-in-process inventory.

automated teller machine (ATM). A machine used by financial institutions and designed to perform many of the banking functions performed by human tellers. (See also **funds transfer terminal.**)

automatic blood analyzer. Equipment used to analyze, detect, and decipher blood types and blood-related diseases.

automatic call distributor (ACD). A computer-based system located at a customer's premises that: (1) provides real-time monitoring of a telephone system's work load; (2) distributes calls to the agent who is idle longest; and (3) uses a queuing or waiting list assignment that holds the callers in queue until an agent is available, averages the random flow of traffic, and decreases peak traffic load. An ACD also contains features known as gates or agent split groups that provide functional divisions within the routing scheme and allow calls to be directed to a specific group or agent.

automatic photoresist processing equipment (colloquial: track). Equipment used to dispense and process photoresist material onto a wafer. Track equipment, as this equipment is usually called, includes wafer clean/bake, wafer prime, wafer coat/bake, wafer develop/bake, and resist stabilization equipment.

automatic test equipment (ATE). Computer-controlled equipment that inspects electronic devices, both active and passive. ATE usually includes analytical and statistical data-reduction capabilities and can document test results by display, hard copy, and electronic storage. ATE can perform printed circuit board (PCB) inspection by mechanical, electrical, and visual means in an automatic, programmable mode. ATE includes both bare boards and boards that have been loaded with electronic devices. In the latter case, diagnostic capabilities are included as a part of the system definition if they are part of the equipment.

automatic warehousing system (AWS). A dedicated storage and retrieval system that is used not on the factory floor but in a warehouse that may or may not be located within a manufacturing facility. An AWS includes a control system and associated material-handling equipment and structures, but excludes the building unless it is a structural part of the automated system. The control system includes both hardware and software.

automation. The system or technique of the production process that minimizes human intervention. Self-controlled machines are used to accomplish human tasks or tasks not able to be accomplished by human intervention.

average selling price (ASP). The average price of a product, inclusive of any discounts. (See also **end-user ASP** and **factory ASP.**)

average usage. The average number of units of product used per unit of time.

average volume. The average number of units of product produced per unit of time.

awarded contract. A binding agreement granted to a specific company.

AWS. See **automatic warehousing system.**

B

balance of trade. 1: The difference between the value of a country's exports and imports of tangible goods over a given period, usually one year. 2: The difference between the value of a country or region's exports of tangible goods to and imports of tangible goods from a second country or region.

banking system. Systems used in the banking/finance industries to facilitate the transmission of funds to improve efficiencies. Systems include: payroll allocation and deduction; demand deposit accounting; savings, both regular and certificates of deposit; and loan processes.

baseband modem. A type of modem that utilizes all of the available analog bandwidth on a line.

basic exchange telecommunications radio system (BETRS). A radio system network that provides cost-effective basic telephone service within remote areas.

benefits administration. A software application with the primary function of administering and aiding in managing an organization's employee benefits.

BETRS. See **basic exchange telecommunications radio system.**

BiCMOS. Bipolar complementary metal oxide semiconductor. See **BiMOS.**

BiMOS (BiCMOS). Bipolar metal oxide semiconductor (MOS). An integrated circuit (IC) manufactured with both bipolar and MOS processes that yields a component with the benefits of both technologies.

bipolar. 1: A semiconductor technology employing two junction transistors. 2: A device in which both majority and minority carriers are present. A transistor structure with electrical properties determined within the silicon material.

bipolar application-specific IC. See **application-specific integrated circuit.**

bipolar cell-based IC. See **cell-based integrated circuit.**

bipolar custom IC. See **custom integrated circuit.**

bipolar digital logic. See **logic circuit.**

bipolar digital microcomponent. See **microcomponent.**

bipolar FPGA. See **field-programmable gate array.**

bipolar gate array. See **gate array.**

bipolar memory. See **memory.**

bipolar nonvolatile memory. See **nonvolatile memory.**

bipolar PLA. See **programmable logic array.**

bipolar PLD. See **programmable logic device.**

bipolar PMD. See **programmable multilevel logic device.**

bipolar standard logic. See **standard logic.**

bipolar transistor. A transistor that uses positive- and negative-charge carriers. Bipolar transistors provide current gain—that is, a current input results in a larger current output.

bit. Abbreviation for binary digit. A unit of information equal to one binary decision, or the designation of one of two possible and equally likely values or states of anything used to store or convey information.

black-and-white television. Television in which the reproduced picture is displayed in shades of gray between black and white. Also known as monochrome television.

board-level computer. A single, or multiple, board-level CPU that is sold individually or incorporated in systems-level products (boxes). Typically, these are products that are not considered complete packaged systems. Prices range from the low hundreds to the low thousands of dollars. Frequently, software is bundled with the board for a specific application.

body control. Electronic equipment used to direct, manage, or guide an automobile or truck. Examples include electronic suspension, cruise control, intermittent wipers, load-sensitive braking, antitheft devices, electronic steering, and electronic mufflers.

book publishing software. Software with the main purpose/use of printing books or written or printed literary works.

boring programmable machine tool. A factory tool designed to machine internal work such as cylinders, holes, and castings.

broadband communications. Communications that utilize a bandwidth greater than a voice-grade circuit.

broadcast. 1: The transmission of packets on a contention bus where all data are heard by all devices on the channel and are selected by each device through address-recognition techniques. 2: To send messages or to communicate simultaneously with many or all points on a circuit. 3: The transmission of radio frequencies from a source to all devices that are capable of receiving the signal. Microwave transmission is one method of transmission. 4: Radio or television transmission intended for public reception.

broadcast and studio equipment. Equipment used to make information public by means of radio or television.

broadcast transmitter antenna. An electronic device for generating and amplifying a radio-frequency carrier for transmission through space from an antenna.

bubble memory. A storage medium that allows information to be stored on magnetically charged crystal chips. Bubble memories can hold data without electricity to sustain them; blackouts, changes in current, and static charges do not affect them. Such memories process material 75 times as fast as disk memories. However, bubble memory processors cannot handle multiprogramming, i.e., performing parallel operations with several programs.

budgeting. An application that supports future resource planning.

building automation. A software application with the primary functions of managing the operations of a facility, including fire detection, energy management, and alarm systems. Large manufacturing plants and skyscrapers use real-time computers to control and monitor conditions. This may include fire detection and control systems; security systems; clocking, documenting, and energy management for heating, ventilation, and air conditioning.

bulk gas. A discrete delivery of gas in a liquid state.

bundled distribution and warehouse package. Hardware and/or software modules used for planning and control of warehouse or product distribution systems. These packages are not available separately from the total warehouse or distribution system.

business. A commercial or mercantile environment usually referred to as a vertical market. See "User Environment" section.

byte. 1: A single group of eight bits processed together. 2: The number of bits that a computer processes.

C

C^3I. See **command, control, communications, and intelligence.**

cable. An assembly of one or more conductors within an enveloping protective sheath, constructed to permit the use of the conductors singly or in groups.

cable television equipment. All equipment for both the head and subscriber ends of a cable television system.

cache. A fast, small memory (typically SRAM) used to enhance CPU performance, separate from main processor memory.

cache controller. A device that governs the area of a system that stores only data the system may need in the immediate future.

CAD. See **computer-aided design, drawing, or drafting.**

CAE. See **electronic computer-aided engineering** and **mechanical computer-aided engineering.**

CAGR. See **compound annual growth rate.**

calculator. A device capable of performing logical and arithmetical digital operations of any kind.

calendaring. 1: An application to support the scheduling of meetings and other events. It is usually a tickler file, reminding people of upcoming commitments. 2: In the papering industry, paper with a hard, smooth finish.

call management systems. The equipment and service that records the calling activity of a centrex, PBX, or key telephone system in order to generate reports that support telephone cost allocation and other telephone management information needs.

call processing equipment. Call processing equipment provides additional functions and capabilities beyond traditional call processing. This classification includes add-on products such as voice-messaging systems, call accounting systems, and automatic call distributors.

CAM. See **computer-aided manufacturing.**

capacitor. A commonly used component that stores electrical energy. It is sometimes referred to as a condenser.

capital assets. An application that assists a company in managing its capital assets, which are any physical property or right that is owned and has a money value.

capital spending. The purchase of a capital asset or an asset that is needed to create a product and is acquired with the intention of keeping (rather than being resold).

captive production. The sale of a good to a division within the manufacturing company.

carrier equipment. A cable-based system that provides transmission of multiple signals over a common metallic or fiber-optic cable. This segment includes subscriber carrier systems, trunk carrier systems, Basic Exchange Transmission Radio (BETR) systems, and repeaters.

cartography. An application that supports map production and/or resource management. May contain a spatially indexed data structure.

cartridge tape drive. A tape drive that uses a special metal and plastic protective device for the tape, which can be used for 1/4-inch or 1/2-inch tape products.

CASE. See **computer-aided software engineering.**

cash register. A device that automatically registers visibly the amount of a specific sale. Many are used to trace inventory and other product information through the sale of the product.

cassette tape drive. A tape drive that uses a small container of tape similar to that used for commercial audio recording purposes.

cathode ray tube (CRT). A television-like display screen which, on receipt of information bearing electronic signals, produces a visual display of the information (text, graphics). The CRT consists of a vacuum tube display in which a beam of electrons is projected onto a fluorescent surface of phosphors, producing a visual display. Used in most computer display terminals. Also referred to as video display terminal/visual display tube (VDT).

CAT scanner. A computerized axial tomography—frequently shortened to CT. A reconstructive imaging technique employing an X-ray source and array of detectors rotated about the body of the patient. The host computer calculates an image based on the appearance of a thin volume in the plane of the rotation.

CBIC. See **cell-based integrated circuit.**

CCD. See **charge-coupled device.**

CCIT. A French acronym for the International Telegraph and Telephone Consultative Committee, a committee of the international standards organization made up of telecommunication authorities of member countries. The committee's primary purpose is to develop and produce standards for telecommunication networks.

CCME. See **computational chemistry/molecular engineering.**

CCTV. See **closed circuit television.**

CD. See **critical dimension** and **compact disc.**

CD-ROM (compact disc read-only memory). See **CD-ROM disc drive.**

CD-ROM disc drive. All CD-ROM discs are 4.7 inches (12cm) in diameter, have a 1.6-micro-inch-pitch single-spiral track, and have 2.048 data bytes per sector.

cell-based integrated circuit (CBIC). An ASIC device that is customized using a full set of photomasks and uses automatic placement of cells and automatic routing.

cellular handset. See **cellular telephone.**

cellular service. One type of mobile communications, where a low-power radio is used between limited-distance "cells."

cellular telephone. Mobile radio equipment associated with cellular radio services.

central office (CO). 1: The physical location that contains the equipment that supports the telephone network. 2: The switching equipment that connects local access lines to toll circuits.

central office switching equipment. Equipment comprised of electronic systems that interconnect local telephone lines (loops) and connect local telephone lines to long distance trunk lines.

central processing unit (CPU). A microprocessor or microcontroller. Central processing unit of a computer.

centrex. An optional service that provides voice/data switching by using the utility's central office.

charge-coupled device (CCD). ICs that combine charge-coupled signal transfer with arrays of photosensors to provide image sensing. CCDs are available as linear or area arrays.

chart. Any table, graph, or drawing depicting a range of technical data.

chart and map generation. A graphics software application that is designed specifically for charts and predefined maps.

check-handling system. A system to improve the speed and accuracy of check-handling processes within the banking and finance industries.

chemical vapor deposition (CVD). A formation of a stable compound on a heated substrate by thermal reaction or decomposition of gaseous compounds. A process that chemically isolates and deposits a specific material on a wafer. CVD equipment includes atmospheric-pressure CVD (APCVD), plasma-enhanced CVD (PECVD), and low-pressure CVD (LPCVD) techniques. Historically, the CVD market was split into APCVD, PECVD, and LPCVD technologies, because each had its own applications. Now, because of advanced reactors that are crossing application boundaries, it makes more sense to divide the market by film application rather than by equipment technology.

chemistry. 1: An application to support the science dealing with the composition structure and properties of substances and with the transformations that they undergo. 2: Chemical processes and phenomena.

circuit. 1: The electrical path between two or more points. 2: A means of two-way communication between two points, consisting of a sending and a receiving channel or a combined sending and receiving channel. 3: A transmission path between two or more points.

CISC MPU. See **complex-instruction-set computing microprocessor.**

citizens band: mobile and base. A frequency band allocated for private individual radio service (460 to 470 megahertz or 26.965 to 27.405 megahertz).

civil aerospace. Civilian travel in space.

civil aircraft flight system. Same as military aircraft, except related to civilian activity.

civil application. A software application used for civil engineering tasks, typically for design and drafting of sites for buildings, streets, highways, bridges, dams, airports, and utilities.

civilian space. Equipment used by civilians to explore the earth's atmosphere. Includes satellites, reconnaissance equipment, and ground control equipment.

civil navigation/communication. Same as military navigation/communications, except related to civilian activity.

civil radar. Same as military radar, except related to civilian activity.

civil simulation and training. Same as military simulation and training, except related to civilian activity.

closed circuit television (CCTV). A television system where television signals are not broadcast, but are transmitted over a closed circuit and received by interconnected receivers.

CMOS. See **complementary MOS.**

CO. See **central office.**

coaxial cable. Type of transmission cable with one or more central conductors, surrounded by an insulator.

CODEC. See **coder/decoder circuit.**

coder/decoder circuit. An integrated circuit that codes a voice signal into a binary waveform or decodes a binary waveform into a voice signal. Such circuits now are used in digital communications applications.

college. A postsecondary school that offers general or liberal arts education, usually leading to an associate, bachelor's, master's, doctor's, or first professional degree. Junior colleges and community colleges are included under this category.

color prepress. A process that converts visual material to electronic signals.

color separation. A process of photographing objects using three filters, each corresponding in color and light transmission to one of the additive primary colors; analogous to seeing.

color television. An electronic system that transmits signals to a visual image that can be viewed in an array of colors on a screen.

combined elementary and secondary school. A school that encompasses instruction at both the elementary and secondary levels. Examples of combined elementary and secondary school grade spans would be 1 through 12 or 5 through 12.

combined PCB tester. Testing equipment that combines functional and in-circuit test techniques and capabilities that result in a test strategy to suit any given board's production history and fault spectrum to achieve the highest board fault coverage at the lowest cost.

command, control, communications, and intelligence (C^3I). Systems used to display the ongoing status of tactical or strategic operations in dynamic scenarios for rapid decision making.

commercial antenna. See **antenna.**

commercial meteorological and general-purpose instrument. Equipment used to obtain quantitative information about the weather.

communication. 1: The transmission of information from one point or person or equipment to another. 2: The sensing of a measurement signal or phenomenon for display, recording, amplification, transmission, computing, or processing into useful information.

communication management. The organization of stations, peripherals, and devices capable of intercommunications but not necessarily on the same channel.

communication peripheral. An interface device for machine-to-machine connections.

compact disc (CD). A disc from which data are read optically by means of a laser.

compact disc player. 1: A recording and playback system used to play recorded music by means of a small plastic optical disc similar to multiplex stereo broadcast and reception. Each wall of the record groove carries a single channel of information. 2: A recording device in which the sounds are mechanically impressed onto a disc.

comparator. A type of amplifier that produces a logic output (1 or 0) based on comparison of an input voltage with a fixed reference voltage. A widely used form of linear integrated circuit.

compiler. 1: Computer routine that translates symbolic instructions to machine instructions and replaces certain items with subroutines. 2: An automatic coding system in a computer that generates and assembles a program from instructions written by a programmer. 3: A computer language system consisting of various subroutines that have been evaluated and computed into one routine handled by a computer. 4: Software used to convert application programs from computer language to machine language.

complementary MOS. A semiconductor technology that uses both P-channel and N-channel transistors on the same silicon substrate to gain the primary advantages of very low power and high noise immunity.

complex-instruction-set computing (CISC) microprocessor. The number of instructions a microprocessor runs for a specific application. Known as a general-purpose processor.

component. An assembly, device, or piece of equipment that is part of a larger assembly or system.

component design. Design of the individual components in an assembly.

composite analysis. The analysis of composite materials (such as carbon fiber) as they change in the manufacturing process and are used in the final assembly.

compound annual growth rate (CAGR). The average rate of growth compounded over a specified period. The formula used to calculate CAGR is:

$$\left(\frac{\text{Value in period } 1+n}{\text{Value in period } 1}\right)^{\left(\frac{1}{n}\right)} - 1$$

computational chemistry/molecular engineering (CCME). The use of computers to model molecular structures, to predict physical properties of molecules, and to design new compounds for specific purposes.

computer-aided design (CAD). Systems that function as tools to expedite mechanical and electronic design. Most CAD systems consist of a graphics computer terminal linked with a computer and a software package with features that aid in design and drafting, keep track of parts, run simulations, and provide illustrated parts or circuit diagrams. Programs complete the layout, geometric transformations, projections, rotations, magnifications, and interval (cross-sectional) views of a part and its relationship with other parts.

computer-aided manufacturing (CAM). The use of computers to program, direct, and control production equipment in the fabrication of manufactured items.

computer-aided software engineering (CASE). A combination of artificial intelligence and structured programming techniques used to aid in the development of large software programs.

computerized energy control system. A system with the resources for producing heat, electricity, and/or power and the capability of running on computers.

computer plotter. A visual display on which a dependent variable is graphed by an automatically controlled pen or pencil or other image development device/technique as a function of one or more variables. See also **plotter.**

computer storage media. The substance upon which data are stored electronically. Media may be flexible disks, rigid disks, tape, or optical disks.

computer storage tape media. Long, thin, flexible tape appropriate for digital magnetic recording and storage of computer data.

computer system. A combination of hardware, software, firmware, and peripheral components that has been assembled to satisfy a particular goal or set of goals.

computer systems performance segments. The following are Dataquest segments for computer systems performance: Level I—low-performance minicomputers, microcomputers, and personal computers; Level II—medium-performance minicomputers and microcomputers, very low end workstations, and high-end personal computers; Level III—low-performance superminis, midrange workstations, and high-performance minicomputers; Level IV—midrange superminis, low-end mainframes, and high-end workstations; Level V—high-performance superminis and midrange mainframes; Level VI—low-end supercomputers and very high performance superminis; and Level VII—supercomputers and high-end mainframes.

computer to PBX interface/digital multiplex interface (CPI/DMI). Two different standards for communication between systems.

computer to plate. A process that merges type and black-and-white images and combines the functions of typesetting, camera photography, and contact platemaking.

conceptual design. An application that supports styling, industrial design, and other design applications emphasizing visualization, aesthetic, and ergonomic considerations.

connector. A device used to join or fasten transistors, establishing a relationship between active and passive devices.

consortium. An international business agreement; an association or society.

consumable. Material that is capable of being consumed.

consumer electronics. The application of electronics in consumer equipment.

consumer integrated circuit (IC). An analog circuit that meets specific consumer end-market applications. These circuits are dedicated to specific applications, such as audio or radio, and would not be used for general purpose.

consumer N.E.C. Consumer equipment not elsewhere classified.

consumer radio. A device used by the general public for communication by electromagnetic waves transmitted through space to produce sound.

consumption. The markets' purchase and use of goods and services, including lease or rental.

contract administration. The management of agreements between a company and its vendors and/or customers.

contract maintenance service. Ongoing repair services based on agreed upon terms and conditions (such as hours of coverage and level of services) as stipulated in a written agreement between the customer and the service provider.

controller. A device or group of devices that serve to govern, in some predetermined manner, the electric power delivered to the apparatus to which it is connected.

controller board. A printed circuit board that provides programmable logic that controls the sequence of operations of the functional stages of a peripheral device.

conversion revenue. The revenue generated by changing from an equipment rental contract to a purchase or lease contract.

coordinate measuring machine. Machine used to measure the physical dimensions of a part.

copier. A reproduction device designed to produce replicas of hard-copy originals. Copiers may use either an analog or a digital scanning system.

coprocessor. A logic device that operates in association with a microprocessor to enhance system performance. Coprocessors are not capable of independent operation.

cordless telephony. The transmission of speech or other information via radio, enabling two persons to converse over almost any distance without a connecting cord to a base unit.

corporate publishing. Publishing that supports the main business of an organization or person; printed and published products are produced in the normal course of operations, but not as a primary source of revenue.

corporate supercomputer. An information system priced at more than $2 million. Performance speed is more than 200 mflops; current upper limit is approximately 2 Gflops. Currently used mainly for batch applications, but the trend is toward interactive use. Optimized for very heavy, numerically intensive applications. Requires special environmental controls and cooling techniques.

cost. The expenditure necessary to produce a product.

cost accounting. An application that supports a branch of accounting that is concerned with the collection, determination, and control of costs, particularly those costs associated with producing products or services.

counter/timer circuit. A circuit that receives uniform pulses representing units to be counted and provides a voltage proportional to their frequency.

counting device. A device register or location in computer storage for storing numbers or number representations in a manner that permits these numbers to be increased or decreased by the value of another number or to be changed or reset to zero or to an arbitrary value.

CPE. See **customer premise equipment.**

CPI/DMI. See **computer to PBX interface/digital multiplex interface.**

CPU. See **central processing unit.**

critical dimension (CD). Refers to a line, element, or feature that must be manufactured and controlled to very tight specifications.

CRT. See **cathode ray tube.**

CT2. See **digital cordless telephone.**

custom/contract programming. Programming services that include applications development and software systems conversions.

customer management. A software application used to maintain lists of purchasers of a company's products and services.

customer premise equipment (CPE). Telecommunication equipment used at an end user's location, as compared with use at the local telephone utility.

customer training/education service. Activities designed to instruct customers in the installation, usage, programming, management, and maintenance of hardware, software, and networking products.

custom integrated circuit. A handcrafted, single-user integrated circuit that is customized using a full set of photomasks and requires manual placement and routing. Can be either bipolar or MOS technology process.

CVD. See **chemical vapor deposition.**

D

daisywheel. See **printwheel.**

DAT. See **digital audiotape.**

data acquisition and control. See **real-time data acquisition and control.**

database. The entire body of data that has to do with one or more related subjects. Typically, it consists of a collection of data files stored in a computer system.

database administration. A control program function that provides access to data sets, enforcement of data storage conventions, and regulation of the use of input/output devices.

database management system (DBMS). 1: A software application that provides storage maintenance functions for data stored in sequential, hierarchical, relational, or object format. Example of DBMS products include FOCUS (hierarchical), Ingres (relational), and GBASE (object oriented). 2: A systematic approach to storing, updating, and retrieving information stored as data items, commonly referred to as data files.

database publishing. A system with the main purpose/use of printing the ordered collections of data.

data capture. A process that takes possession or control of information.

data center. A program designed primarily to acquire, analyze, process, store, retrieve, and disseminate one or more types of data.

data center construction/relocation services. Services in which a vendor performs or manages the contracting of site management services including the design and building of a customer's data center and/or the relocation and installation of customer's equipment.

datacom equipment. See **data communications equipment (DCE).**

data communications equipment (DCE). Equipment used for transmitting data between points of origin and reception. It includes products such as modems, statistical multiplexers, T-1 multiplexers, front-end processors, data PBX systems, data network management systems, DSU/CSU equipment, local area networks, and private packet data switching equipment.

data converter. An integrated circuit that changes alternating current to direct current or direct current to alternating current.

data creation. The process of producing or originating information.

data network management system. A product or device that diagnoses, isolates, reinstates, or accumulates information for network components or provides reports and analysis of network performance.

data PBX system. A digital private branch exchange system that allows terminals to switch and contend for computer ports by providing RS-232-C connections. This system does not provide voice switching. Data PBX base units and add-on channels also are included in this classification.

data processing (DP). 1: The preparation of source media that contain data or basic elements of information and the handling of such data according to precise rules of procedures to accomplish such operations as classifying, sorting, calculating, summarizing, recording, and computing. 2: The handling of information in a sequence of reasonable operations.

data service unit (DSU) and channel service unit (CSU). These provide an interface to digital services, such as the AT&T Dataphone Digital Service (DDS).

data storage device. A product designed to hold data until needed. Storage devices are rated by technology (rigid, flexible, and optical disk drives and tape drives), physical size in inches (diameter for rigid and flexible disk drives, width for tape drives), and capacity in bytes. (See also **disk drive, tape drive.**)

data translation. 1: A device that transforms computer information to data from one language to another language without affecting the meaning. 2: To change one binary word to another.

DBMS. See **database management system.**

DCE. See **data communications equipment.**

dealer. 1: Independent businesses selling products under contract to one or more vendors. 2: A product reseller selling to end users. A dealer's primary added value is distribution; secondary added values are service, training, and support.

defibrillator. An electronic instrument used for stopping spontaneous, local contraction of muscle fibers (fibrillation) during a heart attack by applying controlled electronic pulses to the heart muscles.

departmental supercomputer. An information system with price ranging from $100,000 to $2 million. Performance speed ranges from 10 to 200 mflops. Acquired usually by users who need heavy number-crunching capabilities but cannot afford a full-scale supercomputer costing more than $2 million. This computer is a vector processor and thus uses a fundamentally different execution technique from scalar processors, such as mainframe computers and superminicomputers, and is typically configured as a uniprocessor rather than a parallel processor. Typical environment is a "cool room" with a raised floor and/or an ordinary office with no special environmental controls. Number of concurrent users typically ranges from 10 to 50.

deposition. The layering of various chemicals on a wafer. The introduction of dopant to wafers in high-temperature furnaces, chemical vapor deposition (CVD), sputtering, and implant.

deposit/loan management. An application that facilitates the control and earning potential of loans and deposits.

design layout. An initial design process in which the major components and part interfaces are defined.

desk-side personal computer. The desk-side personal computer meets all the qualifications listed for desktop personal computers but is further defined as being a personal computer that has been specifically designed to be placed next to or under the computer operating or desk surface, including foot/stand on bottom of system.

desktop personal computer. The desktop computer classification includes all personal computers except those products that are designed and sold as local area network servers, desk-side personal computers, and all forms of portable computers. Further, these systems are based on keyboard input devices.

desktop publishing. 1: Generalized computing platforms used to perform electronic publishing tasks as one of many applications. 2: The formatting of text and graphics into publishing-quality printed output.

desktop terminal equipment. Telecommunications equipment that is actually used on a desktop. This segment includes products such as single-line telephone equipment and integrated voice/data workstations.

desktop video. Tabletop televised images.

detail drafting. The representation of a part in standard geometric drafting format. This representation will include all part geometry dimension and notations describing mechanical/structural, functional, and material characteristics.

detection and tracking. A real-time application that detects, tracks, and controls various systems and processes. (See also **data acquisition and control.**)

device interface. 1: An electronic device that enables one piece of gear to communicate or control another. 2: A device linking two incompatible devices. 3: A card containing circuits that allow a device to interface with other devices.

diagnostic. 1: Pertaining to the detection, discovery, and further isolation of a malfunction or mistake. 2: Medical applications that aid in diagnosing medical problems. X-rays, CAT scans, and ultrasound are examples.

dialysis. The separation of substances in solutions by means of their unequal diffusion through semipermeable membranes.

diathermy. The therapeutic use of high-frequency electric currents to produce localized heat in body tissue.

dictating/transcribing machine. A device that automatically records human speech onto a form of magnetic tape that can be played back for transcription.

diffusion. 1: A process used in the production of semiconductors that introduces minute amounts of impurities into a substrate material. 2: The movement of particles away from regions of higher concentration caused by the random thermal motion of atoms and molecules to areas of lower concentration.

digital. 1: Pertaining to the class of devices or circuits in which the output varies in discrete steps. 2: Circuitry in which data-carrying signals are restricted to either of two voltage levels, corresponding to logic 1 or 0.

digital access cross-connect system. A system that is composed of multiplex equipment that allows digital lines to be remapped electronically at a different digital level.

digital audiotape (DAT). A 4mm helical scan device (i.e., data recorded at an angle rather than parallel).

digital cordless telephone. Mobile telephone that uses digital radio transmission technology. CT2 is a standard for these devices.

digital design verification. A software application that includes logic simulation, timing analysis, hardware accelerators, hardware modelers, electrical rule checking, mixed signal simulation, transmission line simulators, and signal noise analysis.

digital panel meter. 1: An electrical switchboard or instrument board using continuously variable electrical signals known as analog signals. 2: Digital signals versus analog signals.

digital radiography. Equipment used for electronically detecting the arrival of X-ray photons transmitted through or emitted from an object on various media and converting the sensed analog signals to digital signals.

digital signal processor (DSP). High-speed general-purpose arithmetic unit used for performing complex mathematical operations such as Fourier transforms.

digitizer. A device used for the creation of digital information from alphanumeric or line artwork. More sophisticated digitizers are able to reproduce halftone images and usually are termed scanners.

diode. 1: A semiconductor device used to permit current flow in one direction in a circuit and to inhibit current flow in the other direction.

direct channel. The sale of equipment directly to the end user by a vendor that contributes significant development or integration to the product. Can be either sales of complete systems by turnkey vendors or sales of components of systems sold by individual suppliers.

direct memory access (DMA). A computer feature, set up by the central processing unit (CPU), that provides for high-speed direct data transfer from a peripheral device to the computer memory or to magnetic disk or tape storage units. This feature releases CPU time to perform other procedures. Most DMA devices employ a CPU-cycle-stealing approach.

direct sales force. A sales method that employs a sales force to move a product through the distribution channel by making face-to-face contact with the consumer. Also referred to as outside sales.

direct thermal printer. A printer that uses point-specific heat and heat-sensitive substrate that change color when exposed to heat.

direct write e-beam. Equipment used in semiconductor manufacturing where electron beams are used to create heat that will expose selected areas of a wafer's surface to create a specific design. (See also **lithography.**)

disaster recovery and contingency planning. The planning and implementation of data backup and recovery procedures for a customer's site, based on an analysis of the critical business functions.

discrete component testers. Equipment used to test, check, and monitor the functionality of devices that have a single functional capability per package. These devices include resistors, capacitors, diodes, transistors, and other devices not classified as integrated circuits.

discrete device, security energy management. A circuit complete in itself used in the security and energy industries.

discrete semiconductor. An individually packaged semiconductor component complete in itself, such as a diode or transistor.

disk. 1: A high-capacity random-access storage device. Data are written onto and read from the surfaces of a stack of revolving record-like disks coated with magnetic material. May be fixed or removable. Capacity ranges from 0 to more than 1,000 pages per disk. Referred to as a rigid disk. (See also **random access.**) 2: A random-access magnetic storage medium in the form of a platter or thin wafer. (See also **magnetic disk.**)

disk drive. The unit that controls the reading and writing of disks.

disk drive IC. An analog IC designed for the mass-storage peripheral market. These ICs include read/write amplifiers, data separators, data processors, servo controllers, and motor controllers.

diskette (floppy disk). A record-like disk of magnetically coated Mylar enclosed in a protective square envelope. Holds from 80 to 250 pages of text. Unlike cassettes or cartridges, which store text serially, diskettes are formatted in a random manner, which allows faster access.

disk, magnetic. A storage device containing information recorded on the magnetizable surface of a rotating disk; a magnetic disk storage system is an array of such devices, with associated reading and writing heads mounted on movable arms.

disk operating system (DOS). 1: A computer system based on the Intel 80XX or 80XXX architecture that use the MS/PC-DOS operating system software. 2: An operating system that uses magnetic disks as its primary on-line storage.

dispatching. A software application used to execute the route plans of multiple vehicles, taking real-world events into account.

display peripheral. A component used to address the man-to-machine interface, whereas communication peripherals are used to address the machine-to-machine interface.

distribution. 1: The act or process of distributing. 2: The path by which a product moves from the manufacturer to the ultimate end user. 3: To place or position so as to properly apportion over or throughout an area.

distribution channel. The route taken either by the title to a product or by the physical product itself as it moves from the producer to the ultimate end user. The channel for a product extends to the last consumer who buys it without requesting any significant change in its form. When form is altered and another product emerges, a new channel is started.

distribution frame. A unit for terminating telephone wiring. This unit is typically used for terminating and cross-connecting telephones to the switching system.

distribution method. A method employed to move a product through the distribution channel. It is separate and distinct from the channel in that many channel members may employ the same distribution method.

distributor. A wholesaler that sells to other resellers or end users. The distributor's primary function is to stock the inventory of multiple manufacturers to provide volume buying power to its end users.

DMA. See **direct memory access.**

documentation/drafting. A software application that includes detail drafting, schematics, technical illustration, charts, specifications, bills of materials, training manuals, and other drawing- or drafting-related applications. International standards such as ISO, DIN, or ANSI can be used to define text and feature format.

document management. A documentation system, generally computerized, that links and tracks all documents (drawings, procedures, specifications) related to an assembly or process.

dopant. Atoms of materials such as phosphorus, boron, or arsenic that are diffused into silicon to create resistors, diodes, and transistors.

DOS. See **disk operating system.**

dot matrix printer. A printer that produces images through selective printing of dots chosen from a dot array matrix. Dot matrix printers are segmented by the number of wires in the printhead: 9, 18, or 24 and greater wires. Within these technology segments, additional segments are defined by speed of printing, expressed in characters per second (cps).

DP. See **data processing.**

DRAM. See **dynamic random-access memory.**

DRAM controller. A device that governs DRAMs in some predetermined manner. Holds a process or condition at a desired level or status as determined by comparison of the actual value with the desired value.

drilling programmable machine tool. A machine tool fitted with an end-cutting tool that is rotated with sufficient power to create a hole or enlarge an existing hole in solid material.

drive. See **tape drive.**

drive, disk cartridge. A disk drive using a removable one- or two-platter cartridge; may incorporate a fixed-media capability.

drive, fixed Winchester. A disk drive that includes all fixed-media Winchester drives.

driver information. An electronic device used to assist the driver by giving visual or audio signals for direction. Examples include digital gauges, service reminders, digital clocks, trip/navigation computers, heads-up display, audio annunciator, CRT display, miles-to-empty indicator, and shift indicator.

dry etch. A technique in semiconductor manufacturing used to produce more uniform pattern definition on wafers without immersing the wafer in a liquid bath. Techniques include plasma etching and reactive etching through which gases and energetic ions remove unwanted chemical material from a wafer.

dry silver. A photosensitive film or paper coated with silver compounds that is developed by the application of heat. Popularized by 3M.

dry strip. A process in semiconductor manufacturing for removing photoresist from the wafer after etching. Dry strip comprises barrel strippers and single-wafer strippers.

DSMPU. See **DSP microprocessor.**

DSP. See **digital signal processing.**

DSP microprocessor (DSMPU). A general-purpose, programmable integrated circuit similar to a conventional microprocessor. Its distinction is characterized by the efficiency with which it implements repetitive multiplications and additions required by DSP algorithms.

DSU/CSU. See **data service unit (DSU) and channel service unit (CSU).**

DTMF. See **dual-tone multifrequency signaling.**

dual-disk drive. A system that provides for the use of two disks at the same time.

dual-tone multifrequency signaling (DTMF). A standard signaling method for touch-tone telephones using a combination of two different tones for any button pushed.

duplicator. 1: A small offset printing press that uses a planographic image carrier. These presses are usually capable of one or two colors and are smaller, easier to operate, but less sturdy than offset presses. 2: Machine that requires a special master to make copies but produces copies at a higher rate of speed than copying. It differs from printing in that a direct-image master is used that yields a limited number of copies. Offset, spirit, gelatin hecto, stencil, and sometimes xerography are considered duplicating processes. (See also **copier.**)

dynamic random-access memory (DRAM). A random-access memory device that must be electrically refreshed frequently (many times each second) to maintain information storage. DRAM densities can range from 16K, with approximately 16,000 bits, to 16Mb, with approximately 16 million bits.

E

8mm tape cartridge. A class of tape drives using 8mm cartridges; used in camcorders.

E-1 multiplexer. An electronic device that consolidates or pools multiple digital streams representing voice or data signals onto a single high-speed E-1 data line. An E-1 line operates at 2.048 Mbits/second, a standard within Europe. See **T-1 multiplexer** for U.S. standard.

earth resources application. Studying the earth resources by performing seismic analysis, mapping, and oil field services.

EATE (electronic automatic test equipment). See **automatic test equipment.**

e-beam. A sophisticated system used in semiconductor manufacturing that uses an electron beam for maskmaking or for projecting patterns onto wafers. E-beam equipment allows smaller geometries (typically less than 1 micron) than are possible under other production methods.

ECAE. See **electronic computer-aided engineering.**

ECL. See **emitter-coupled logic.**

EDA. See **electronic design automation.**

education. The process of providing schooling or training by formal instruction and supervised practice.

educational publishing. A system with the main purpose/use of printing materials used for the process of educating.

EEPROM. See **electrically erasable programmable read-only memory.**

elapsed time meter. An electronic measuring instrument that counts the actual time taken to observe a recurring event.

electrically erasable programmable read-only memory (EEPROM). A nonvolatile memory device that can be erased and programmed electrically.

electrocardiograph. An instrument used to graphically record electrical manifestations of heart activity obtained from the body's surface.

electroencephalograph. An instrument used to graphically record electrical discharges of the cerebral cortex by electrodes attached to the surface of the scalp.

electronic calculator. A product with components that perform calculations and digitally display results. (See also **calculator.**)

electronic computer-aided engineering (ECAE). Computer-aided tools used in the engineering or design phase of electronic products (as opposed to the physical layout phase of the product). Examples of ECAE applications are schematic capture, simulation, and test pattern creation. ECAE systems are used most often by electrical engineers.

electronic design automation (EDA). Computer-based tools that are used to automate the process of designing an electronic product, including boards, ICs, and systems. Formerly referred to as ECAD.

electronic forms generation. The process of automatically producing documents requesting information.

electronic game. Home electronic games that typically are attached to television receivers.

electronic keyboard. A keyboard on which characters are generated or encoded by electronic means, usually by contact closure, as opposed to mechanical linkages. Electronic keyboards have a different feel, and some have a built-in artificial bottoming feel and/or audible click to assure the operator a key actually has been depressed.

electronic mail (e-mail). An application that supports the movement of information between users connected to a networked computer system.

electronic musical instrument. An instrument that allows the transmission of musical sound by the use of transistors.

electronic publishing. Fully integrated automation of the printing procedure.

electronic warfare (EW). Electronic operations between enemies. Includes warning receivers, jammers, assorted electronic countermeasure systems, and associated test equipment.

electrostatic plotter. A plotter using the corona from high voltages applied to needles or nibs to produce shaped electrostatic charges on paper; toner is attracted to the charged area, and heat and pressure are used to fuse the toner to the paper.

elementary/secondary school. A regular school, defined as schools that are part of state and local school systems and most nonprofit private elementary/secondary schools, both religiously affiliated and nonsectarian.

e-mail. See **electronic mail.**

emerging technology. A technology that is not in widespread use and that appears to have potential for widespread acceptance.

emitter-coupled logic (ECL). 1: A form of integrated circuit used to implement very high speed logic functions. 2: The emitters of the input logic transistors are coupled to the emitter of a reference transistor.

employees. All civilians, who, during a reference time period, did any work for pay or profit (minimum of an hour's work) or worked 15 hours or more as unpaid workers in a family enterprise.

encryption. Process of encoding data, voice, or video transmissions for security purposes.

encryption unit. A device that encodes/decodes data, voice, or video transmissions for security purposes.

end user. The final purchaser of a finished product.

end-user average selling price. The average price that a user pays for a product inclusive of channel markups and discounts.

end-user revenue. End-user average selling price multiplied by shipment quantity.

enhanced service. Equipment and service charges associated with enhanced data communication networks, which may include protocol, electronic mail, or facsimile.

enrollment. In education, the total number of students registered in a given school unit at a given time, generally in the fall of a year.

entertainment system. 1: Electronic equipment used for amusement or pastime and not intended to, but may, increase productivity or skill. Examples include: radio, seek/scan, graphic equalizer, power amplifiers, noise reduction, cellular telephone, optical disk, CB radio, and digital audiotape. 2: A computer application to keep or hold the mind, something directing or engaging.

entry-level workstation. A low-cost computer workstation, priced less than $15,000. It is targeted at the end user who is sensitive to price. This segment tends to be dominated by occasional users who are not paid for producing documents on their system. Entry-level workstations mainly run 2-dimensional graphics and have a rating of less than 12 mips and a rating of 0.5 to 1.5 mflops.

environment. Where a product is used ultimately.

epitaxial wafer. Single-crystal silicon grown on a crystalline silicon substrate.

EPROM. See **erasable programmable read-only memory.**

equipment/maintenance management. A software application that assists in the management of equipment and the respective maintenance requirements and contracts. May also calculate depreciation.

erasable programmable read-only memory (EPROM). A nonvolative memory device that can be erased by ultraviolet (UV) light and reprogrammed by the user.

ET. See **typewriter.**

etch-and-clean equipment. Equipment used in semiconductor manufacturing to remove and clean material from wafers.

EW. See **electronic warfare.**

expenditure. Charges incurred, whether paid or unpaid, which are presumed to benefit the current fiscal year. These include all charges for current outlays plus capital outlays and interest.

export. The delivery of products to a foreign country for the purpose of trade or sale.

F

fab. Abbreviation for wafer fabrication. See **fabrication.**

fabrication. A manufacturing operation that makes components rather than assemblies.

fabric ribbon. Fabric ribbons are struck repeatedly by the print mechanism until all the ink is depleted. Such ribbons are used commonly for general-purpose printing and are the most economical and durable ribbon substrate. Most fabric ribbons are made of nylon and are available in several forms, e.g., cartridge or web ribbon.

facilities design/management. A software application used to lay out, inventory, and manage assets (such as personnel, space, equipment, and utilities) within a building or geographic service area.

facilities management service. The responsibility of providing ongoing administration of a data processing or communications facility by a vendor.

facility planning and simulation. A facility system model is exercised and refined through a series of simulation steps until a detailed, optimum configuration is reached.

facsimile (fax). 1: An electronic device that uses telephone lines to transmit documents to and receive documents from a second facsimile machine. 2: An exact copy or the process of transmitting printed matter or still pictures by a system of either telephones, telegraph, or radio for reproduction.

factory automation equipment. Equipment that includes various types of capital equipment that are automated and used throughout a manufacturing facility.

factory average selling price. The average price per unit that is paid for a product. This figure takes into account discounts given to the distribution channel and multiple-purchase discounts.

factory revenue. The amount of money received by a manufacturer for its goods.

fast packet switch. A packet-switching technique in which small packets are switched at high-speed using hardware for the transport of voice, data, and video.

fast SRAM. A static RAM device that runs at speeds less than 70 nanoseconds. (See also **static random-access memory.**)

fatigue. In electronics, the degradation of the performance of materials, parts, or circuits with time.

fault detection, fault management, and adaptive control. A software application that determines if a manufacturing system or a process is functioning or performing within control limits. Fault management and adaptive control is a control method in which control parameters are continuously and automatically adjusted in response to measured process variables to achieve near-optimum performance.

fax. See **facsimile.**

FDDI. See **fiber distributed data interface.**

federal government. A form of government in which power is distributed between a central authority and a number of constituent territorial units.

FERRAM. See **ferroelectric random-access memory.**

ferroelectric random-access memory (FERRAM). A nonvolatile, radiation-hard, fast read/write memory that can store data over long periods of time without power.

fiber distributed data interface (FDDI). A standard for high-speed packet switched data.

fiber optic. 1: The technique of transmitting light through long, thin, flexible fibers of glass, plastic, or other transparent material. Bundles of fiber can transmit complete images. 2: A technique used in electromagnetic wave propagation in which infrared and visible light frequencies are transmitted by a light-emitting diode (LED) or a laser through a low-loss glass fiber. This method is used in very high frequency (VHF) radiation transmission.

field-programmable gate array (FPGA). An integrated circuit incorporating an array of programmable logic elements that are not preconnected. Interconnections between the various elements are user programmable and consist of predetermined levels of interconnect that can be connected to, or disconnected from, other interconnect lines as defined by the user. Can be of either bipolar or MOS technology.

field-programmable logic array (FPLA). A logic array in which programming is accomplished by blowing fuse links or shorting base-emitter junctions.

film ribbon. See **single-strike ribbon** or **multistrike ribbon.**

finance. An application to support the management of money or other liquid resources and their respective management within an organization.

fixed asset. An application that supports the management of an organization's fixed assets, which are a capital asset that cannot be readily liquidated, such as plant, land, equipment, and long-term investments. Management of expected costs based on a specific level of production or other activity.

fixed disk. A memory disk that cannot be removed from the read/write device, as opposed to a removable hard disk, diskette, or magnetic tape.

fixed media rigid disk drive. A fixed media rigid disk drive has the platter enclosed in a housing that is not designed to be accessible to the user.

fixture design. The design of a variety of structural aids that hold the component or assembly during the manufacturing process.

flexible disk. See **flexible disk computer storage media.**

flexible disk computer storage media. A flexible disk made of a 3-mil polyester substrate coated with gamma ferric iron oxide particles dispersed in an epoxy binder and encased in a vinyl jacket. These are commonly supplied in 3.5- or 5.25-inch diameters.

flexible manufacturing system programmable machine tool. A manufacturing system that typically consists of a computer-integrated group of numerical control (NC) machines or workstations linked with material transfer devices for complete automatic processing of differing product parts or the assembly of these parts into different units.

floating-point coprocessor. A separate microprocessor used in the efficient handling of floating-point operations.

floppy (flexible) disk. A small, thin, electromagnetic media used for storing digital information.

floppy disk controller. A device controlling the storage and retrieval of data from a floppy disk.

font generation. Process whereby typeface and size is selected.

font management. The understanding, use, and control of fonts or typefaces that are displayed on a terminal or monitor, or printed out on a device such as a printer, plotter, or typesetter. Font management requires the understanding of the physical location of where the fonts reside—whether in diskette, hard disk, ROM, RAM, card, or cartridge. It also requires the knowledge of the type of font—whether bit map or outline, scalable or fixed point and pitch—and the applications and print system capability to address and place the fonts accurately on the screen or printing media.

forecasting. To estimate in advance or anticipate; to predict future events, trends, business conditions, etc.

form. 1: Any material that has been printed for the primary purpose of facilitating the entry of written information by hand or machine. A form has repetitive information printed in fixed positions. Blank paper may be included, especially if it is continuous and has undergone some alteration such as punching or perforating to facilitate manual or machine entries. 2: Allows the user to graphically design a form for publication—may include data entry and database capabilities.

four-year institution. An institution legally authorized to offer and that does offer at least a four-year program of college-level studies wholly or principally creditable toward a baccalaureate degree.

FPGA. See **field-programmable gate array.**

FPLA. See **field-programmable logic array.**

front-end processor. A computer-based product expressly designed to relieve host computers of certain communications processing tasks. Included are remote concentrators that are not attached directly to a host computer. This segment does not include general-purpose computer systems functioning as front-end processors.

full-color copier. A reproductive device that can recognize the full range of colors on an original and reproduce them using the three subtractive primary colors and produce a full-color copy.

fully formed printer. A printer that prints fully formed characters by applying pressure on or to the paper and obtaining the characters from a wheel, band, type train, or drum. Such devices can be serial, fully formed printers and line, fully formed printers.

functional design. An application that supports component design, assembly verification, linkage and mechanism design, and other detail or functional design activities.

functional PCB tester. An equipment tester that accesses the normal input/output interface of the unit under test (UUT). Generally, this consists of the edge-connector pins, plus any special interface that may have been provided for testing. Provides stimulus patterns and measurement verification that the UUT actually operates correctly.

funds transfer terminal. A machine used by financial institutions and designed to perform many of the banking functions performed by human tellers. (See also **automated teller machine.**)

G

GaAs. See **gallium arsenide semiconductor.**

GaAs analog IC. There are two overlapping subsets in this segment; analog products and monolithic microwave integrated circuits (MMICs). Analog products have output that are linearly proportional to their inputs and function at a varying range of frequencies across the spectrum, depending on particular device design. MMICs operate in the microwave frequency spectrum (above 3 GHz).

gallium arsenide semiconductor (GaAs). A compound of gallium and arsenic used as a semiconductor material. GaAs devices are relatively expensive devices exhibiting very low internal noise and very high speed.

game. A software application or activity engaged in for diversion or amusement.

gas. A consumable material used throughout the fabrication of semiconductor devices. Includes both bulk and specialty gases.

gate array. 1: An ASIC device that is customized using the final layers of interconnect. (Included in this category are generic or base wafers that include embedded functions such as static RAM.) May be of either bipolar or MOS process technology.

gateway. Equipment or conceptual point that connects two otherwise incompatible systems. (See also **protocol converter.**)

general analysis. A software application designed to solve various technical problems and to further research subjects. The analysis is usually mathematical in nature and performed by scientists, physicists, chemists, biologists, and engineers.

general ledger. A software application that supports the business function of entering accounting transactions and their subsequent transferring and reporting.

general operating system. An operating system with use not restricted to a particular type of computer or a specialized application.

general productivity. A software application that is used to enhance productivity within general disciplines.

general-purpose computer system. A computer system that is not configured for a specific purpose but rather for a general application. This category includes supercomputers, minisupercomputers, parallel processor computers, mainframes, workstations, and the like.

general-purpose input/output (I/O) circuit. A circuit that permits a system to communicate via a wide variety of input/output (I/O) devices with the outside world, which can include printers, modems, and monitors.

general test equipment. Test equipment not included under the definition of automatic test equipment (ATE).

geographic information system (GIS). A mapping software application that contains the functions of cartographic software and also allows data analysis through Boolean operations on multiple data layers.

geophysical instrument. An instrument used to observe and measure the physics of the earth and its environment.

GIS. See **geographic information system.**

global positioning system. Equipment that calculates location based on one of several technologies such as radio or internal navigation.

golf ball. A type of print element invented by IBM for use in the IBM Selectric typewriter. It is a round, metal element with raised characters.

government. The organization, machinery, or agency through which a political unit exercises authority and performs functions and which is usually classified according to the power within it. Includes the executive, legislative, judicial, administrative, and regulatory functions.

graphic design art. A method of applied art used to form a visual end product that conveys information. Methods include drawing, painting, photography, printing, and bookmaking.

graphics. Software that permits the pictorial representation of information at a screen or printer. Early graphics packages showed bar charts or line graphs on a character-based terminal by placing characters such as + or * on grids created by repetitions of characters such as | and or _ . The term has come to apply usually to bit-mapped graphics, which are capable of processing images, freehand input, and icons on a pixel-by-pixel basis. Examples of graphics software include MacDraw and MacPaint.

graphics/animation/imaging. A software graphics application used by scientists and engineers to process and display complex technical data. It also includes applications that use computers to generate or manipulate graphics images that are the end product, i.e., cartoons.

graphics board. An add-on board connected to the bus that provides video capabilities for a personal computer.

graphics controller. A device that governs information flow used to create visual images of data.

graphics draw/paint. A software application that creates, retrieves, modifies, and prints graphic images.

graphics supercomputer. The performance of mips, mflops, transforms per second, and shaded polygons per second distinguishes graphics supercomputers from superworkstations. Performance ratings range from 20 to 40 mips and 16 to 40 mflops. The best distinction between graphics supercomputers and superworkstations is the graphics performance ratings, 100K to 600K 3-D vector transforms/second and 25K to 150K Gouraud-shaded polygons/second. The average price ranges from $75,000 to $150,000.

graphics terminal. A display terminal that provides graphical presentation of information to the operator. 1: Data conversion graphics terminals support the use of graphics to summarize or otherwise relate discrete data that were not originally graphics data. 2: Concept design graphics terminals support graphics displays that help realize accurate images of ideas conceived in the human mind. 3: Imaging graphics terminals display a real image, visible or nonvisible, that was digitized to allow enhancements or data extraction.

grinding programmable machine tool. A standalone machine with expanding use of computer numerical control (CNC) and with advance efforts to incorporate grinders into flexible, automated systems. Creep-feed is a type of grinding technology.

gross lease additions. The total volume of new equipment leases.

H

hand-held personal computer. The hand-held personal computer is a less-than-2-pound, fully functional personal computer. To be considered a hand-held personal computer, units must operate using a fully implemented version of MS-DOS and be able to run some of the shrink-wrapped MS-DOS-based applications. These units are expected to have a subsize keyboard and utilize nonstandard mass storage devices. The criterion for inclusion in this classification is that the device may be held in one hand using the other hand for data entry via the included keyboard. They are fully battery powered units.

hard disk. See **rigid disk.**

hard disk controller. A device that controls the storage and retrieval of data from a user's hard disk drive.

hardware. Electronic equipment, systems, or peripheral devices.

hardware maintenance service. Remedial repair services for equipment, systems, and peripherals. Hardware maintenance can include on-site support, telephone/remote support, preventive maintenance, and other activities necessary to maintain hardware operation.

HDTV. See **high-definition television.**

head; manganese-zinc, landable. A type of head used in sealed fixed-media drives where heads land on the lubricated media surface and use hot-pressed manganese-zinc pole pieces.

health care. An environment or industry that includes establishments primarily engaged in providing medical, surgical, and other health services.

helical scan tape drive. A storage tape drive that records data on an angle rather than parallel. Tape dimensions can be 4mm, 8mm, 13mm, or 19mm. Segments of this category are VHS, DAT, 8mm, and other. (See also **VHS, DAT.**)

high-definition television (HDTV). A television standard with high-resolution, digitized images; wide, theater-like screen; and digital stereo sound. Requires a broader video bandwidth to accommodate increased picture transmission.

higher education. Study beyond secondary school at an institution that offers programs terminating in an associate, baccalaureate, or higher degree.

high school. A secondary school offering the final years of high school work necessary for graduation, usually including grades 10, 11, and 12 or grades 9, 10, 11, and 12.

home. The usual place of residence. A home-based business is an enterprise producing goods or services that is operated in or from the home.

horizontal-turning programmable machine tool. The tool of a machine that holds a piece along the horizontal axis for a certain function to be performed such as cutting, boring, or drilling.

host/vendor independent terminal. A host-independent display terminal produced by an independent manufacturer. It may operate in either character or block mode. The independent manufacturer does not supply mainframes or minicomputers to which its display terminals may attach. Not included is any terminal that is from an independent manufacturer and that is protocol-specific to either a minicomputer-based or a non-IBM, protocol-specific terminal.

hotels and lodging. An environment or industry that includes commercial and noncommercial establishments engaged in furnishing lodging, or lodging and meals, and camping space and camping facilities.

household. The set of persons occupying a housing unit. Thus, counts or estimates of households, householders, and occupied housing units are always defined the same.

hybrid. 1: Made up of several different components. 2: A hybrid integrated circuit is made by putting several integrated circuit die and/or passive components on a ceramic substrate with a metal pattern. 3: A substrate containing more than one component. The substrate consists of multiple ceramic layers and also can contain multiple packages. 4: A device in a speech transmission system consisting of transformers that convert a two-wire channel into a four-wire channel, thus creating a separate wire pair for each direction of transmission.

hybrid analog IC. An analog IC that combines one or more semiconductor chips with other technologies, such as chip capacitors and film resistors, on a single substrate.

hydrogen. A chemical element used for hydrofining for sulfuration of petroleum products or to reduce metallic oxide ores.

I

IBM 3270 protocol terminal. A terminal that is protocol-specific to IBM's 3270 Information Display System. Included is any IBM 3270-type terminal or 3270-compatible terminal produced by another manufacturer. A terminal that can provide the appearance of a 3270 device when used with a protocol converter is **not** included.

IBM/VM/MVS. An IBM standard multiuser operating system.

IC. See **integrated circuit.**

IC layout and verification. A software application tool that is used to create and validate physical implementations of an integrated circuit (IC). IC layout tools include polygon editors for creating geometric data, symbolic editors, placement and routing (gate array, cell, and block), and DRC/ERC verification tools.

IDVT. See **integrated voice/data workstation.**

if-sold revenue. The amount of money paid for products based on list price. List price does not take into account discounts or markups.

if-sold value. A measure that reflects unit shipments multiplied by list price.

IGBT. See **insulated gate bipolar transistor.**

illustration software. An object-oriented software program that allows the user to create original artwork consisting of lines, arcs, and other mathematically generated geometric objects. (Line art is a term sometimes used to describe the results of illustration software.) Some illustration software can perform raster-to-vector conversion by allowing users to trace over scanned raster art. This trace can occur on screen or on a graphics tablet. Illustration software usually offers raster-fill patterns that extend to cover an area in an illustration bounded by geometric objects.

image communication. Equipment used in a business or residence to transmit image and text. Facsimile equipment, video teleconferencing, telex, and videotex are included in this classification.

image-editing software. A software program that allows a user to modify existing artwork existing in raster format. This art may have been scanned or captured as analog signal data and converted to digital data. Image-editing software can handle binary data, in which case it is called print software; or it can handle grey-scale and/or color data, in which case it is called image-retouching software.

image generation. Synonymous with image synthesis and equivalent to the historical use of graphics.

image management. The process of directing, controlling, or handling something that closely resembles another.

image processing. A series of actions, changes, or functions that bring about a particular result for something that resembles another.

imaging. See **graphics/animation/imaging.**

imaging subsystem. A peripheral device that does not possess video display terminal (VDT) functionality, but acts as output devices for the display of graphics and/or image data.

impact printer. A family of printers that use direct impression impact of a type bar, type head, or matrix pin to exert pressure against a paper ribbon and a platen to create a character.

import. The supply of products from a foreign country for the purpose of trade or sale.

in-circuit PCB tester. An equipment tester that incorporates pin electronics (drivers and receivers) that verify the functionality of each part on an assembled circuit board. Verifies each component's parameter and limited functionality.

indirect channel. A variety of distribution channels in which product is brought to the end user. It includes value-added resellers (VARs) and original equipment manufacturers (OEMs).

inductor. A passive component that stores energy in the form of a magnetic field (flux) around a core body.

industrial design. A process that integrates the design tools defining the style and functional aspects of the total design.

industrial electronic equipment. Electronic equipment used in a manufacturing environment or industry.

industrial marking. A specified format on media that is recognized by electronic or visual means. Examples are the printing and use of forms, bar codes, ticket printing (lottery and airline, for example), and labels.

industry. A collective term for many of the productive activities of a nation or other large group. A collective term in which a number of firms produce the same kind of commodity or service or are engaged in the same kind of operation.

INEWS. See **integrated electronic warfare system.**

information center. A center designed specifically for storing, processing, and removing information for dissemination at regular intervals, on demand or selectively, according to the user's needs.

information resource management. A program that works with definitions, uses, values, and distribution of information that is processed by a user and handled by a computer system.

infrared. Those radiations, such as are emitted by a hot body, with wavelengths just beyond the red end of the visible spectrum. Wavelengths longer than those of visible light and shorter than those of radio waves.

ink jet. An image-producing process currently used in electronic printers, plotters, and full-color copiers that uses piezoelectric technology to expel a very small droplet of liquid ink through nozzles onto the output paper.

ink jet printer. A nonimpact printing method that uses ink droplets to form a printed image. This technology usually is classified by the nature of the drop stream; two major categories are continuous flow and drop-on-demand.

input/output (I/O) device. 1: Equipment used to communicate with a computer. 2: A general term applied to equipment used in communicating with a computer and the data involved in the computer. 3: The transmission of information from an external source to a computer or vice versa.

input/output (I/O) ratio. 1: A ratio of the value of a resource input to the value of the final product output, typically expressed as a percentage. 2: A measure of throughput for a computer system.

inspection. The process of testing or measuring an object or process by remote sensing in imaging technology.

installed base. The total number of product in active, day-to-day use.

institutional support. In higher education, the expenditures that include day-to-day operational support for colleges, excluding expenditures for physical plant operations. Examples of institutional support include general administrative services; executive direction; planning, legal and fiscal operations; and community relations.

instruction. In higher education, expenditures of the colleges, schools, departments, and other instructional divisions of higher education institutions and expenditures for departmental research and public service that are not separately budgeted. Includes expenditures for both credit and noncredit activities. Excludes expenditures for academic administration where the primary function is administration.

instructional. Products used to increase the understanding (either problem-solving or self-improvement) of a specific subject matter. The primary focus of these products is the imparting of knowledge or skills to the user.

instructional staff. In education, the number of full-time equivalent positions, not the number of different individuals occupying the positions during the school year.

instrumentation. Designing, manufacturing, and using instruments for detection, observation, measurement, automatic control, automatic computation, communication, or data processing.

insulated gate. A gate that is separated from other conducting surfaces through a nonconducting material.

insulated gate bipolar transistor (IGBT). A power transistor that has the insulated gate properties of a MOS transistor with the low saturation ON voltage of a bipolar transistor.

insurance. An environment or industry that covers carriers of all types of insurance and insurance agents and brokers.

integrated application. A software application that combines several functions into one software package, which may include word processing, database management, and spreadsheet capabilities but is not exclusive to these functions. Data must be able to be shared among these functions.

integrated circuit (IC). A combination of interconnected semiconductor elements inseparably associated on or within a continuous substrate. Complete module of components manufactured as single, solid units made by either a film deposition or a diffusion process.

integrated electronic warfare system (INEWS). A combination of interconnected circuit elements associated on or within a continuous substrate to produce integrated systems used specifically in military operations.

Integrated Services Digital Network (ISDN). A digital network having the capabilities of simultaneous signaling, switching, and transporting over a single facility. A new worldwide telephone standard that will make it easier to communicate information such as voice, data, and video over phone lines.

integrating and totalizing meter for gas and liquid. A meter that registers consumption and positive displacement, including meters, fuel dispenser meters, and gas meters.

integrated voice/data workstation (IDVT). Terminal that possesses both telecommunications and computational capability.

integration. Integration of data types can be achieved using page composition and pagination applications.

intelligent terminal. An interactive terminal in which part of the processing is accomplished by a small computer or processor contained in the terminal itself. This type of terminal is sometimes referred to as a smart interactive terminal. Such a terminal has the following characteristics: (1) self-contained storage; (2) user interaction—with the terminal or the central computer; (3) stored program; (4) part of processing accomplished in the terminal; (5) on-line via communications line with large central computer and database; (6) human-oriented input—such as keyboard and light pen; and (7) human-oriented output—such as serial printer and CRT.

interactive language. Within a system, a human user or device serviced by the computer can communicate directly with the operating program or language.

intercom systems. A system that provides internal communication, allowing calling to be confined to inside the system. In most cases, key systems provide the intercom lines that allow quick communication between stations on the key system.

interconnect and bare-board tester. Equipment designed to check, monitor, and identify printed circuit boards for electrical connectivity and detect manufacturing defects.

interface IC. An analog IC that is dedicated to interfacing digital information (in bits) with external nonsemiconductor devices such as displays, lines, solenoids, and other peripheral devices.

internal transfer. The process of conveying or moving goods and services from the producer within a company.

international telephone service. Telecommunication services between offices or stations in different states or between mobile stations that are not in the same state or are subject to different states.

interrupt controller. 1: An internal controller chip that can break into the normal flow process of a routine such that the flow can be resumed from that point at a later specified time. 2: A condition or event that temporarily suspends normal processing operations. 3: A temporary disruption of the normal operation of a routine by a special signal from the computer. 4: Copying technology: A feature that allows a job to be stopped to allow another job to be run without the loss of programming for the first job.

intrusion-detection alarm system. A warning system used to detect when someone or something has intruded in a specified area. (See also **alarm system.**)

inventory. Items used in the process of manufacturing a product and distributing it to the end user. Inventory can be stored at a stock point or at a work-in-process location. Inventory may consist of finished goods, parts of intermediate items, work-in-process, or raw materials.

inventory and distribution management. An application that monitors the status of materials at all levels of production, including receipts, issues, and inventory balances. It identifies both unit quantities and dollar values and provides essential input to both the general ledger for cost accounting and the production planning modules.

I/O device. See **input/output device.**

ion implantation. The use of an ion beam to bombard a silicon wafer, altering the concentrations of p-type and n-type material. This method of doping allows for very precise control of the device parameters. This process introduces dopant atoms into the surface of silicon wafers and accelerates them so that they bombard the wafer, causing them to penetrate the exposed portions of the wafer.

ion milling. A technique in semiconductor manufacturing in which a beam of charged particles is used to remove material from a wafer.

I/O ratio. See **input/output ratio.**

IR. See **infrared.**

ISDN. See **Integrated Services Digital Network.**

IVR. See **interactive voice response system.**

J

joint venture. Two or more companies providing capital or other resources to invest or make available for investment in the ownership of a new enterprise.

K

keyboard. An input device that allows an operator to enter alphanumeric characters through a typewriter-style key arrangement augmented with special function keys—manual operation of keys will generate electrical signals or cause tape to be punched, or both.

keyboard controller. A device that governs the functions of a keyboard transmitting a command to do something within a system.

key entry equipment. Data entry equipment such as key disk, key tape, or keypunch equipment.

key telephone system. A customer premises telephone switching system that allows telephones to interface to the public telephone central exchange or office without using an access code. This category includes the electromechanical 1A2 and electronic segments.

L

label. 1: A set of symbols used to identify or describe an item, record, message, or file. May be the same as the address in storage. 2: Matter attached to a document to identify or provide information. 3: To assign a symbol, acronym, or word as a means of identification to create a specialized record or filing handle. 4: A descriptive or identifying word or phrase. 5: To address, using self-adhesive addressing labels.

laboratory. 1: A software application that involves the use of computers inside analytical instruments and in linking these instruments together (instrumentation automation). Mass spectrometers and blood/gas analyzers are examples. 2: A place equipped for experimental study in a science or for testing and analysis.

laboratory and scientific apparatus. Any instrument, material, or equipment designed for a specific operation or particular use in the laboratory.

LAN. See **local area network.**

LAN-based e-mail. A software application that enables users of a local area network (LAN) to send and receive textual data. Some LAN-based e-mail software can send and receive computer files and graphic images.

language. In software, a set of commands that permits the programmer to perform arithmetic functions on data and/or give commands to specific hardware components of the computer system, such as the printer, terminals, disk, or memory. Statements in languages are generally required to be performed in a fixed order, although the order may be affected by loops and branches in the program and the values of parameters that control the looping and branching. Examples of low-level languages are C and assembler; high-level, or third-generation, languages include FORTRAN, COBOL, BASIC, and PL/1.

language editor. A set of computer commands forming code to edit files. May involve deleting undesired information, selecting desired information, inserting invariant symbols, and applying standard processes.

laptop A/C. The laptop A/C units reflect the standard laptop design, i.e., clamshell-style case with the display mounted in the top portion of the shell and covering the keyboard until the unit is opened for use. These units, like transportables, are designed to be easily moved from place to place but operate only on A/C power and do not contain batteries of any kind.

laptop D/C. The laptop D/C units are identical in style to the laptop A/C units except that they are powered by batteries and can be operated without direct connection to A/C power lines. Some of these laptop D/C units have a combination of battery- and A/C-power capability.

laptop personal computer. The laptop-case style is conducive to operation on the user's lap and is designed to be used in areas where space is restricted. This case style is referred to as the clamshell-type of system, with the display screen mounted in the top of the unit in such a way as to cover the keyboard when closed and be at the proper viewing angle in relationship to the keyboard when opened and ready for operation. This unit is completely self-contained and can be carried as a single unit that includes the keyboard, display, mass storage, and main system unit.

large-format plotter. This plotter uses media engineering size C (17 x 22 inches) or larger and corresponding metric sizes. (See also **plotter.**)

laser (light amplification by stimulated emission of radiation). 1: A device that transmits an extremely narrow and coherent beam of electromagnetic energy in the visible light spectrum. 2: A laser that operates at optical frequencies. In communications, lasers may be amplitude-modulated and used to carry speech information that is received by a light beam detector.

laser diode. A laser diode is a laser that is constructed with a semiconductor material. Many III-V semiconducting materials can be made to emit coherent light, creating a laser.

laser plotter. A device that produces an inscribed visual display of the variation of dependent variable as a function of one or more variables by the use of intense coherent beams of light.

laser printer. A type of nonimpact printer that combines laser beams and electrophotographic technology to form images on paper.

laser system. Any electronic device or system that is actuated by beams of coherent visible and infrared light to accomplish a task.

LCD. See **liquid crystal display.**

learning. An application that assists the user in learning. The subject can range from classic school subjects to games, art, and languages.

lease. A contract by which one conveys equipment, facilities, or property for terms specified.

lease accounting. An application that supports the management of leases.

leased circuit. A service offering that provides a customer with permanent (rather than dialed) connections to all points on the circuit for the duration of a contract.

lease/rental conversion. The volume of contractual conversions between rental and lease options.

LED. See **light-emitting diode.**

library management. A software application that supports the administration of a library, including cataloging.

LIDM. See **line, impact, dot matrix.**

LIFF. See **line, impact, fully formed.**

light communication system. Electromagnetic radiation of a wavelength originating at one place and reproduced at a distant point.

light-emitting diode (LED). A pinhead-size device with a pn junction formed from combinations of gallium, arsenic, and phosphorus. Light emission is the result of hole-electron recombinations that take place near the junction of the p-doped and n-doped regions. As the electrons in the n region of the diode travel through the area near the junction, they recombine with a hole. As a result of this recombination between an electron and atom, light in the form of photons is produced. The wavelength of color of the light is determined by the energy level.

light-emitting display. Light-emitting diodes grouped together in a matrix of dots to form characters.

linear array/ASIC. An ASIC that is purely analog.

linear IC. An IC that is purely analog; both inputs and outputs are analog signals. Sometimes, linear and analog ICs are used interchangeably. Dataquest uses linear as an analog-only segment of the analog market (mixed signal analog/digital is the other segment).

line conditioner. Equipment that changes/enhances the transmission characteristics of a circuit.

line, impact, dot matrix (LIDM). A printer that prints one line of dots at a time using an array of elements in a printhead.

line, impact, fully formed (LIFF). A printer that creates one line of characters at a time by placing characters—from a band, type train, or drum—on the paper by the pressure of an impact mechanism (hammer).

line, nonimpact, thermal transfer (LNTT). A printer that prints a line at a time, using an electrically heated element to produce images.

line printer. A printer that usually prints one line at a time at a higher speed than a character printer. Typical line printers use a drum, chain, or train of print elements and have a hammer for each print position in the line. They usually have a buffer to hold one print line. Line printers are segmented by technology (dot matrix, fully formed, thermal) and by speed, expressed in lines per minute (lpm).

linkage mechanism. An assembly of components, with two or more movable parts usually providing some means of power, control, or fastening application.

liquid crystal display (LCD). A high-contrast, black-on-white display screen that uses closely spaced crystal segments on a square dot matrix. The crystal segments butt together to form solid characters. A liquid crystal hermetically sealed between two glass plates.

list price. The price of a product as indicated in the seller's price book. This figure is usually quantity one and is synonymous with manufacturer's suggested retail price.

lithography. 1: A printing process that prints from a planographic image on a printing plate. Lithographic presses are configured as sheetfed and web presses, depending on the format of the paper used. 2: A technique used in semiconductor manufacturing in which a silicon wafer is coated uniformly with a radiation-sensitive film (the resist) and an exposing source illuminates selected areas of the wafer's surface through a mask or template for a particular design.

LNTT. See **line, nonimpact, thermal transfer.**

local area network (LAN). The hardware, software, and peripherals that enable connection of a device to a cable-based network system that serves a building or a campus environment. Excluded are connections that are point-to-point, or go through PBXs or data PBXs. Ethernet and Token-Ring are popular LAN technologies.

local government. The political unit or organization governing counties, municipalities, townships, school districts, and numerous kinds of special districts.

local loop. The portion of the telecommunications system that connects the customer's equipment with the local telephone company's network.

local telephone service. A service that includes message telecommunications services, private line services, wide-area telecommunications services (WATS), and centrex services.

logic circuit. 1: A circuit (usually electronic) that provides an input-output relationship corresponding to a Boolean-algebra logic function. 2: An electronic device or devices used to govern a particular sequence of operations in a given system. 3: Circuits that perform basic logic decisions *and/or/not*, used widely for arithmetic and computing functions. Circuits can be of either bipolar or MOS technology.

long distance telephone service. The revenue generated by all long distance carriers for interstate and intrastate long distance telephone services.

M

machining-center programmable machining tool. A machine that is designed to fabricate a complete or near complete part of a single machine, with machining centers that perform a number of different operations in a single setup.

machining robot system. A robot that can pick up parts and place them in a new location. Parts are usually moved in and out of machinery or transferred from station to station.

mag card/mag tape. A tape or card that is coated or impregnated with magnetic material, on which information may be stored in the form of coded polarized spots.

magnetic. The effects of magnetism/flux on the system.

magnetic disk. 1: A random-access storage device consisting of magnetically coated disks accessible to a reading and writing arm, similar to an automatic record player. Data are stored on the surface of each disk as small, magnetized spots arranged in circular tracks around the disk. The arm is moved mechanically to the desired disk and then to the desired track on that disk. 2: A flat, circular plate with a magnetic surface on which data can be stored by selective magnetization of portions of the flat surface.

magnetic ink recognition. Property of automatic devices that can detect or read ink-containing particles of magnetic substance, i.e., the ink used for printing on some bank checks for magnetic ink character recognition (MICR).

magnetic media. Any of a wide variety of belts, cards, disks, or tapes (as contrasted with paper tape) coated or impregnated with magnetic material for use with the appropriate equipment and on which dictation or keystrokes can be recorded and stored.

magnetic recording head. A magnetic head that transforms electric variations into magnetic variations for storage on a magnetic medium such as tape or disk.

magnetic resonance imaging. Equipment used on an object placed in a spatially varying magnetic field that is subjected to pulses of radiation; the resulting nuclear magnetic resonance spectra are combined to give cross-sectional images.

magnetic tape. A serial-access magnetic storage medium. Typically, a flat ribbon of metal, plastic, or paper that is coated on one side with material that can be magnetized; information is stored on the tape by a combination of magnetized spots in certain patterns. (See also **magnetic media.**)

mailing/letter-handling/addressing equipment. Mailing systems and equipment that have been automated with components to increase capabilities and to streamline efficiencies.

mail order. A sales method by which a consumer may order products through a catalog.

main distribution frame (MDF). A unit used in telephone wiring for terminating and cross-connecting telephone wiring to the telephone-switching system. The MDF is the primary (or first) distribution point. (See also **distribution frame.**)

mainframe computer. A general-purpose information system with price range of $350,000 and up. CPU bit width ranges from 32 to 64 bits. Physical environment can be either with or without special environmental controls and requires full-time support by professional computer systems support staff with 10 or more members. Number of concurrent users is 250 or more.

maintenance management. The upkeep of property, equipment, or tooling through planning, analysis, and documentation of maintenance functions.

management. An application that supports the management of data that can be achieved using document image management software and systems.

manufacturer. A producer or assembler of goods.

manufacturer's representative/agent. An independent contractor who represents multiple manufacturers. She or he does not take title to the product.

manufacturer's suggested retail price. See **list price.**

manufacturing automation. The use of a computer to aid and improve a manufacturing process.

manufacturing EATE N.E.C. Equipment that tests electronic systems that are composed of a number of subsystems. The testing equipment must verify operability and be capable of locating a faulty subsystem or component in event of failure.

manufacturing engineering tools. The small segment of manufacturing engineering that is concerned with tool and fixture design and the development of manufacturing processes.

manufacturing system. A system used to process raw material into a finished product.

mapping. Computer-aided tools that allow geographically related data to be captured, edited, analyzed, and managed. Typical users are civil and utility engineers, geophysicists, and geologists.

market. The demand for a product or service.

market share. A comparison of a company's performance with the total market so that its relative position and the amount of the market it captured is derived.

markup. 1: The amount added to the cost to determine the selling price for a specific product. 2: The amount added to the cost to determine the selling price for a specific product.

maskmaking e-beam. Semiconductor production equipment utilizing a method that allows submicron pattern generation for producing semiconductor mask plates or maskless lithography. (See also **lithography.**)

mask ROM. A semiconductor read-only memory programmed to the customer's specified pattern during the manufacturing process. (See **read-only memory.**)

mass merchandiser. A segment of the distribution channel with storefront locations. It differs from a dealer in that its primary business is the sale of a broad range of consumer goods.

mass property. The analysis of the physical characteristics of a part, assembly, or system. The evaluation of multiple properties—measures volume, weight, and surface area and locates center of gravity.

mass storage peripheral. A device that interfaces with the system or machine to external memory storage.

material. The designation of a number of basic metals, compounds, and gases to make up thermoelectric materials.

material-handling equipment and systems. Equipment such as 1: Movement—Automated guided vehicle systems, conveyors, and monorails;

cranes and lift trucks are included only when they are computer-controlled; material-handling robots are included in Robotics in Manufacturing. 2: Storage—Automated storage and retrieval systems; miniload, microload, and carousels. 3: Identification—Bar codes, radio frequency, machine vision, and other sensors used for identification are covered in Sensors in Manufacturing. 4: Controls—Computers, programmable controllers, and software used in material handling are included in Computers in Manufacturing and Software in Manufacturing.

material-handling/loading robot systems. Robotics used in the loading, moving, storage, and unloading of materials.

material requirement planning (MRP). A planning method that uses bills of material, inventory data, and a master production schedule to calculate material requirements. This method makes recommendations to restock materials inventory. Further, because material requirements planning is time-phased, this method makes recommendations to reschedule open orders when due dates and need dates are not in phase. Originally seen only as a better way to order inventory, material requirements planning is thought of today primarily as a scheduling technique, i.e., a method to establish and maintain valid due dates on orders.

matrix printer. An impact printer that uses wire, hammer-like bristles, or needles to create characters formed by small dots. Matrix printers produce either serial or line output. The serial printer employs a moving printhead with a matrix block (i.e., 5 x 7 or 7 x 9) of needles. The printhead sweeps across the page to print full characters one at a time. The line printer uses a horizontal band with raised dots that moves from left to right across the paper. The individual needles strike programmed character dots to form one row of dots per sweep across the page. Successive passes of the line printer form complete characters and complete rows of textual data. High-resolution text, comparable to daisywheel output, may be produced by overlapping matrix printers that print characters via a highly concentrated matrix or successive, staggered passes of the printhead. Fonts for matrix printers are stored in ROM or PROM memory.

MBE. See **molecular beam epitaxy deposition.**

MCAE. See **mechanical computer-aided engineering.**

MCU. See **microcontroller.**

MDF. See **main distribution frame.**

mechanical. Mechanical CAD/CAM is the software application of computer-aided tools to design, analyze, document, and manufacture discrete parts, components, and assemblies.

mechanical assembly equipment. 1: Machinery or equipment that assembles mechanical parts into subassemblies or final products. 2: Dial or rotary assembly machines; in-line transfer machines; flexible assembly equipment (except robots).

mechanical computer-aided engineering (MCAE). The application of CAD/CAM tools for mechanical design and analysis. MCAE applications range from conceptual product design through detailed product design and analysis to supporting production design. Commonly used MCAE products are solid modeling and finite element analysis technology.

mechanical computer-aided manufacturing. See **mechanical.**

media-to-media data conversion equipment. Computer output-to-microfilm recording units, tape print units, card-to-tape conversion units, as well as document entry devices.

medical. An environment or industry that uses computers to control and/or collect and analyze data from patients, medical equipment, and/or instruments.

memory. 1: A device into which data can be entered and stored for later retrieval. 2: An integrated current (IC) designed for the storage and retrieval of information in binary form; can be either bipolar or MOS technology and includes dynamic random-access memory (DRAM), static random-access memory (SRAM), read-only memory (ROM), programmable read-only memory (PROM), erasable programmable read-only memory (EPROM), and electrically erasable programmable read-only memory (EEPROM).

memory management unit (MMU). 1: An integrated circuit that manages the storage and retrieval of data found by cell location or address. 2: A component (or set of components) that implements the memory management function in a processor-based system.

merchant production. The sale of a good to a company other than the manufacturing company.

merger and acquisition. In financial terms, it means to absorb or acquire one company by another.

metalorganic CVD (MOCVD). A technique used to deposit material onto a wafer.

metal oxide silicon (MOS). 1: A circuit in which the active region is a metal oxide semiconductor sandwich. The oxide acts as the dielectric insulator between the metal and the semiconductor. 2: A process that results in a structure of metal over silicon oxide over silicon. 3: Technology that employs field effect transistors having a metal or conductive electrode that is insulated from the semiconductor material by an oxide layer of the substrate material.

meteorological instrument. An instrument used to monitor and observe the weather.

metropolitan statistical area. A large population nucleus, together with adjacent communities, that has a high degree of economic and social integration with that nucleus. Each metropolitan statistical area (MSA) must include at least: (a) one city with 50,000 or more inhabitants, or (b) a census bureau-defined urbanized area of at least 50,000 inhabitants and a total MSA population of at least 100,000 (75,000 in New England).

microcomponent. 1: An integrated circuit (IC) with high-speed, low-power density considered as a single part. 2: An IC that contains a processing unit or acts as an interface chip to such a device. Types of microdevices include microprocessor (MPU), microcontroller (MCU), microperipheral (MPR), and digital signal processor (DSP).

microcomputer. An information system with price ranging up to $100,000, with the majority priced at less than $50,000. CPU bit width is normally 32 bits, but can be as low as 8 bits. Traditionally used as a desk-side or desktop system configuration. Normally a multiuser system used in a common work area. Usually has a merchant (nonproprietary) microprocessor.

microcontroller (MCU). An integrated circuit, containing a CPU, memory, and I/O capability, that can perform the basic functions of a computer.

microperipheral (MPR). A support device or circuit for a microprocessor or microcontroller that either interfaces with external equipment or provides system support.

microprocessor (MPU). A single-chip component, or a collection of architecturally interdependent components, functioning as the central processing unit (CPU) in a system. A microprocessor may contain some input/output circuits, but it usually does not operate in a standalone environment.

microprogrammable digital signal processor (MPDSP). An integrated circuit that allows high-performance, modular DSP architectures to be designed using standard off-the-shelf components. Products include bit-slice and building block components.

microwave. 1: Any radio wave with a frequency higher than 890 MHz or a wavelength of between 1ml and 1m. 2: A form of electromagnetic radiation that has frequencies of 1 GHz. These high-frequency bands of energy are used extensively for radar and wideband communications.

microwave antenna. A device used for receiving and transmitting microwave signal beams. (See also **antenna.**)

microwave monolithic integrated circuit (MMIC). An electronic circuit employing monolithic integrated circuit technology fabricated by microelectronic techniques and capable of operating at frequencies above 1 GHz.

microwave oven. An oven that uses electron waves to produce heat for faster cooking of foods.

microwave radio equipment. Equipment that includes transmitter/receiver systems, power supplies, repeaters, and other equipment used in microwave radio systems. It also includes analog and digital equipment used both in common carrier and in private industrial systems.

midrange. The combination of microcomputer, minicomputer, and superminicomputer.

military/aerospace electronic equipment. Electronic equipment used in the military and civilian aerospace industries.

military communication equipment. Voice, data, and cryptographic equipment used for communication in the military.

military computer system. A computer system used for military purposes; a set of hardware components that form a system intended solely for military applications. This category includes general-purpose CPUs, storage, input/output, and terminals and includes both commercial, ruggedized, and mil'spec versions for integration into military systems and for government-sponsored programs.

military electronic equipment. Electronic equipment used exclusively by the military. Usually, this equipment must meet government specifications and regulations.

military simulation and training. The performance of military maneuvers/exercises as training for real-life military situations. This category includes flight and battle simulators and equipment operation and maintenance systems.

milling programmable machine tool. A machine tool for the removal of metal by feeding a workpiece through the periphery to remove the material through the motion of workpiece and cutter.

minicomputer. An information system with prices ranging from $10,000 to $300,000 but mainly falling between $25,000 and $150,000. CPU bit width ranges from 8 to 16. Minicomputers are situated usually in a common work area and occupy more floor space than most tower configurations. Number of concurrent users ranges from 15 to 100. System usually incorporates proprietary processor, with notable exceptions, and is often packaged with third-party application software and/or peripherals and then resold into specialized applications or vertical markets. Examples of models are the HP 1000, HP 3000/70, PDP-11/84, and IBM Series/1.

minicomputer-based terminal. A display terminal provided by a minicomputer manufacturer or a display terminal that is protocol-specific to an IBM System/34, /36, or /38 computer. This terminal may operate in either character or block mode. Excluded from this category is any minicomputer-compatible terminal supplied by an independent manufacturer.

miscellaneous military equipment. Equipment that includes classified systems, test equipment (N.E.C.), vehicle control, medical equipment, assorted development and office equipment, and research and development equipment; all used in the military.

mixed signal ASIC. An ASIC that has one analog input or output and one digital input or output.

mixed signal IC. An integrated circuit that has one analog input or output and one digital input or output.

MMIC. See **microwave monolithic integrated circuit.**

MMU. See **memory management unit.**

mobile communications equipment. Equipment (base stations, mobile units, and antenna) used primarily for portable public or private communications.

mobile infrastructure. The central base station and other central equipment that provide mobile communication services.

mobile radio base station equipment. The base/centralized station equipment associated with cellular radio systems. This category includes both switching equipment and radio transmitter/receiver equipment.

mobile radio service. Service or network revenue associated with cellular radio systems. (See also **mobile service.**)

mobile radio system equipment. Electronic equipment used in the transmission and receiving of radio signals. Equipment includes main central control, base control mobile stations, and handheld car units. Used primarily with cellular and other mobile communication technologies.

mobile service. Radio service between a fixed location and one or more mobile radio stations, or between mobile stations.

mobile telephone service (MTS). Radio communication between a mobile (portable) unit and the public switched network including cellular service.

modeling. An application that supports the representation of a process or system by using equations that simulate and represent behavior under varying conditions.

modem. 1: An electronic device that provides modulation and demodulation functions of transmitted data signals over telephone lines. They convert digital data signals to analog for transmission over leased lines or the analog public switched telephone network. 2: The integrated circuits used in a modem.

molecular beam epitaxy deposition (MBE). A technique used in semiconductor manufacturing to deposit a single crystal layer on a substrate by use of a molecular beam.

molecular engineering. See **computational chemistry/molecular engineering.**

money management. An application that identifies and controls the source, flow, location, and earning potential of an organization's cash and investments.

monitor. 1: To check the operation and performance of a system or circuit by examining parts of transmissions. 2: The physical CRT unit, associated electronics, and housing used in display systems. 3: A station or equipment arranged to supervise system operation. 4: To supervise and verify the correct operation of a system, device, or program. 5: The screen of a video display terminal. 6: An analog monitor can display an almost infinite number of colors, while a digital monitor can display a more limited range of colors.

monolithic analog integrated circuit. An analog IC constructed from a single piece of material. All circuit components are manufactured in or on top of a single crystal of semiconductor material.

MOS. See **metal oxide silicon.**

MOS application-specific IC. See **application-specific integrated circuit.**

MOS cell-based IC. See **cell-based integrated circuit.**

MOS custom IC. See **custom integrated circuit.**

MOS digital. A semiconductor technology in which the active devices are n-channel, p-channel, or complementary MOS transistors that operate in a digital or binary mode. (See also **digital.**)

MOS FPGA. See **field-programmable gate array.**

MOS gate array. See **gate array.**

MOS logic. See **logic circuit.**

MOS memory. See **memory.**

MOS microcomponent. See **microcomponent.**

MOS microcontroller. See **microcontroller.**

MOS microperipheral. See **microperipheral.**

MOS microprocessor. See **microprocessor.**

MOS nonvolatile memory. See **nonvolatile memory.**

MOS PLA. See **programmable logic array.**

MOS PLD. See **programmable logic device.**

MOS PMD. See **programmable multilevel logic device.**

MOS standard logic. See **standard logic.**

MOS transistor. A field-effect transistor (FET) with a gate that is insulated from the semiconductor substrate by a thin layer of silicon dioxide. Being field-effect transistors, MOS-FET provide a voltage-input-to-current-output relationship called transconductance. MOS-FET are excellent switches because voltage at the gate turns the output current on or off.

mouse. A hand-held device that is moved on a surface to provide coordinate input to a graphics system. It is used most often to position a pointer or cursor.

MPDSP. See **microprogrammable digital signal processing.**

MPR. See **microperipheral.**

MPU. See **microprocessor.**

MPU load programmer. A device that allows engineers and IC designers to program a variety of programmable devices (ICs), thereby speeding up the design process. The device to be programmed is loaded directly on the device programmer.

MTS. See ***mobile telephone service.***

multilingual publishing. A system with the purpose/use of printing in a variety of languages.

multimedia. A process that uses more than one form of communication.

multiplexer equipment. Public telecommunication equipment used to combine a number of channels for transmission over a common medium, such as satellite, microwave radio, cable carrier, or fiber-optic cable. Excluded from this are data-only customer premises multiplex equipment and multiplex equipment that is integral to carrier or microwave radio systems.

multistrike ribbon. A ribbon that advances only part of a character width; characters slightly overlay one another on the ribbon, but no character hits the exact same spot on the ribbon.

multiuser system. A computer system inherently designed for environments with multiple users.

N

natural resources and construction. An environment or industry that includes establishments primarily engaged in agricultural production, forestry, commercial fishing, hunting and trapping, and related services; and mining or quarrying, developing mines, or exploring for nonmetallic minerals except fuel. Also, certain well and brine operations and primary preparation plants, such as those engaged in crushing, grinding, washing, or other methods of concentration.

navigation, military. A process for directing ships, aircraft, spacecraft, and other crafts to a specific destination. Equipment determines position, distance, and course of vessel or craft.

n-channel metal oxide semiconductor (NMOS). Pertaining to MOS devices made on p-type silicon substrates in which the active carriers are electrons that flow between n-type source and drain contacts. The opposite of PMOS. NMOS is two to three times faster than PMOS. (See also **MOS.**)

net additions. 1: The change in stock, such as installed base or inventory. 2: The relative increase or decrease in the total installed base of a product.

NETVIEW. IBM network management product.

network management. A software application that controls the logical connections and information flow among computers on a network. This software may have additional functions such as performance measurement and diagnostic and accounting functions.

network support services. All services that help customers better utilize their networking facilities. The services include site planning, installation, and ongoing on-site and remote maintenance support, as well as professional services such as network design/planning, integration, administration, and operations management.

network terminating devices. Equipment that connects a data network to the data terminal.

new placement demand. The total end-user demand for new products (as compared with replacement products).

newspaper publishing. A system with the main purpose/use of printing newspapers; typically daily or weekly publication containing such elements as news, feature articles, and advertising.

nitrogen. A chemical element.

NMOS. See **n-channel metal oxide semiconductor.**

non-IBM, protocol-specific terminal. A terminal that is protocol-specific to a Burroughs, Honeywell, or Sperry mainframe computer. Included is any terminal of this type that connects to another computer by means of protocol emulation.

nonimpact printer. A hard-copy computer output device that forms images through electrostatic or other nonimpact methods. These printers include ink jet, laser, and thermal printers. (See also **ink jet printer.**)

nonvolatile memory. An integrated circuit using two-junction transistor technology where memory retains information when the power is off. Also known as core or permanent memory. Can be either bipolar or MOS technology process.

nonvolatile random-access memory (NVRAM). A read/write semiconductor memory device that does not lose information when the power is turned off.

notebook personal computer. The notebook personal computer is a system that resembles a laptop personal computer in general form factor and appearance. This personal computer is smaller and lighter in weight than a laptop D/C unit. The "standard" notebook size is 8.5 inches by 11 inches by 2 inches or less, and the weight of these units is in the 5- to 7-pound range. Notebook computers also, presently, make use of industry-storage mass storage media including 3.5-inch floppy disk.

nuclear radiation detection and monitoring instrument. An instrument used to detect, inspect, monitor, and control alpha particles (neutrons, protons, and electrons) that emanate from the atomic nucleus as a result of radioactivity and nuclear actions.

numerical control. 1: Computer instructions that automate machining and drafting tools. 2: A technique of simulating the operation of a machine tool. 3: Descriptive of systems in which digital computers are used for the control of operations, particularly of automatic machines. A technique of controlling a machine or process through the use of command instructions in coded numerical form.

numerical-control (NC) part programming. The programming of a numerical-control machine tool or automated processing system. Graphics and language-based programming tools are available.

NVRAM. See **nonvolatile random-access memory.**

O

OCR. See **optical character reader.**

OEM. See **original equipment manufacturer.**

office equipment. Equipment used in a business or office environment. Equipment may include copiers and duplicators, electronic calculators, dictating machines, electronic typewriters, word processors, banking systems, cash registers, and mail- and letter-handling equipment.

off-line robotics programming. A special-purpose process simulation that graphically represents the sequence of steps to program a robot for a particular operation. The resulting data can be downloaded to a robot to update its control program.

oil field services. A software application that uses small computers in the oil rigs or the wellhead areas to log and analyze data from sensors in the well.

OLTP. See **on-line transaction processing.**

one-time programmable read-only memory (OTP ROM). An EPROM packaged in plastic without a quartz window for erasure. Such a device is therefore programmable only once.

on-line transaction processing (OLTP). The input, tracking, and output of a well-defined record of information, processed in real time rather than batch. Examples include ATMs and airline reservations systems. OLTP systems are usually large and complicated enough that each one is customized, so there are few generic OLTP products. The RAMP-C and Debit-Credit benchmarks are examples of OLTP standards.

op amp. See **operational amplifier.**

open systems interconnection (OSI). A communication standard for network architecture that allows communication between various equipment.

operating environment. A set of conventions for screen appearance, keyboard, mouse and screen operations, and program functions. Operating environments function within an operating system.

operating system. 1: The software program in a computer that maps logical constructs to physical locations in the computer. The operating system is the program that lets a user access data by a file name without knowing where the file is physically located on the disk. 2: The operating system controls the computer's operations by managing disk, screen, file maintenance, and printer activity, while loading and running application programs.

operating utilities. A program or routine of general usefulness and applicable to many jobs or purposes.

operational amplifier (op amp). A type of integrated circuit (IC) that generates an amplified output that is exactly proportional to its input.

operator support system. Special equipment and/or software that facilitates the operation of a switchboard or comparable equipment.

optical CD/wafer inspection. Critical dimension (CD) refers to the line, element, or feature that must be manufactured and controlled to stringent specifications. Wafer inspection refers to the inspection of a patterned wafer for process defects by visual image process techniques.

optical character reader (OCR). 1: A device or scanner that can read printed or typed characters and convert them into a digital signal for input into a data or word processor. 2: The machine identification of printed characters through the use of light-sensitive devices; computer-input-only hardware.

optical disk controller. A device that controls the storage and retrieval of data from a video disk that is sensed through a laser beam.

optical disk drive. A data storage device utilizing laser technology. Types include CD-ROM, WORM, and erasable optical disk drives.

optical jukebox. A library system that holds multiple disk drives and optical disks to create a large storage environment on optical media.

optical media. The substance on which data are stored electronically and read by laser technology.

optical-scanning equipment. See **optical character reader.**

opto. See **optoelectronic.**

optocoupler. 1: A device that transmits electrical signals, without electrical connection, between a light source and a receiver. Also called an optoisolator. 2: A device that consists of an LED separated from a photo detector by a transparent, insulating, dielectric layer, all mounted in an opaque package. A current pulse in the LED causes a radiation pulse to flow across the dielectric layers to a photo detector, which produces a current pulse at the output. The input and output circuits are coupled with high-standoff voltage isolation.

optoelectronic (opto). A semiconductor device in which photons cause electron flow or vice versa. Optoelectronic chips contain transducers used between photonic circuit media and electronic media; they also may contain amplifiers, logic functions, and/or other photonic or electronic functions.

order entry and sales support. An application to support the process of accepting and translating what a customer wants into terms used by the manufacturer. This can be as simple as creating shipping documents for a finished goods product line to a more complicated series of activities including engineering effort for make-to-order products.

order entry/processing. Acceptance and translation of customer requirements into terms used by a manufacturer.

organization operation. A software application that supports the day-to-day running of an organization.

original equipment manufacturer (OEM). 1: An OEM may manufacture a product for assembly into another system or larger configuration by another manufacturer or vendor. 2: A purchaser of materials, components, or equipment to be incorporated into its product line. 3: A product reseller that integrates hardware, software, and/or services. The reseller may or may not own the hardware or software. An OEM differs from a VAR in that it adds its own label to the product and backs up its warranties.

OSI. See **open systems interconnection.**

OS/2. Computer systems based on the Intel 80XXX architecture and using OS/2 operating system software.

other. A subject or segment that is not distinctly defined within the Dataquest High-Technology Segmentation scheme.

OTP ROM. See **one-time programmable read-only memory.**

P

PABX. See **private automatic branch exchange.**

pacemaker. An electronically pulsed oscillator implanted in the body to deliver electric pulses to the heart at a fixed rate in response to a sensor that detects when a person's heart rate slows.

packet assembler/disassembler (PADS). A system element that buffers data sent to and from character-mode devices and assembles and disassembles the packets needed for X.25 operation.

packet data switching. Data network switches that connect terminals and packet assemblers/disassemblers to a pre-edit node using a high-speed link (56,000 bps). Can be public or private.

PADS. See **packet assembler/disassembler.**

page composition. Refers to the page composition software used to produce finished draft or camera-ready pages whereby text and graphics have been aesthetically laid out using an editable WYSIWYG display environment.

page, nonimpact, plain paper (PNPP). A printer with the ability to buffer, in part or in whole, a page of images received from an electronic source and then to transfer these images to a receiving substrate.

page printer. A printer that prints characters one at a time to full-page format. Page printers are rated by speed categories, expressed in pages per minute (ppm).

paging equipment. Communication equipment that produces an audio signal in a radio receiver carried by an individual to tell him that he is needed at the telephone. Communication system for summoning individuals or making public announcements.

paging system. The equipment necessary to selectively alert individuals by tone or voice paging, either by pocket radio receivers or speakers within a building.

painting robot system. A system consisting of a number of robots programmed to paint by carrying spray guns and applying a coating of material. Also known as finishing robot.

PAL. See **programmable array logic.**

panel-type instrument. 1: Switches, dials, and buttons that are mounted on an electronic unit that controls and monitors a system. 2: Electronic instrumentation devices mounted on a panel for a variety of equipment purposes.

paper. Sheets of fiber formed on a fine screen from a water suspension. There are hundreds of different types of paper based on weight, brightness, color, opacity, and coating.

particle accelerator. A device that accelerates electrically charged particles (protons, electrons) to high energies.

part process design. The design of the actual manufacturing process and sequence.

parts service. Spare hardware modules or components used in the repair and/or replacement of failed hardware units.

passive device. 1: An inert component that may control, but does not create or amplify, energy. 2: A device that exhibits no transistance. A component that does not provide rectification, amplification, or switching but reacts to voltage and current. 3: Pertaining to a general class of device that operates as signal power alone.

patient monitoring. Equipment used to monitor, control, and record data on activity concerning or affecting a patient's health.

pay phones. A telephone instrument located in a public location that accepts coins for operation.

payroll. A software application that supports an organization making payment to its employees for work performed.

PBX-private branch exchange. See **PBX telephone system.**

PBX telephone system. A telephone switching system on the customer premises that, by dialing an access code, permits a telephone to interface to the public telephone central exchange or office.

PC. See **personal computer system.**

PCB layout. Products that are used to create the layout of the traces and components to be placed on a printed circuit board.

p-channel metal oxide semiconductor (PMOS). An MOS device made on an n-type silicon substrate in which the active carriers are holes (p) flowing between p-type source and drain controls.

PC logic chipset. A semiconductor device (or set of devices) that integrates standard logic and controller functions onto a very large scale integration (VLSI) chip, resulting in a reduced component count on the PC motherboard.

PCN. See **personal communications network.**

pen-based personal computer. This is a new classification of portable computers for 1991. The general identifier for this class of machines is that they utilize a pen or stylus for data input and do not normally require a keyboard to operate. (Keyboard options are included in some of these models, but the system can be fully utilized without the inclusion of a keyboard.) Pen-based computers do not have to be able to run MS-DOS or applications that run under DOS. It is expected that there will be three or more operating systems utilized in this product: PenPoint by GO Corporation, Pen Windows by Microsoft, and others that have not been made public at the time of publication.

percent retirement. See **retirement.**

periodical publishing. A system with the main purpose/use of printing publications issued at intervals.

peripheral device. 1: Any instrument, device, or machine that enables a computer to communicate with the outside world, or areas in the operation of the computer. 2: Equipment that is connected to a computer but is not part of the computer. Examples include printers, terminals, and disk drives.

peripheral I/O management. 1: A program that interacts with the central processing unit (CPU) of a computer to communicate with devices beyond the CPU. The program interprets and responds to instructions from the CPU. 2: Information flows between the CPU and a unit of peripheral equipment.

personal communications network (PCN). A class of communications technology that allows communication with a mobile entity. Sample technologies include mobile radio, cellular, and paging services.

personal computer operating system. A personal computer operating system is a program that supervises and controls the operation of a personal computer.

personal computer system. A personal computer intended for use on the user's desk or work surface and not designed to be readily moved from place to place. Personal computers are those systems that include, as part of the basic system, a BIOS- or ROM-based software code that is designed to permit the use of the system with any of the existing personal computer operating systems.

personal electronics. Electronic equipment for personal use.

personal finance. A software application that records, processes, and reports on personal financial data, including personal banking, credit card management, and budgeting. These applications are suitable for small businesses as well as home use.

personnel management. A software application that supports an organization in managing its employees; may include many subapplications.

photoblank. A blank glass plate that is processed to become a photomask for use in semiconductor manufacturing.

photomask. A glass plate covered with an array of patterns, used to form circuit patterns on semiconductor wafers. Photomasks may be made of emulsion, chrome, iron oxide, silicon, or a number of other materials.

photoreceptor. The photoreceptor is the central element in an electrophotographic copier or nonimpact printer. The photoreceptor consists of two parts; a support or substrate, usually in the form of a drum or flexible belt, and a photoconductive coating consisting of one or more layers.

photoresist. The light-sensitive film spun onto semiconductor wafers and exposed using high-intensity light through a photomask.

photosensitive. Capable of emitting electrons when struck by light rays.

photosensitive plotter. A plotter that uses photosensitive properties to create an image.

photosensor. An optoelectronic semiconductor that responds to radiant energy. Examples are photodiodes and phototransistors.

physical property test, inspection, and measurement. An instrument designed to inspect and measure physical property.

physical vapor deposition (PVD). A process through which specific materials are physically layered on a wafer. Includes sputtering and evaporation.

pin diode. A diode made by diffusing the semiconductor with p-dopant from one side and n-dopant from the opposite side with the process so controlled that a thin or intrinsic region separates the n and p regions. (See also **power diode.**)

PLA. See **programmable logic array.**

placement. End-user consumption of a product that is either purchased, leased, or rented.

planning. An application that facilitates the quantitative aspects of business planning, such as modeling, budgeting, analysis, and forecasting.

plasma etchant. A highly ionized gas (plasma) in the manufacture of high-density semiconductors.

plastic-processing machinery. Numerically controlled machinery used for injection, structural foam, extrusion, blow molding, thermoforming, and reaction injection.

plastics. 1: A polymetric material of large molecular height that can be shaped by flow; usually refers to the final product. Examples include polyvinyl chloride, polyethylene, and urea formaldehyde. 2: Displaying or associated with plasticity.

PLC. See **programmable logic controller.**

PLD. See **programmable logic device.**

plotter. 1: A recorder that charts, in graph form, a dependent variable as a function of one or more variables with an automatically controlled pen or pencil. 2: Any (vector or raster) computer hardcopy devices that perform mainly graphics functions. These devices include pen plotters, electrostatic plotters, photographic and laser plotters, and ink jet plotters.

PMD. See **programmable multilevel logic device.**

PMOS. See **p-channel metal oxide semiconductor.**

PMR. See **private mobile radio.**

PMR. See **projection microradiography.**

PNPP. See **page, nonimpact, plain paper.**

point-of-sale terminal. A terminal device that operates as a cash register in addition to transmitting information.

polysilicon. A silicon layer grown on a wafer in a furnace.

population. The total of individuals occupying an area or making up a whole. A *de facto* population should include all persons physically present in a country (state, province, region, city, or town) or designated area at a reference date. A *de jure* population, by contrast, should include all usual residents of a given country or designated area, whether or not they are physically present at the reference date. By definition, therefore, a *de facto* total and a *de jure* total are not entirely comparable.

portable electronic measuring instrument. An electronic measuring instrument that can be carried or transported with ease.

portable radio receiver transmitter. A device for converting radio waves into perceptible signals.

portfolio management. A software application that allows investors to clarify, estimate, and control the sources of risk and return in their portfolio.

postsecondary education. The provision of formal instructional programs with a curriculum designed primarily for students who have completed the requirements for a high school diploma or equivalent.

potentiometer. A device for the measurement of an electromotive force by comparison with a known potential difference.

power diode rectifier. A diode is a two-terminal device that permits current flow in only one direction. This property is used in diodes and rectifiers to convert AC current to DC.

power grid control. See **power management.**

power IC. An analog integrated circuit that can control one or more amps of current, dissipate one or more watts of power, or is capable of operating with voltages exceeding 100 volts.

power management. A real-time application that monitors and controls power generation equipment and power line grids.

power supply. 1: A unit that supplies electrical power to another unit. 2: Energy source that provides power for operating electronic apparatus.

power train. The mechanism by which power is transmitted from the engine to other part of the vehicle that it drives. Examples include ignition, spark timing, fuel control, turbo control, emissions systems, voltage regulator, alternator, engine control, and diagnostics.

power transistor. 1: A transistor that dissipates power of one or more watts. 2: A transistor designed for high-current, high-voltage applications.

premises switching equipment. Voice equipment that provides switching or call-routing functions. Includes equipment such as PBX telephone system and key telephone system.

presentation graphics. 1: A software application with a principal function of formatting text or numeric data into specified formats for the presentation of ideas. This may include graphs, charts, and/or lists suitable for professional presentations. 2: An image written, printed, drawn, or engraved; an image outlined or set forth for commercial, professional, or industrial purposes.

print element. The mechanisms used in fully formed character printers and typewriters by which marks are made on the paper. The three types of print elements are printwheels, also known as daisywheels, golf balls, and thimbles.

printer. The unit that produces copy on paper—a typewriter or a line printer. Often connected to a CPU that transforms electronic data into hardcopy form. (See also **ink jet printer** and **line printer.**)

printer controller. 1: Within a printer, the device used to regulate, accelerate, decelerate, start, stop, reverse, or protect devices connected to an electric controller. 2: A device or instrument that holds a process or cartridge at a desired level. 3: Hardware and/or software, usually either printed circuit board- or diskette-based, that takes data streams from software and converts it to printer-specific commands. The controller may reside in a CPU; may be connected to the print engine by an interface cable, a diskette or chip set in the CPU or printer; or, as in most cases, may be a physical attachment to or integrated component of the printer itself.

printer controller board. See **printer controller.** (Except all devices are loaded onto a board.)

printer, impact. Family of printers that use direct impression impact of a typebar, type head, or matrix pin to exert pressure against a paper ribbon and a platen to create a character.

printer, nonimpact. A printer capable of imaging on a substrate without physically striking it; these include ink jet, laser, and thermal printers.

print system network. Hardware and software that is integrated to manage the information sent to one or a number of printers, usually shared by more than one user. The system may be as simple as a switch box connected to two CPUs and one printer, or as complex as a full local area network that controls print streams to many printers from multiple CPU systems and controls job-queuing management, printing error conditions, spooling, and rerouting.

printwheel. A print element for certain character printers. The characters are engraved at the end of spokes, the entire printwheel resembling a daisy. Also known as daisywheel.

private automatic branch exchange (PABX). One type of telephone switching system that is typically used in larger businesses. The PABX allows computer-like programming of incoming and outgoing calls to optimize network configurations and provide additional call management features.

private line. A telecommunications network connection for the exclusive use of one organization. (See also **leased circuit.**)

private mobile radio (PMR). See **cellular service.**

private packet data switching. A private packet data network switch connects terminals and packet assemblers/disassemblers to a packet node using a high-speed link (56,000 bps). (See also **packet data switching.**)

private school or institution. A school or institution that is controlled by an individual or agency other than a state, a subdivision of a state, or the federal government; usually supported primarily by funds other than public funds; and is operated by other than publicly elected or appointed officials.

process control, nonunified system. System-type instruments and related equipment for process control activated from standardized electrical transmission signals, in which control and signal conditioning are separated from the display and operator interface.

process control system. 1: Monitoring and maintaining the operation of plants that manufacture homogeneous materials such as oil, chemicals, and paper. Process control systems are capable of detecting errors in input variables and environment and taking corrective action. Closed-loop systems are self-correcting, and open-loop systems alert an operator. 2: A computer-based system that controls physical transformation and/or the mixing of products in a fluid state.

process control system, auxiliary station. Peripheral equipment of a process control system not in direct communication with the central processing unit or system.

process control system, controller. The controller describes that portion of a process control system that continuously measures the value of a variable quantity or condition and then automatically acts on the controlled equipment to correct any deviation from a desired present value.

process control system, indicator. A portion of the process control system that produces a diagram measuring the pressure volume changes in a running system.

process control system, industrial process computer. A computer that monitors the manipulations and changes of numerous conditions within a process control system automatically.

process control system, recorder. A portion of a process control system that makes a graphic or acoustic record of one or more variable quantities.

processing terminal. A display terminal that has local processing capability but is dependent on communication with a host, controller, or server to provide files and application programs. Such a terminal does not have a mass data storage device.

process manufacturing. 1: *Continuous process* produces a continuous stream of products, the units of which are not differentiated from one another (i.e., gasoline). 2: *Batch processing* produces product by reference to a recipe (i.e., bread).

processor. A device for handling information in a sequence of reasonable operations. Any device that can perform operations on data.

process planning and control. See **process control system.**

process simulation. The computerized simulation of the sequence and interdependencies of manufacturing processes. Also involves process modeling and includes NC part programming as a subset.

product. A good or service.

product category. A grouping of similar products.

production. The manufacture of goods.

production planning and control. Software used to plan for factory resources of a manufacturing company.

professional publishing. Systems dedicated exclusively to the job of publishing; typically, PC-based professional publishing systems focus on a single task or stage in the document production cycle, rather than managing the entire document production process.

professional services. A range of services including consulting on information technology, contract/custom programming, systems integration, facilities management, education, and ongoing maintenance.

programmable array logic (PAL). PAL is a trademark of Monolithic Memories, Inc. (now part of Advanced Micro Devices), referring to a family of logic devices that are customer programmable.

programmable logic array (PLA). 1: A form of programmable logic device containing a structured, partially interconnected set of gates and inverters that are fuse programmed by the user. Can be manufactured in bipolar or MOS technology.

programmable logic controller (PLC). A device or transmission control unit in which hardwired functions have been replaced with software or microcode. A programmable controller enables a user to add, change, or tailor computer capacities to the user's needs; programmable solid-state devices that replace mechanical relays for controlling sequential operations, timing, counting, and similar simple control actions. Where the capabilities exist as a function of the PLC, this definition includes more sophisticated tasks such as mathematical computations, data acquisitions, reporting, and process equipment control.

programmable logic device (PLD). A type of application-specific integrated circuit (ASIC) that is user programmable (after assembly) rather than mask programmable. The function of a PLD is determined by blowing fuse links or programming memory devices to create the desired interconnections between the fixed logic elements on the device. Can be either a bipolar or MOS technology. (See also **programmable logic array.**)

programmable machine tool. Numerical control (NC), computer numerical control (CNC), direct numerical control (DNC), and flexible machining centers used for metal cutting and metal forming.

programmable multilevel logic device (PMD). A semiconductor that can be manufactured by a bipolar or MOS technology process. The device, evolved from the basic programmable logic array (PLA), incorporates architectures to implement complex logic functions efficiently. PMDs can implement multiple levels of logic without sacrificing input/output or I/O cells or pins.

programmable read-only memory (PROM). A nonvolatile fuse-programmable solid-state memory circuit that is programmable only once, with special equipment. It is a programmed ROM that may be programmed after manufacture by blowing fuse links or shorting base-emitter junctions. PROMs provide high-speed access to frequently needed data and instructions. They allow a vendor company to customize a system before delivery to the user.

projection/aligner. Wafer fabrication lithography equipment that uses mirrors instead of lenses. The wafer and mask are separated by distance, not allowing the entire wafer to be exposed. This process lines up two or more layers of a wafer so that the components of one layer are compatible with the components of the other layer. (See also **lithography.**)

projection microradiography (PMR). An electron beam is focused onto an extremely fine pencil, generating a point source of x-rays; enlargement is achieved by placing the sample very near this source and several centimeters from the recording material.

project management. A software application that supports the ordering of activities across time. This application assists in planning and implementing projects by providing tools for forecasting requirements, projecting costs, and providing other charting and analysis features.

PROM. See **programmable read-only memory.**

prosthetic medical equipment. Equipment used in the surgical and dental specialties concerned with the artificial replacement of missing body parts.

protocol. A set of rules (not a program) for software programs to conform with in data communications. A program that reacts properly to data sent to it in a form that does not conflict with these rules and that sends data in conformance with these rules is said to support, or be in compliance with, the particular protocol. An example of a protocol is the one used by humans over two-way radio: the protocol is that one person finishes speaking by saying "over"; the other party then speaks, until finished and says "over"; the end of transmission is signalled by saying "over and out." Examples of protocols in data communications are BSC (IBM) and T201 (Tymnet).

protocol converter. Equipment that converts data from one format (protocol) to another. (See also **gateway.**)

proximity/contact aligner. Equipment that places a mask in direct contact with the wafer after the mask is aligned. With proximity, the mask does not come into direct contact with the wafer. (See also **lithography.**)

PTT. Postal, telegraph, and telephone organization. An organization that provides basic telecommunications services. For U.S., see regional bell operating companies.

public data network service. A packet-switched or circuit-switched network service available for public use. It includes the equipment and service charges associated with data communications networks that are offered to the general public. These networks connect user terminals and computers to the network and may offer enhanced or value-added services, such as conversion of speeds, codes, protocols, electronic mail, or facsimile.

public packet data switching. See **packet data switching.**

public school or institution. A school or institution controlled and operated by publicly elected or appointed officials and deriving its primary support from public funds.

public switching equipment. Equipment used in public telecommunications to switch or route voice and data calls. This segment includes equipment such as digital central office switching equipment and digital access cross-connect systems.

public telecommunications equipment. Equipment that includes public network services and equipment. It includes the various voice and data communications services provided by common carriers and the transmission and switching equipment used to implement these networks.

public telecommunications service. A service provided by public telecommunications carriers. It includes services such as local telephone, long distance telephone, international telephone, leased circuit, public data network, enhanced network, and mobile communications.

public transmission equipment. The equipment used in public telecommunications to transmit voice and data signals. It includes equipment such as multiplex equipment, carrier equipment, microwave radio equipment, and satellite earth state equipment.

publishing. 1: The business or profession of the commercial production and issuance of literature and information. 2: Computer-aided systems to automate the creation and printing of documents.

punch/shear/bend programmable machine tool. Describes the action that occurs to a composite or material, generally metal, on a machine. Punching literally punches a hole in the material, shearing cuts the material, and bending forms the material to a specified predetermined shape. These three activities are performed on three separate machines.

purchasing. A software application that has computer-assisted generation or procurement documents specifying materials, quantities, and delivery times.

purchasing and vendor management. Contains statements as to the quantity, description, and price of the goods; agreed terms as to payments, discounts, date of performance, and transportation.

PVD. See **physical vapor deposition.**

PW—private wire leased circuits. See **private line.**

Q

QC. See **quality control.**

QC analysis. Quality control analysis is generally performed throughout the manufacturing process, comparing the actual part shape or feature size to the design specification.

quality. The measure of how well a product or service meets customer expectations. Alternately, the ability to produce consistently a product or service within control limits or well-defined specifications.

quality assurance. The establishment and execution of procedures to measure product quality and adherence to acceptance criteria.

quality control. Process by which product is measured to ensure conformance to specification and standards.

query language. A generalized computer language that is used to interrogate a database.

R

R&D. See **research and development.**

radar. A radio device used to locate objects by frequency waves reflected off the object and received by the sender, allowing the sender to determine characteristics of an object. Includes airborne, shipboard, and ground search, flight control acquisition, detection, tracking, and associated test systems.

radio. 1: The use of electronic waves/signals to produce sound. 2: Home radio receivers including AM, AM-FM, and FM radios that are classified as table models, clock models, and portable radios. This category does not include high-fidelity receivers, radio-phonograph combinations, and television receivers, nor does it include automobile radios, stereos, or tape players.

railroad control. An application that monitors and controls railroad and urban rapid transit traffic.

RAM. See **random-access memory.**

random-access memory (RAM). An integrated circuit permitting read-and-write access to any memory cell or address in a completely random sequence. Can be of either bipolar or MOS technology process. A memory device with the qualities of allowing arbitrary reading or writing of a desired data location. The system accesses the addressed material without reading through intervening data. Information may be retrieved more speedily from RAM than from serial media, such as tape. Also called read-and-write and scratchpad memory.

rapid thermal processing (RTP). Process that uses machines of low temperature for contact alloying and systems for the deposition of thin gate oxides. Similar to the diffusion furnace.

RBOC. See **regional bell operating company.**

reactant gas. Molecules that act upon one another to produce a new set of molecules.

read-only memory (ROM). 1: Computer memory that can be read from but not written to. Permanent memory on chips wherein information can be retrieved but not stored. Memory is not lost when the power to the computer system is turned off. 2: A memory device the contents of which can be read but not altered. (See also **mask ROM.**)

real estate. An environment or industry that includes owners, lessors, lessees, buyers, sellers, agents, and developers of real estate.

real-time clock. A clock that indicates actual time, such as elapsed time, as opposed to a fictitious time established by a program.

real-time data acquisition and control. 1: The process by which events in the real world are translated to machine-readable signals. 2: Automated systems in which sensors of one type or another are attached to machinery. 3: Data processing is performed so that the results are available in time to influence the controlled or monitored system.

reconnaissance. Equipment used to secure data/information about activity and resources concerning an enemy or potential enemy's territory.

reduced-instruction-set computing microprocessor (RISC MPU). The number of instructions a microprocessor runs for a specific application are reduced from a general-purpose complex-instruction-set computing (CISC) microprocessor to create a more efficient computing engine.

reel-to-reel tape drive. A tape format in which the running tape is wound onto a separate take-up reel. Also known as open reel.

regional bell operating company (RBOC). Seven holding companies formed by the divestiture of AT&T to provide regulated and nonregulated telecommunications services in the United States.

relational database management system. A software application for the storage, retrieval, update, and analysis of multiple databases. These databases are linked (related) through one or more identical fields, called keys.

relay. 1: An electronic or electromechanical device for transferring a signal from one electrical circuit to another. 2: To forward a message through an intermediate station. (See also **passive device.**)

remote batch. A method.of entering jobs into the computer from a remote terminal.

remote control. Any system of control performed from a distance. The control signal may be conveyed by intervening wires, sounds, light, or radio signals.

remote processing. A procedure in which the operating system can be used to process messages received from remote locations via telephone lines and telephone equipment. In effect, it is an extension of the data processing and programming facilities of the computer to remote locations.

remote sensing. The acquisition of information (usually in the form of an image) about an object or area by recording electromagnetic radiation emanating from or reflected from the target. The electromagnetic energy is received and processed by a detector system that is not in physical contact with the target under study. Common platforms for detector systems are aircraft and satellites, but the definition is not restricted to these two.

removable media disk drive. Removable media rigid disk drive has the platter enclosed in a housing that is designed to be user-accessible.

replacement demand. The subsequent demand by end users for new equipment.

research and development (R&D). Basic and applied research directed toward the discovery, invention, design, or development of new products and processes.

research supercomputer. An information system defined by a minimum of 32 low-performance computing nodes. Optimized to run highly parallel applications. Price ranges between $300,000 and $2 million.

residual value. The value of a product at the end of its useful life. Typically used with depreciation and leasing calculations.

resistor. A passive device that measurably opposes the passage of an electric current (e.g., doped silicon). (See also **passive device.**)

respiratory analysis. Equipment used to examine, detect, and analyze the respiratory system.

retail trade. An environment or industry that includes establishments engaged in selling merchandise for personal or household consumption and rendering services incidental to the sale of the goods. In general, retail establishments are classified by kind of business according to the principal lines of commodities sold.

retirement. The number of products that are removed from use. A product is considered retired from the installed base if it is scrapped, returned to the manufacturer, or placed in storage.

return. The number of units previously sold outright that have been returned or retired by the customer. (See also **retirement.**)

revenue. The amount of money that a company receives from its customers for goods and services.

rewritable optical disk drive. An optical disk drive that uses removable media that can be erased and reused many times (also called erasable optical disk drive).

ribbon. A strip of inked material or fabric, which when struck with a print element forms a character on paper. (See also **single-strike ribbon, web ribbon, film ribbon, multistrike ribbon.**)

rigid disk. See **rigid disk computer storage media.**

rigid disk computer storage media. A rigid disk has a nonflexible substrate and can be made of aluminum, plastic, glass, or other rigid material.

RISC MPU. See **reduced-instruction-set computing microprocessor.**

robot. A reprogrammable multifunctional manipulator designed to move objects through variable motions for the performance of a variety of tasks. Intelligent robots commonly rely on vision systems to control their behavior through their ability to recognize objects.

robotic electronic assembly. Electronic manipulative machines that can perform functions ordinarily ascribed to humans in the assembly of material.

robotic nonelectric assembly. Same as robotic electronic assembly except that robots are mechanically maneuvered rather than through the methods and principles of electronics.

robot programming and simulation. The use of computer-controlled manipulators or arms to automate a variety of manufacturing processes such as welding, material handling, painting, and assembly.

robot system. Programmable manipulative machines that can perform functions ordinarily ascribed to humans. Included are robotic mechanisms, control hardware and software, and all associated peripheral equipment. These peripherals include end effectors and grippers that are used for the processing of parts, tools, and assemblies within the factory.

ROM. See **read-only memory.**

routing. An application that supports route planning. It is used to schedule the sequence of stops a transport vehicle makes.

RTP. See **rapid thermal processing.**

S

safety and convenience. Equipment related to the automobile and truck industry including devices that prevent loss, hurt, or injury, or that lend ease and comfort to passengers. Examples include: climate control, light reminder, keyless entry, heated windshield, sensing wipers, automatic door lock, automatic headlights, dimming, rear window defogger, antiskid braking, window control, and airbags/restraint control.

satellite. 1: A specialized radio transmitter/receiver placed in orbit around the earth to provide transmission channels for information to be transmitted over great distances. 2: A celestial body orbiting another of larger size.

satellite communication equipment. Equipment used for communication by use of an active or passive satellite to extend the range of a radio, or other transmitter, by returning signals to earth from an orbiting satellite.

satellite earth station equipment. The total earth-based equipment used in connection with orbiting, geostationary satellites. This category includes the Very Small Aperture Terminals (VSAT), as well as the antennae and electronic transmitting/receiving terminals.

scanner. Input devices used for the optical sensing of images and text and/or graphics for conversion to dot patterns for incorporation into a document. This category includes both ICR and OCR scanners with a resolution of less than 400 dpi.

scheduling. An application that supports the scheduling of events.

schematic. This is a detailed diagram. In a mechanical application, schematics are used to describe hydraulic and pneumatic systems. A set of symbols are available for both applications representing standard components.

scholarships and fellowships. College expenditures applying only to money given in the form of outright grants and trainee stipends to individuals enrolled in formal coursework, either for credit or not. Aid to students in the form of tuition or fee remissions is included. College work-study funds are excluded from this category and are reported under the program in which the student is working.

Schottky TTL (STTL). A form of transistor-transistor logic using Schottky diodes as transistor clamps to increase the speed of circuit operation. A high-speed form of bipolar logic.

scientific application. A diverse group of software applications covering varied subject matter and research on the natural sciences when these are concerned with the physical world and its phenomena. Applications are divided into two subcategories: general analysis and scientific research. General analysis is the use of computers to solve various technical problems and to further research on subjects; this use is generally mathematical in nature. Scientific research applications are used specifically in the following fields: thermonuclear chemistry, nuclear physics, general physics, mechanical sciences, electronics research, geophysics, fluid dynamics, thermodynamics, materials research, and genetic engineering.

scientific research. A software application that pertains to research and development, not to applied science.

scientific visualization. An image computer is used for scientific modeling, technical data analysis, medical imaging, or similar large-volume data analysis.

security. 1: The existence and enforcement of techniques that restrict access to data and the conditions under which data can be obtained. 2: A measure taken by a command to protect a system from espionage, observation, sabotage, annoyance, or surprise. 3: Protection of a system by use of commands and codes.

security/energy management. Safety and power management within industrial equipment and manufacturing.

seismic analysis. 1: Seismic analysis helps support exploration activities by indicating favorable conditions for finding oil or coal reservoirs. 2: Analysis relating to an earth vibration caused by earthquakes, or other natural phenomena.

semiconductor. 1: A group of materials that are electrical nonconductors in a pure state that can be altered by the selective introduction of impurities into its crystalline structure. Its resistivity can sometimes be changed by light, an electric field, or a magnetic field. 2: An electronic device made using semiconductor material.

semiconductor tester. Equipment designed to test, check, and monitor the functionality of electronic circuit packages of varying complexity and functionality.

serial, impact, dot matrix (SIDM). A printer that creates a character image by selectively placing individual dots on the substrate using mechanical force.

serial, impact, fully formed (SIFF). A printer that prints one character at a time using type elements to create fully formed character impressions.

serial input/output (SIO). 1: A device that permits data to be transmitted into and out of a computer over a single conductor one bit at a time. 2: Pertaining to time sequential transmission of, storage of, or logical operations on parts of data words. 3: A technique for handling binary data words (which have more than one bit). 4: A device or technique where data are transferred to or from an I/O port in a serial or in-line manner.

serial, nonimpact, direct thermal (SNDT). A printer that creates the desired image a dot at a time using point-specific heat and a heat-sensitive substrate that changes color when exposed to heat.

serial, nonimpact, ink jet (SNIJ). A printer that creates the desired image a character at a time by emitting ink from an array of orifices or nozzles.

serial nonimpact, thermal transfer (SNTT). A printer that creates the desired image a dot at a time using point-specific heat to transfer ink from a ribbon to a receiving substrate.

server. A processor that provides a specific service to a network, such as connecting nodes of different networks.

services. Intangible items of trade, such as education, transportation, banking, and legal and medical care.

SFDSP. See **special-function DSP products.**

sheet feeder. A sheet feeder is mounted on top of a printer and automatically inserts cut sheets into the printer and receives the ejected paper in a hopper. Sheet feeders may be single or dual tray for the feeding of letterhead and second sheets, or they may incorporate an envelope-feed tray for the printing of letters and envelopes simultaneously.

shipment. The number of products delivered.

shop floor and cell control. A system for utilizing data from the shop floor as well as data-processing files to maintain and communicate status information on shop orders and work centers. Provides actual output data for capacity control purposes.

shop floor planning and control. See **shop floor and cell control.**

SIDM. See **serial, impact, dot matrix.**

SIFF. See **serial, impact, fully formed.**

silicon epitaxy deposition. A process through which vaporized silicon is deposited on a wafer. (See also **deposition.**)

silicon precursor gas. A specialty gas used in semiconductor manufacturing. Gases such as silane, dichlorosilane, trichlorosilane, and silicon tetrachloride are used in epitaxial and chemical vapor deposition (CVD) processes to deposit layers of silicon or silicon components onto silicon substrates.

silicon wafer. A nonmetallic element that is the most widely used semiconductor material today. Silicon is used in its crystalline form as the substrate of semiconductor devices.

simulation. An application or system that uses representative or artificial data to reproduce various conditions in a model that are likely to occur in the actual performance of a system. Simulation frequently is used to test the behavior of a system under different operating policies.

simulation and training equipment. Equipment used to augment the acting out of real-life maneuvers/exercises as training in preparation for real-life situations. Equipment includes aircraft, flight and situation simulators, equipment operation, and maintenance systems.

single-strike ribbon. A film ribbon. Each time a character strikes the ribbon, the ribbon advances far enough so that the next character has a completely new ribbon area to strike. The ink formulation is such that the ink on the ribbon is depleted from the area where the print element strikes the ribbon. These ribbons produce the highest print quality, but ribbon life is low compared with that of fabric and multistrike ribbons.

single-user enhanced system. See **workstation computer.**

SIO. See **serial input/output.**

slow SRAM. A random-access memory (RAM) integrated circuit (IC) that runs at speeds greater than 70 nanoseconds. (See also **static random-access memory.**)

small-format pen plotter. A computer plotter that uses engineering-size A (8.5 x 11 inches) or B (11 x 17 inches), architectural-size 1 (9 x 12 inches) or 2 (12 x 18 inches), or metric-size A4 (21 x 29.7 centimeters) or A3 (29.7 x 42 centimeters) media. (See also **plotter.**)

small-signal diode. A diode with a forward current of less than 100 milliamperes (0.1 amperes). The sides of the silicon chip are metallized and encapsulated in a tubular glass package.

small-signal transistor. A transistor that dissipates power of less than 1 watt.

smart card. A credit card or credit-card-size device that contains one or more integrated circuits. These devices usually are carried by an individual. Common applications include financial transactions, record keeping, and user identification.

smart interactive terminal. See **intelligent terminal.**

smart power. An integrated circuit (IC) that contains both control logic circuits and power control elements.

smoke alarm. A detector that is activated automatically when exposed to smoke.

SNA. See **system network architecture.**

SNDT. See **serial, nonimpact, direct thermal.**

SNIJ. See **serial, nonimpact, ink jet.**

SNTT. See **serial, nonimpact, thermal transfer.**

socket. An opening that supports and electrically connects to vacuum tubes, bulbs, or other devices or components when they are inserted into it.

software. 1: Any set of explicit procedures constituting a computer program. 2: Programs, procedures, rules, and any associated documentation pertaining to computer operations.

software support service. Activities that assist the end user in use and implementation of software products. Software support includes bug fixing, updates, and documentation, as well as support of ongoing operating problems including product-specific consulting, programming services, and training.

solar cell. A pn junction device that converts the radiant energy of sunlight directly and efficiently into electrical energy.

solid modeling. An application that represents the external and internal part geometries, allowing the solid nature of an object to be represented in a computer. Solid models are constructed in two ways: using primitive building blocks (constructive solid geometry) and/or using boundary definitions (boundary representation).

solid state. Pertaining to circuits and components using semiconductors. (See also **semiconductor.**)

solid-state subsystem. Computer memory products that comprise a block of semiconductor memory, a controller/formatter for it, a power source or access to power, a host bus interface, hardware, and software. These include modules external to the computer and kits for installation inside computers.

sonar. A device used to detect submerged objects by sonar waves reflected off the object. Also can be used to measure depth or distance. Includes search, detection, tracking, guidance, navigation, communication, sonabuoys, and associated test systems.

SONET. See **synchronous optical network.**

space military equipment. Military equipment used beyond the earth's atmosphere. Includes satellites with accompanying communication and reconnaissance equipment, various other space platforms, launch vehicles, and ground control.

special automotive IC. An analog IC designed for a specific automotive application.

special consumer IC. An analog IC designed for use solely in consumer home entertainment and appliance products.

special-function analog IC. An analog integrated circuit function used in specialized applications. Examples are sensors, timers, and oscillators. These devices differ from application-specific standard products (ASSPs) in being functional blocks rather than complex configurations of functions for specific applications.

special-function DSP products (SFDSP). Products built using DSP techniques and architectures but designed for specific functions. Examples include: modems, codecs, speech processors, digital television circuits, digital filters, and fast Fourier transform (FFT) chips. Generally, these devices cannot be programmed by users to perform operations other than their defined function.

special-function IC. A linear IC that does not fall into the standard product categories. This product has a specific function such as timer, oscillator, signal generator, or sensor but is not limited to a single application or market.

special-purpose computer system. A computer system designed for a specific purpose. For example: a banking computer system, word processor, or cash register.

specialty gas. A gas used in manufacturing semiconductors that is supplied in gas cylinders rather than in bulk because smaller volumes are used.

splice. A joint used to connect two lengths of conductor with good mechanical strength and good conductivity. (See also **passive device.**)

spot-welding robot system. A robot carries a resistance welding gun to produce welds.

spreadsheet. An application with the principal function of organizing data into columns and rows to allow the user to perform numerical analysis.

SRAM. See **static random-access memory.**

standard cell. An integrated circuit designed to a customer's specifications using precharacterized cells as building blocks.

standard logic. Off-the-shelf integrated circuits belonging to "families." Bipolar digital families include AS, FAST, LS, and ALS. MOS digital families include HC, HCT, and FACT. Standard logic is available from a number of suppliers and may be used in many different applications. Sometimes referred to as glue logic. Normally has less than 150 logic gates.

start-stop tape drive. A tape drive that starts and stops on reading or writing a data record.

state government. One of the constituent units of a nation having a federal government.

static random-access memory (SRAM). A RAM that maintains memory as long as power is applied and does not require refreshing. SRAM densities can range from 1K, with approximately 1,000 bits, to 4Mb, with approximately 4 million bits.

statistical multiplexer. An electronic device that consolidates several data streams onto a single high-speed bit stream for transmission over a telephone line.

stepper. A semiconductor manufacturing device that uses a step-and-repeat process to transform the pattern image of a reticle or mask onto the surface of the semiconductor wafer.

stereo headphone. A device worn on the head that permits the transmission of sound through two earphones connected by a band.

stereo (hi-fi) component. Equipment that produces high-fidelity reproduction of sound.

storage controller board. 1: A board containing input data or parameters for an application of a general routine. 2: Those parts mounted on a board that carry out the instructions in proper sequence, interpret each instruction, and apply the proper signal.

storage management. Functions that manage the storage of information in which information can later be retrieved. Includes storage protection, storage temperature, storage print, and storage allocation.

storage subsystem. Computer memory product that comprises a storage device(s), a controller/formatter for it, a power source or access to power, a host bus interface, hardware, and software. These include modules external to the computer and kits for installation inside computers.

streamer tape drive. A tape drive that uses a continuously moving tape; one that does not start and stop on each data record.

streaming tape drive. Tape drives (1/4-inch and 1/2-inch width) where the data stream over the head without stopping (continuous flow).

structural. The dynamics of the physical system; usually refers to the static stability/integrity of a part, assembly, or system.

structural modeling/analysis. A software application for modeling and analysis of the integrity of a structure.

STTL. See **Schottky TTL.**

studio transmitter link. Equipment used to generate and amplify a radio signal.

styling. A detailed design process where aesthetic considerations are foremost. Systems supporting this application have special refinements for rendering, modeling, and editing functions.

subsidiary. A company partially or wholly owned by another company.

supercomputer. A high-performance computer designed for numerically intensive applications. The current price ranges from approximately $100,000 to $20 million.

superminicomputer. An information system with price ranging typically from $100,000 to $1 million, with a minority below $100,000. CPU bit width ranges from 32 to 48 bits, with emphasis on 32. Environment is almost exclusively an ordinary office with no special environmental controls. Equipment typically is supported full-time by a professional computer systems support staff of fewer than 10 members. It usually is built around proprietary processor and typically supports from 32 to 350 concurrent users. Examples of models are the HP 3000/930 and 950, DEC VAX 8700 and Micro VAX 3500, and IBM 9370.

superworkstation. A superworkstation has higher graphics performance than a traditional workstation. It also has a higher processing performance rating to support graphic computations. The average price is $40,000 to $80,000 with performance ratings of 8 to 20 mips and 2 to 16 mflops.

surgical support. Equipment relating to, or having connection with, surgery.

surveying and drafting instrument. An instrument used to detect, access, and measure radiation. The instrument is used in the drawing of objects, structures, or systems by engineers and scientists.

switch. 1: A mechanical or electrical device that competes with or breaks the pattern of a current or sends it over a different path. 2: A device that connects, disconnects, or transfers one or more circuits and is not designated as a controller, relay, or control valve. (See also **passive device.**)

switch/multiplexer IC. Analog switches gate analog signals under the control of logic. Multiplexers are specialized analog switches that select only one of many inputs.

synchronous optical network (SONET). An emerging standard for optical networks.

system management. The administration and operation of a computer system including staffing, scheduling, equipment, and service contract administration, equipment utilization practices, and time-sharing.

system network architecture (SNA). An IBM standard for data communication.

systems integration service. The implementation phase of tying together dissimilar devices. Services are coordinated by a single contractor who manages the procurement, installation, integration, and support of all software, hardware, and communications devices.

systems integrator. See **value-added reseller.**

system software. Software that provides support structure in which applications may operate. This includes operating systems, operating environments, and utilities.

systems planning and design. "Front-end" consulting services that are required to determine the nature of a customer's needs and the actions necessary to meet those requirements.

system subroutine library. An organized collection of computer programs that is maintained online with a computer system by being held on a secondary storage device and is managed by the operating system.

system support peripheral. An integrated circuit (IC) considered a traditional peripheral, where each processor has a set of six to eight dedicated peripherals that provide rudimentary functions necessary to construct a microprocessor (MPU)-based system. (See also **traditional peripheral.**)

system utilities. Products that aid in the maintenance and/or repair of computer hardware, operating systems, or data recovery.

T

2-D modeling. The representation of a part in two dimensions (has an x and y coordinate). This format requires three or more views (top, front, side) to depict all aspects of the part. This is the most common geometric modeling format and is used extensively with a drafting function.

3-D modeling. The representation of a part in three dimensions, usually in a wire-frame format (has an x, y, and z coordinate). This format is used commonly in high-level CAD systems to determine the placement and fit of components in an assembly. This format is not generally used for final drafting, although some systems have the capability to translate the 3-D image to a 2-D standard drafting format.

T-1. A high-speed, time-division, digital network link operating at 1.544 Mbps and above.

T-1 multiplexer. A unit that allows multiplexing, or combining, several voice and/or data channels onto one communications link, in this case, a high-speed T-1 channel.

tape drive. A class of computer backup device that uses reel-to-reel, cartridge, or cassette tapes as media.

tape recorder. A device that records and plays sound from magnetic tape.

tax accounting. An application concerned with keeping records for tax purposes, setting up accounts for paying taxes, making tax computations, and preparing tax returns.

TDM. See **time-division multiplexer.**

teaching machine and aid. Equipment designed to assist in the training, educating, and instructing of persons to acquire knowledge or skill in a particular field(s) of interest.

technical data analysis. An application that analyzes technical or experimental data. The data may have been generated from instruments, captured from other electronic measuring devices (such as thermocouples or strain gauges), or generated by other analysis programs.

technical illustration. A drawing of a component or assembly that generally is intended for publication. This drawing will omit unnecessary dimensions and other detailed drating items and will be drawn so as to depict the part realistically.

technical productivity. An application that enhances the productivity of technical disciplines and is specialized for the engineering, scientific, or manufacturing fields.

technical publishing. The printing of user manuals or guides.

telecommunication integrated circuit (IC). An analog IC designed for the voice and data communication market.

telecommunications. Products and services that provide or manage the flow of information from person to person, person to machine, machine to person, or machine to machine. The telecommunications market is segmented into a combination of the premises and public telecommunications market segments.

telecom services. Includes that portion of telecommunications charges related to access and use of the public network. These charges typically are seen as a monthly usage charge for local, long distance, and private line access/utilization.

teleconferencing. Equipment and services related to one-way and two-way video communications that use specialized video equipment and/or transmission networks. These communications enable conferencing between locations.

telemarketing. A sales method that employs a sales force to move a product through the distribution channel by contacting the consumer via the telephone. Also referred to as inside sales.

telemetering system. See **telemetry.**

telemetry. Transmission of data from remote measuring instruments by electrical or, usually, radio means.

telephone. A terminal or handset used for voice and data transmission and communications. It functions as an interface between a user and a telephone switching system.

TELeprinter EXchange (TELEX). A worldwide dial-up telegraph service enabling users to communicate directly and temporarily among themselves by means of start-stop apparatus and circuits of the public telegraph network.

teletex. An interactive communications network designed for transmission of text and graphics to televisions or other low-cost terminals.

TELEX. See **TELeprinter EXchange.**

tension arm tape drive. A 1/2-inch reel-to-reel tape drive that uses mechanical tension arms to provide tape tension and buffing.

terminal equipment. 1: A device at a node of a network through which information can be entered, extracted, or monitored. 2: Any device capable of sending and/or receiving information over a communications channel. Includes a keyboard and display that cannot stand alone because it lacks processing capability. Terminals are usually simple ASCII text-entry devices.

terms and conditions. The provisions of a contract that are stated or offered for acceptance that determine the nature and scope of the agreement.

test and measurement. The process of determining the magnitude of the response of an object to a given stimulus. Also the degree to which an object may be characterized along a dimension (quantification of an entity). Computer-based inspection and test systems used for quality and/or process control data analysis; data may be collected by manual input or sensory devices.

test equipment. Equipment designed to test, check, monitor, and identify varying degrees of device functionality and complexity that may include quality, speed, and performance. Automated test systems and equipment such as IC testers and PC-board testers, as well as general test equipment (such as oscilloscopes, spectrum analyzers, and digital multimeters).

text capture. Process whereby words or groups of words are controlled.

therapeutic. Medical applications involved in treating specific medical conditions.

thermal. The effects of temperature on the system.

thermal plotter. 1: A process that produces a visible image by heat-induced chemical reactions or chemically reactive media. 2: A thermally induced phase change process of a pigment-binder mixture, which is transferred from a donor sheet to the media.

thermal transfer printer. An imaging process using heated printing elements to produce prints or copies; can be either dye diffusion (coated paper) or wax based (plain paper). This process currently is used in electronic printing, facsimile machines, and full-color copiers.

thimble. A thimble-shaped print element that floats freely across the platen of a character printer, working in a similar fashion to a daisy-print element. It is shaped like a cup, with the spokes extending around the rim of the cup, with characters positioned at the end of the spokes.

thyristor. A type of diode that consists of a four-layer slice of silicon. The device is characterized by continuous switching. Once a thyristor has been triggered into conducting current, it will continue to conduct current until the main current falls to zero.

ticketing. A software application that supports the sale and management of tickets. The application may be as simple as ticketing a single event or as complex as ticketing airline reservations.

tie ratio. A ratio that describes the relationship between two or more product units, usually used when one product is part of or connected to another product. For example, a disk drive tie ratio to PCs of 0.8 indicates that 80 percent of the PCs contain a disk drive.

time and materials service. Remedial repair services on a per-call basis. Pricing is based on the actual length of time-to-repair, travel charges, and specific parts or materials required to complete repairs.

time-division multiplexer (TDM). One of several technologies used to multiplex, or combine, several voice and/or data channels onto one communications link. TDM uses "time slicing" to allocate blocks of time to each channel. See also **statistical multiplexer.**

TLX. See **TELeprinter EXchange.**

toner. The substance used that develops a latent xerographic image from a photoreceptor onto a substrate, usually paper. Monocomponent toner contains both the imaging material and the carrier (usually called developer) needed to transport the toner to the latent image. In dual-component toner, the imaging material and developer are held separately until they are mixed by the copier or printer itself. Liquid toner has the imaging material suspended in a solvent.

tool design. The design of custom-made tooling to facilitate an effective manufacturing process.

tools. A software program that is used by application developers or users to create applications. Examples are spreadsheets, word processors, editors, macro languages, screen painters, and report generators. Tools are higher-level products than languages; a tool is written in a language. Unlike languages, most tools are nonprocedural, i.e., they do not require users to create code that is sequentially executed. A good example of this is a spreadsheet, where the developer/user navigates up, down, and sideways with the arrow keys or mouse and can add or delete rows and columns at any time. Examples of tools include Lotus 1-2-3 (spreadsheet); Multimate (word processor); EDLIN (line editor); and Ojectworks (graphical editing and object manipulation environment).

trading turret/dealer board. A specialized type of telephone system that allows simultaneous access to multiple telephone lines. This system is used in any business that requires frequent conversations between two or more parties (i.e., stock brokers).

traditional peripheral. An integrated circuit that has an intermediary control device, which links a peripheral unit to the control processors.

traditional workstation. A midrange workstation priced between $15,000 to $50,000. Its performance ratings are 4 to 15 mips and 0.5 to 2 mflops.

traffic control. A real-time software application, mechanism, and system used to monitor and control, exert control over, and/or enforce the movement of vehicles.

transducer. Any device or element that converts an input signal into an output signal of a different form. (See also **passive device.**)

transistor. A transistor is as a current-amplifying device or switch, as follows: 1: Current amplifying—a small change in a small current flows between the collector and the emitter. 2: Switch—a sufficiently large voltage applied to the base causes the maximum amount of collective current to flow. It can be manufactured in bipolar or MOS technology process. A bipolar transistor consists of a sandwich of doped silicon layers. The transistor has three electrical connections: base, emitter, and collector. Each of these areas provides access to one of the doped regions.

transistor-transistor logic (TTL). A logic circuit design with the diode inputs replaced by a multiple-emitter transistor.

translator. The process performed by an assembler, compiler, or other routine that accepts statements in one language and converts them to another language. 2: A device that transforms signals from one form to another form. 3: A system that has a number of inputs and outputs and is connected so that input signals representing information expressed in a certain code result in output signals that represent the input information in a different code.

transmitter. 1: A device for transmitting a coded signal. 2: The carbon device in the telephone handset used to convert speech to electrical energy.

transparency. 1: The property of being insensitive to the meaning of a code being manipulated. An example is a paper-tape transmitter capable of transmitting any code submitted to it. If a device interprets and reacts to coded information that it is handling, it is said to be code sensitive (not transparent). 2: Clear substrates upon which images can be written, copied, or printed for projection onto a screen by an overhead projector.

transportable personal computer. The transportable personal computer is a self-contained system that can be moved from place to place as a single unit. These systems include, in a single unit, the keyboard, display, mass storage, and main system unit. Such a personal computer operates on A/C power only (no battery power).

transportation. An environment or industry that includes establishments providing, to the general public or the other business enterprises, passenger and freight transportation.

transportation electronic equipment. Electronic equipment used in the automotive railway and airline industry.

transportation management. The planning, analysis, and control of activities for transporting or being transported.

TTL. See **transistor-transistor logic.**

two-year college. A postsecondary school that offers general or liberal arts education usually leading to an associate degree or courses that are creditable toward a baccalaureate degree.

two-year institution. An institution legally authorized to offer and offering at least a two-year program of college-level studies that terminates in an associate degree or is principally creditable toward a baccalaureate degree.

typewriter. A machine for writing in characters by means of a keyboard operated by striking through an inked ribbon. Usually refers to the standard office typewriter (mechanical, electrical, or electronic).

U

UART/USART. See **universal asynchronous receiver/transmitter/universal synchronous asynchronous receiver/transmitter.**

ultrasonic cleaners, drills. 1: An instrument used to clean debris and swarf from surfaces by immersion in a solvent in which ultrasonic vibrations are excited. 2: A drill in which ultrasonic vibrations are generated by the compression and extension of a core electrostrictive or magnetostrictive material.

ultrasonic generator. A generator consisting of an oscillator driving an electracoustic transducer used to produce acoustic waves.

ultrasonic scanner, medical. A device that produces a picture display of ultrasonic frequency waves sent through the sample to be inspected or examined.

ultraviolet electrically programmable ROM. An EPROM that is erasable with an ultraviolet light source.

unit. A single quantity.

universal asynchronous receiver/transmitter/universal synchronous asynchronous receiver/transmitter (UART/USART). An electronic circuit that converts data between the parallel format and the serial format transmitted sequentially over a communication line.

UNIX. An operating system designed to be used with microprocessors and with the C programming language.

useful life. The economic life of a product. Typically used to determine depreciation and leasing schedules.

user interface. 1: The point at which a user interacts with a computer. 2: An interactive computer program that sends messages to and receives instructions from a terminal user.

users per system. The typical number of simultaneous users that a computer system will support.

utilities. An environment or industry that includes establishments providing electricity, gas, steam, water, or sanitary services to the general public or to other business enterprises.

UV EPROM. See **ultraviolet electrically programmable ROM.**

V

vacuum column tape drive. A 1/2-inch reel-to-reel tape drive with start-stop capability that uses vacuum columns to provide tape tension and buffing.

value-added network (VAN). A data communication network that provides enhanced services such as protocol conversion.

value-added reseller (VAR) systems integrator. A product reseller that integrates hardware, software, and/or services; it does not apply its label to the product. Systems integrators are a type of VAR and may or may not own the hardware or software.

VAN. See **value-added network.**

VAR. See **value-added reseller systems integrator.**

VAX/VMS. A Digital Equipment Corporation standard multiuser operating system.

VCR. See **videocassette recorder and player.**

vertical-turning programmable machine tool. The tool of a machine that holds a workpiece along the vertical axis for a certain function to be performed such as boring, drilling, and cutting.

vibrational. The effects of vibration and shock on the system.

video. 1: Relates to the bandwidth (megahertz) and spectrum position of the signal arising from television scanning. 2: The reception or recording of electronic signals that create images on a screen or display.

video camera. A camera that records visual images and sounds on magnetic tape.

videocassette recorder and player (VCRs or VTRs). A complete system that has a tape format such as beta, VHS, or 8mm.

videodisc player. A complete video system that has a disc format.

video equipment. Equipment includes amplifiers, television cameras, and other equipment such as synchronization equipment, live cameras, and control consoles.

video home system (VHS) helical scan tape drive. A 13mm helical scan tape drive commonly used for recording television broadcasts.

videotex. An information delivery system that uses information from a database that allows the user to interact with the service, selecting information to be displayed on the user's CRT providing financial services, electronic mail, and teleshopping.

virtual private network (VPN). Similar in function to a leased circuit with the exception that the circuit is not dedicated to one customer.

VLSI. Very large scale integration.

VMS. See **voice-messaging system.**

voice-messaging system (VMS). A computer-based system that enables flexible, nonsimultaneous voice communications. This definition does not include personal-computer-board-level products.

voice-recognition computer device. The capability of a computer to recognize spoken commands. Each user must first "train" the computer by speaking a series of words that the computer can analyze and match with stored information.

voice response unit (VRU). A computer-connected device that selectively links sentences of stored words, creating a spoken word.

voice synthesizer. A device that simulates speech by assembling a language's elements under digital control.

voice terminal. See **telephone.**

voltage regulator and reference IC. 1: A device that provides power to other circuits at a specified DC voltage. 2: A device that provides a specified constant DC voltage to a load over a wide range of variations in input voltage and output current.

VPN. See **virtual private network.**

VRU. See **voice response unit.**

VTR. See **videocassette recorder and player.**

W

wafer. A thin (10 to 20 mils) disk of semiconductor material from which semiconductors are fabricated.

wafer fab. The integrated circuit production process—from raw wafers through a series of diffusion, etching, photolithographic, and other steps to finished wafers.

wafer fabrication equipment. Machinery used to produce wafers in the semiconductor industry. (See also **e-beam, etch-and-clean equipment, stepper.**)

wafer inspection. Inspection of patterned wafers for process defects by visual and image-processing techniques.

water quality and sewage control. A real-time software application that monitors and controls water quality and sewage.

WATS. See **wide area telephone service.**

web ribbon. Web or towel ribbons are wide ribbons used on line, dot matrix, and line, fully formed printers. They are as wide as the print line is long—usually approximately 15 inches.

wet chemical. A chemical used in semiconductor wafer fabrication. Examples are acids and solvents.

wet etch. Immersing method for wafers in an etching solution. Chemical removal of a material by bathing the wafer in acid.

white-collar worker. A person working in an occupation classified by the Bureau of Labor Statistics under the following category headings: managerial and professional specialty and technical, sales, and administrative support.

wholesale trade. An environment or industry that includes establishments or places of business primarily engaged in selling merchandise to retailers; to industrial, commercial, institutional, farm, construction contractors, or professional business users; or to other wholesalers; or acting as agents or brokers in buying merchandise for or selling merchandise to such persons or companies.

wide area telephone service. An enhanced telephone company service allowing reduced costs of certain telephone call arrangements. This service can be in-wats or 800-number service (calls can be placed to a location from anywhere at no cost to the calling party) or out-wats (calls can be placed out from a central location).

word processing. A software application with the principal function of editing, entering, and formatting text.

word processor (WP). A standalone word processor capable of functioning independently from a central controller or storage device, although they may communicate with each other. These products generally have removable magnetic media. Products that have evolved from electronic typewriters generally are not included in this category. The ability to share a printer among workstations does not disqualify a product from being a standalone word processor; shared-system word processors are connected to an external file server or controller; word-processor file servers are centralized data storage devices that are accessible and dedicated to shared word processing units.

work force. All persons of either sex who furnish the supply of labor for the production of economic goods and services during a specified time period.

workstation computer. A single-user computer that is distinguished from a personal computer by its features and by the user's potential migration path within the platform. A technical workstation is a system designed with integrated networking; high-performance graphics; floating point; coprocessor; and a virtual, multiuser/multitasking operating system (DOMAIN, UNIX, VMS).

WORM. See **write-once/read-many.**

WP. See **word processor.**

write-once/read-many (WORM). 1: The WORM optical disk market includes drives that can read and write data using various optical diskette media. 2: A data storage device using laser technology that uses a removable disk ranging in size from 3.5 to 14 inches.

X

X-ray (lithography). A machine that uses an X ray for generating a mask plate of direct image transfer to a semiconductor wafer.

X-ray, medical. Equipment used to detect, examine, treat, or analyze body systems through photographic X-rays.

X.25. A CCITT standard that defines the interface between a public data network and a pocket-mode user device; also defines the services that these user devices can expect from the X.25 public data network.

Y

year-average population. The installed base of a product computed at the midyear between the beginning installed base and the ending installed base of the same year.

Z

zener diode. 1: A diode that has a controlled, reverse-voltage/current relationship. 2: A two-layer device that has a sudden rise in current above a certain reverse voltage.

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Market Statistics

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Wafer Fab Equipment Market Share Estimates 1991

April 27, 1992

Source: Dataquest

Market Statistics

Dataquest

Semiconductor Equipment, Manufacturing, and Materials

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Wafer Fab Equipment Market Share

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Market Statistics

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Wafer Fab Equipment Market Share

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Note: All tables show estimated data.

Chapter 1

Introduction to the Wafer Fab Equipment Database

Introduction

This document contains detailed information on Dataquest's view of the semiconductor wafer fabrication equipment market for the years 1987 through 1991. This database is the result of an extensive research project conducted by SEMMS whereby we contact the world's wafer fab equipment manufacturers to obtain detailed regional and company market share data.

Market

Dataquest has organized the wafer fab equipment market into 10 major categories of front-end processing equipment. These categories, along with key subcategories, are shown in Table 1.1.

This equipment is used to perform five key tasks in the semiconductor device fabrication process, as follows:

- Patterning of a thin film (lithography and automatic photoresist processing equipment)
- Etching and cleaning of thin films and/or substrate surfaces (wet process, dry strip, dry etch equipment)
- Depositing a thin film (chemical vapor deposition, physical vapor deposition, silicon epitaxy, metalorganic CVD and molecular beam epitaxy equipment)
- Modify the properties of a thin film or substrate (diffusion and ion implantation)
- And finally, verify that all previous steps in the fabrication process have been perfromed correctly (process control equipment including optical critical dimension (CD) measurement, CD scanning electron microscopy (SEM), and wafer inspection)

Table 1.1
Wafer Fab Equipment Categories

1. Lithography
Contact/Proximity
Projection Aligners
Steppers
Direct-Write Lithography
Maskmaking Lithography
X-Ray
2. Automatic Photoresist Processing Equipment
3. Etch and Clean
Wet Process
Dry Strip
Dry Etch
Ion Milling
4. Deposition
Chemical Vapor Deposition
Physical Vapor Deposition
Silicon Epitaxy
Metalorganic CVD
Molecular Beam Epitaxy
5. Diffusion
6. Rapid Thermal Processing
7. Ion Implantation
Medium Current
High Current
High Voltage
8. Process Control
Optical CD
CD SEM
Wafer Inspection
Other Process Control
9. Factory Automation
10. Other Equipment

Source: Dataquest (April 1992)

Capital spending by the world's merchant and captive semiconductor manufacturers consists of three components: spending for front-end, or wafer fab equipment; spending for back-end, or assembly and test equipment; and spending for property and plant. The total world market for the 10 categories of wafer fab equipment as defined in this database is equal to the total capital spending for front-end equipment by the world's semiconductor manufacturers.

Most of the equipment categories are self-explanatory; however, a few categories require further definition. The Other Process Control category represents a broad market that includes mask inspection and repair equipment, process monitoring equipment, surface analysis equipment, and analytical instrumentation. This is a highly fragmented market with dozens of companies selling into a multitude of noncompetitive market niches.

Factory Automation includes CIM software for shop floor control, factory host computer systems, cell controllers and interface hardware, and wafer transport systems including automatic guided vehicles, robotics, and rail transport systems.

Other Equipment is a general, catchall category that includes the other capital equipment used throughout the fab but not classified with the other nine major types of wafer processing equipment. Included in this segment are decontamination systems, wafer markers, gas analyzers, storage stations, and other types of equipment.

Conventions

The data in the tables represent end-user revenue for calendar year shipments, organized by company or by region. For companies with a different fiscal year, calendar year shipments have been estimated. Shipments do not include spare parts or service but do include retrofits and upgrades. In addition, our market estimates reflect only equipment used in the front-end wafer fabrication process. We do not include equipment used in other market applications such as flat panel display manufacturing, thin film head manufacturing, or multichip modules. Finally, as part of our convention to report end-user revenue, the revenue associated with equipment kits sent from one company to be fabricated and assembled by another company is valued at the full system shipment price to the semiconductor manufacturer, rather than at the value of the kit. Thus, for public companies, the sales reported here may be different from the sales reported in the annual reports. The compound annual growth rate (CAGR) is calculated over the years 1987 to 1991 for each major line item.

Exchange Rates

Worldwide market share estimates combine data from many countries, each of which has different and fluctuating exchange rates. Estimates of non-U.S. market consumption or revenue are based upon the average exchange rate for the given year. As a rule, our estimates are calculated in local currencies, and then converted to U.S. dollars.

For example, Japanese-manufactured equipment sold in Japan is valued in dollars in the database tables at the average exchange rate for each year, as shown in the following:

Yen/Dollar Exchange Rate

1987	1988	1989	1990	1991
144	130	139	144	135

Equipment Companies

Table 1.2 presents a list of the equipment companies found in the database tables by region of company ownership. (Please note that Table 1.2 includes companies that are currently active in the wafer fab equipment industry in addition to those companies that, for whatever reason, are no longer participants.) The database comprises a total of 96 U.S. equipment companies, 58 Japanese companies, 38 European companies, and 8 joint venture companies. These 200 companies account for virtually all of the world's wafer processing equipment for lithography, automatic photoresist processing, etch and clean, deposition, diffusion, rapid thermal processing, ion implantation, and optical CD/wafer inspection.

Table 1.3 presents a summary of recent mergers and acquisitions in the wafer fab equipment industry. Merger and acquisition activity is often accompanied by a change in company name. These changes have been incorporated in our market share tables. For example, Vickers Instruments was acquired by Biorad in early 1989. Thus, Vickers' sales of optical CD and CD SEM equipment in 1989 is found under the company's new name, Nanoquest; subsequently, estimates under the Vickers category drop to 0.

Notes on Market Share

In the process of conducting data collection and evaluating market statistics, Dataquest will sometimes consolidate or revise previously published market estimates. We revise one year of history only in those situations when an individual company's market position or the size of a given regional market for a segment of wafer fab equipment would be altered significantly.

Dataquest believes that the estimates presented within this document are the most accurate and meaningful statistics available.

Despite the care taken in gathering, analyzing, and catergorizing the data in a meaningful way, careful attention must be paid to the definitions and assumptions used herein when interpreting the estimates presented in this document. Variuos companies, government agencies, and trade associations may use slightly different definitions of product catergories and regional groupings, or they may include different companies in their summaries. These differences should be kept in mind when making comparisions between data and numbers provided by Dataquest and those provided by other suppliers.

Table 1.2
Wafer Fab Equipment Companies

	North American Companies	
Advantage Production Technology	Gemini	Poly-Flow Engineering
AG Associates	General Signal Thinfilm Company	Process Products
Alameda Instruments	Genus	Process Technology Ltd.
American Semiconductor Equip. Tech.	Hampshire Instruments	Pure Aire Corporation
Amray	High Temperature Engineering	Rapro
Angstrom Measurements	Innotec	Reichert-McBain
Anicon	Insystems	S&K Products International
Applied Materials	Integrated Air Systems	Santa Clara Plastics
Ateq	Ion Tech	SCI Manufacturing
Athens	IPEC	Semiconductor Systems Inc.
Biorad	IVS Inc.	Semifab
Bjorne Enterprises	KLA Instruments	Semitherm
Branson/IPC	Kurt J. Lesker	Semitool
BTU International	Lam Research	Silicon Valley Group
CFM Technology	LFE	SiScan Systems
CHA Industries	Machine Technology Inc.	Solitec
CPA	Materials Research Corp.	Spectrum CVD
Crystal Specialties	Matrix	Spire
CVC Products	Mattson Technologies	Sputtered Films
CVD Equipment	Metrologix	SubMicron Systems Inc.
Denton Vacuum	Micronix	Tegal
Dexon	Moore	Tempress
Drytek	MR Semicon	Thermco
Eaton	MRL Industries	Tylan
Emcore	Nanometrics	Ultratech
Epitaxy Inc.	Nanoquest	Universal Plastics
Estek	Nanosil	Varian
Etec	National Electrostatics	Veeco
Focus Semiconductor	Novellus Systems Inc.	Verteq
FSI International	Optical Specialties Inc.	Watkins-Johnson
Fusion Semiconductor Systems	Peak Systems	
Gasonics	Perkin-Elmer	
GCA	Plasma-Therm	

(Continued)

Table 1.2 (Continued)
Wafer Fab Equipment Companies

	Japanese Companies	
ABT Corporation	Japan Production Engineering	Seiden Sha
Advanced Film Technology Inc.	JEOL	Seiko
Amaya	Kaijo Denki	Shibaura
Anelva	Kokusai Electric	Shimada
Canon	Koyo Lindberg	Shinko Electric
Chemitronics	Kuwano Electric	Sugai
Chlorine Engineering	Kyoritsu	Sumitomo Metals
Dainippon Screen	Maruwa	Tazmo
Daiwa Semiconductor	MRC (Sony)	Tohokasei
Dan Science Co. Ltd.	Musashi	Tokuda
Denko	Nidek	Tokyo Electron Ltd.
Disco	Nikon	Tokyo Ohka Kogyo
Eiko	Nippon EMC	Topcon
Elionix	Nippon Sanso	Toshiba
Enya	Nissin Electric	Toyoko Chemical
Ergo Plasma Systems	Plasma Systems	Ulvac
ETE Company Ltd.	Ramco	Ushio
Fuji Electric	Ryokosha	Yuasa
Hitachi	Samco	
Holon	Sankyo Engineering	
	European Companies	
AET	Helmut Seier	Sitesa
Addax Technologies	ISA Riber	Technics
Aixtron	Jipelec	Temescal
ASM International	Karl Suss	Thomas Schwonn
ASM Lithography	Leica	VG Instruments
Balzers	Leica Lasertechnik	Vickers Instruments
BCT Spectrum	Leybold-Heraeus	Wellman Furnaces
Cambridge Instruments	LPE	Wild Leitz
Centrotherm	Micro-Controle	Wild Leitz Instruments
Convac	Nano-Master	Zeiss
CVT	Plasma Technology	
E.T. Electrotech	Pokorny	
EEV	Sapi Equipments	
Heidelberg Instruments	Semco Engineering	
	Joint Venture Companies	
Alcan Technology	TEL/LAM	Ulvac/BTU
BTU/Ulvac	TEL/Varian	Varian/TEL
Sumitomo/Eaton Nova	m•FSI	

Dataquest (April 1992)

Table 1.3
Summary of Mergers and Acquisitions Incorporated in the Wafer Fab Equipment Database

Company	Action	Company	Now Identified As	First Year Change Noted In Database
Angstrom Measurement	acquired by	IVS, Inc.	IVS, Inc.	1992
BCT Spectrum	acquired by	MRC Sony	MRC Sony	1992
Ateq Corporation	merged with	Etec Systems Corporation	Etec Systems, Inc.	1992
Tokuda	acquired by	Shibaura	Shibaura	1991
Denko Systems	name change to	Shinko Electric	Shinko Electric	1991
Sitesa S.A.	acquired by	Addax Technologies	Addax Technologies	1991
ABT Corporation	acquired by	Toshiba	Topcon	1991
BTU/Ulvac	acquired by	Ulvac	Ulvac	1991
Ulvac/BTU	acquired by	Ulvac	Ulvac	1991
Micro-Controle	name change to	Nano-Master	Nano-Master	1991
Spectrum CVD	acquired by	Balzers AG	BCT Spectrum	1991
Semiconductor Systems Inc.	management buyout from	General Signal	Semiconductor Systems Inc.	1991
Branson/IPC	merged with	Gasonics	Gasonics	1991
ASM Lithography (e-beam lithography group)	acquired by	Cambridge Instruments	Leica	1990
Circuits Processing Apparatus (GSTC)	management buyout from	General Signal Thinfilm	CPA	1990
Materials Research Corp.	acquired by	Sony	Materials Research Corp.	1990
Nanoquest	name change to	-	Biorad Micro-measurements	1990
Perkin-Elmer (e-beam lithography group)	acquired by	industry consortium	Etec Systems, Inc.	1990
Perkin-Elmer (optical lithography group)	acquired by	Silicon Valley Group	SVG Lithography	1990
Wild Leitz	merged with	Cambridge Instruments	Leica	1990
Wild Leitz Instruments	name change to	-	Leica Lasertechnik	1990
ASM Lithography (50% of joint venture)	acquired by	Philips	ASM Lithography	1989
Cambridge Instruments (MOCVD group)	acquired by	MR Semicon	MR Semicon	1989
Estek (wet processing equipment group)	acquired by	Verteq	Verteq	1989
GCA Corporation	acquired by	General Signal	GCA Corporation	1989
Heidelberg Instruments	acquired by	Wild Leitz	Wild Leitz Instruments	1989

(Continued)

Table 1.3 (Continued)
Summary of Mergers and Acquisitions Incorporated in the Wafer Fab Equipment Database

Company	Action	Company	Now Identified As	First Year Change Noted In Database
TEL/Thermco	acquired by	Tokyo Electron Ltd.	Tokyo Electron Ltd.	1989
Thermco	acquired by	Silicon Valley Group	Silicon Valley Group	1989
Tylan (diffusion and CVD group)	management buyout from	Tylan	Tystar	1989
Vickers Instruments	acquired by	Biorad	Nanoquest	1989
General Ionex	acquired by	Genus	Genus	1988
TEL/Lam	acquired by	Tokyo Electron Ltd.	Tokyo Electron Ltd.	1988
Tempress	merged with	Circuits Processing Apparatus	General Signal Thinfilm	1988
AET Addax (RTP group)	acquired by	Sitesa	Sitesa Addax	1987
Anicon	acquired by	Silicon Valley Group	Silicon Valley Group	1987
Gemini	acquired by	Lam Research	Lam Research	1987

Source: Dataquest (April 1992)

Chapter 2

Wafer Fab Equipment—Summary Data by Category

This section of the equipment database consists of two summary tables for the worldwide fab equipment market. Both tables present sales by equipment category for the years 1987 to 1991. In Table 2.1, the annual sales for each equipment category are organized by region of equipment sales; in Table 2.2, annual sales for each equipment category are organized by equipment vendor nationality (United States, Japan, and Europe). Joint venture equipment companies have their own listing.

For example, the total worldwide sales for contact/proximity aligners of $24.6 million in 1987 is the same in both Table 2.1 and Table 2.2; however, whereas Table 2.1 breaks the sales down by region, Table 2.2 breaks the sales down by nationality of the companies supplying the aligners.

In Table 2.2, the subtotal fab equipment line item designates that portion of the total worldwide fab equipment market for which detailed company data are available. For some of the categories in Table 2.2 (Ion Milling, Other Process Control, Factory Automation, and Other Equipment), detailed company data are not complete. For these categories, top-down estimates have been made and included in Tables 2.1 and 2.2 so that world fab equipment sales are consistent across all tables. Detailed company data are available for approximately 86 percent of the total worldwide wafer fab equipment market for 1991.

Table 2.1
Revenue from Shipments of Wafer Fab Equipment into Each Region
(End User Revenue in Millions of U.S. Dollars)

Company:	All
Product:	Each
Region Of Consumption:	Each

	1987	1988	1989	1990	1991	CAGR (%) 1987-1991
Lithography						
Contact/Proximity						
North American Market	10.0	8.9	7.3	6.2	2.6	(28.6)
Japanese Market	5.2	4.0	5.7	8.6	7.9	11.0
European Market	5.0	5.4	6.0	5.3	7.0	8.8
Asia/Pacific-ROW Market	4.4	4.0	3.6	3.9	3.3	(6.9)
Total Contact/Prox.	24.6	22.3	22.6	24.0	20.8	(4.1)
Projection Aligners						
North American Market	66.4	60.7	22.4	24.8	14.8	(31.3)
Japanese Market	36.7	63.3	43.9	36.9	30.7	(4.4)
European Market	17.3	16.3	13.0	15.1	7.6	(18.6)
Asia/Pacific-ROW Market	8.2	7.4	15.0	16.6	15.3	16.9
Total Projection	128.6	147.7	94.3	93.4	68.4	(14.6)
Total Steppers						
North American Market	184.0	280.0	336.4	289.0	277.5	10.8
Japanese Market	212.8	436.6	532.4	535.5	502.1	23.9
European Market	58.5	90.0	110.6	131.8	94.1	12.6
Asia/Pacific-ROW Market	47.8	114.4	201.3	95.9	155.4	34.3
Total Projection	503.1	921.0	1,180.7	1,052.2	1,029.1	19.6
Direct-Write Lithography						
North American Market	17.2	13.6	10.0	15.9	7.3	(19.3)
Japanese Market	32.7	35.9	34.5	27.1	35.6	2.1
European Market	15.2	17.2	20.4	24.1	7.3	(16.8)
Asia/Pacific-ROW Market	2.0	2.0	5.2	9.1	5.1	26.4
Total Direct-Write	67.1	68.7	70.1	76.2	55.3	(4.7)
Maskmaking Lithography						
North American Market	13.6	16.0	15.4	14.7	9.5	(8.6)
Japanese Market	38.0	27.5	40.1	22.9	29.8	(5.9)
European Market	13.0	7.6	8.2	3.5	3.0	(30.7)
Asia/Pacific-ROW Market	3.0	11.0	5.5	6.0	3.5	3.9
Total Maskmaking	67.6	62.1	69.2	47.1	45.8	(9.3)
X-Ray						
North American Market	.0	3.4	2.0	.0	2.4	NM
Japanese Market	.0	1.6	.0	.0	1.8	NM
European Market	.0	1.4	2.8	1.6	.0	NM
Asia/Pacific-ROW Market	.0	.0	.0	.0	.0	NM
Total X-Ray	.0	6.4	4.8	1.6	4.2	NM

(Continued)

Table 2.1 (Continued)
Revenue from Shipments of Wafer Fab Equipment into Each Region
(End User Revenue in Millions of U.S. Dollars)

Company: All
Product: Each
Region Of Consumption: Each

	1987	1988	1989	1990	1991	CAGR (%) 1987-1991
Total Lithography						
North American Market	291.2	382.6	393.5	350.6	314.1	1.9
Japanese Market	325.4	568.9	656.6	631.0	607.9	16.9
European Market	109.0	137.9	161.0	181.4	119.0	2.2
Asia/Pacific-ROW Market	65.4	138.8	230.6	131.5	182.6	29.3
Total Lithography	791.0	1,228.2	1,441.7	1,294.5	1,223.6	11.5
Automatic Photoresist Processing Equipment						
North American Market	60.9	78.0	91.1	90.7	110.4	16.0
Japanese Market	65.4	113.6	156.2	171.4	179.3	28.7
European Market	28.5	36.5	38.6	35.5	34.5	4.9
Asia/Pacific-ROW Market	12.9	25.3	47.7	28.4	44.4	36.2
Total Track	167.7	253.4	333.6	326.0	368.6	21.8
Etch and Clean						
North American Market	65.6	83.3	87.8	74.9	105.6	12.6
Japanese Market	69.2	138.8	201.7	245.8	204.8	31.2
European Market	22.1	29.2	43.3	44.0	34.7	11.9
Asia/Pacific-ROW Market	10.3	25.6	44.0	35.3	59.9	55.3
Total Wet Process	167.2	276.9	376.8	400.0	405.0	24.8
Dry Strip						
North American Market	16.7	23.0	27.0	25.1	32.2	17.8
Japanese Market	33.7	64.2	75.9	75.5	62.1	16.5
European Market	2.9	5.9	6.9	9.3	9.2	33.5
Asia/Pacific-ROW Market	4.6	7.3	11.4	7.8	15.6	35.7
Total Dry Strip	57.9	100.4	121.2	117.7	119.1	19.8
Dry Etch						
North American Market	118.1	171.1	186.1	184.5	173.1	10.0
Japanese Market	113.0	240.1	329.9	365.9	356.6	33.3
European Market	58.3	72.9	74.5	95.6	77.8	7.5
Asia/Pacific-ROW Market	18.0	49.1	79.0	44.4	97.2	52.4
Total Dry Etch	307.4	533.2	669.5	690.4	704.7	23.0
Ion Milling						
North American Market	3.7	4.0	3.0	3.0	3.8	.7
Japanese Market	1.5	2.0	5.0	5.0	7.0	47.0
European Market	1.6	2.0	3.0	3.0	2.1	7.0
Asia/Pacific-ROW Market	1.0	1.5	1.5	2.0	3.8	39.6
Total Ion Milling	7.8	9.5	12.5	13.0	16.7	21.0

(Continued)

Table 2.1 (Continued)
Revenue from Shipments of Wafer Fab Equipment into Each Region
(End User Revenue in Millions of U.S. Dollars)

Company: All
Product: Each
Region Of Consumption: Each

	1987	1988	1989	1990	1991	CAGR (%) 1987-1991
Total Etch and Clean						
North American Market	204.1	281.4	303.9	287.5	314.7	11.4
Japanese Market	217.4	445.1	612.5	692.2	630.5	30.5
European Market	84.9	110.0	127.7	151.9	123.8	9.9
Asia/Pacific-ROW Market	33.9	83.5	135.9	89.5	176.5	51.1
Total Etch and Clean	540.3	920.0	1,180.0	1,221.1	1,245.5	23.2
Deposition						
CVD						
North American Market	92.7	152.3	193.3	224.4	188.6	19.4
Japanese Market	93.0	190.2	262.4	343.7	369.7	41.2
European Market	58.0	74.7	73.2	92.9	76.4	7.1
Asia/Pacific-ROW Market	16.4	49.2	82.3	55.5	112.7	61.9
Total CVD	260.1	466.4	611.2	716.5	747.4	30.2
PVD						
North American Market	93.8	105.1	111.8	132.2	133.0	9.1
Japanese Market	99.8	138.1	175.0	197.6	232.4	23.5
European Market	40.7	36.0	45.0	50.7	43.3	1.6
Asia/Pacific-ROW Market	16.6	22.8	36.6	28.0	65.3	40.8
Total PVD	250.9	302.0	368.4	408.5	474.0	17.2
Silicon Epitaxy						
North American Market	13.4	43.0	31.7	35.7	24.8	16.6
Japanese Market	13.0	23.5	20.7	18.2	46.1	37.2
European Market	6.4	13.4	16.5	11.9	11.0	14.5
Asia/Pacific-ROW Market	2.7	5.6	6.1	2.4	6.7	25.5
Total Silicon Epitaxy	35.5	85.5	75.0	68.2	88.6	25.7
Metalorganic CVD						
North American Market	11.0	13.8	14.9	12.2	13.9	6.0
Japanese Market	14.1	16.9	16.6	16.2	22.9	12.9
European Market	9.2	10.6	9.6	13.5	9.4	.5
Asia/Pacific-ROW Market	.3	.7	3.5	2.4	5.2	104.0
Total MOCVD	34.6	42.0	44.6	44.3	51.4	10.4
Molecular Beam Epitaxy						
North American Market	19.7	21.3	20.8	9.3	10.5	(14.6)
Japanese Market	32.6	36.3	22.3	25.1	29.8	(2.2)
European Market	11.7	19.0	23.7	12.2	10.6	(2.4)
Asia/Pacific-ROW Market	4.0	4.3	7.2	11.4	8.0	18.9
Total MBE	68.0	80.9	74.0	58.0	58.9	(3.5)

(Continued)

Table 2.1 (Continued)
Revenue from Shipments of Wafer Fab Equipment into Each Region
(End User Revenue in Millions of U.S. Dollars)

Company: All
Product: Each
Region Of Consumption: Each

	1987	1988	1989	1990	1991	CAGR (%) 1987-1991
Total Deposition						
North American Market	230.6	335.5	372.5	413.8	370.8	12.6
Japanese Market	252.5	405.0	497.0	600.8	700.9	29.1
European Market	126.0	153.7	168.0	181.2	150.7	4.6
Asia/Pacific-ROW Market	40.0	82.6	135.7	99.7	197.9	49.1
Total Deposition	649.1	976.8	1,173.2	1,295.5	1,420.3	21.6
Diffusion						
North American Market	37.1	85.2	87.8	77.1	79.9	21.1
Japanese Market	59.1	105.4	128.2	172.8	154.1	27.1
European Market	39.2	46.9	46.2	41.1	36.3	(1.9)
Asia/Pacific-ROW Market	10.0	58.0	68.4	33.0	64.8	59.5
Total Diffusion	145.4	295.5	330.6	324.0	335.1	23.2
Rapid Thermal Processing						
North American Market	10.1	11.7	10.4	14.6	18.4	16.2
Japanese Market	4.5	6.2	7.0	9.2	14.4	33.7
European Market	2.7	3.2	4.1	3.1	6.9	26.4
Asia/Pacific-ROW Market	.9	1.2	3.6	2.8	2.1	23.6
Total RTP	18.2	22.3	25.1	29.7	41.8	23.1
Ion Implantation						
Medium Current						
North American Market	9.9	17.4	23.5	17.2	16.3	13.3
Japanese Market	29.6	64.1	76.8	69.7	59.6	19.1
European Market	15.1	17.9	8.7	7.9	13.7	(2.4)
Asia/Pacific-ROW Market	6.4	18.5	22.3	18.7	17.9	29.3
Total Medium Current	61.0	117.9	131.3	113.5	107.5	15.2
High Current						
North American Market	27.6	44.5	59.3	58.4	38.6	8.7
Japanese Market	46.3	139.4	164.7	136.1	129.7	29.4
European Market	21.5	32.6	26.3	27.1	26.5	5.4
Asia/Pacific-ROW Market	11.5	24.6	50.4	27.9	23.3	19.3
Total High Current	106.9	241.1	300.7	249.5	218.1	19.5
High Voltage						
North American Market	8.1	6.2	7.4	2.6	2.9	(22.6)
Japanese Market	5.9	8.1	15.5	4.2	11.4	17.9
European Market	4.0	4.1	.0	.0	3.3	(4.7)
Asia/Pacific-ROW Market	.0	.0	1.7	.0	.0	NM
Total High Voltage	18.0	18.4	24.6	6.8	17.6	(.6)

(Continued)

Table 2.1 (Continued)
Revenue from Shipments of Wafer Fab Equipment into Each Region
(End User Revenue in Millions of U.S. Dollars)

Company: All
Product: Each
Region Of Consumption: Each

	1987	1988	1989	1990	1991	CAGR (%) 1987-1991
Total Implantation						
North American Market	45.6	68.1	90.2	78.2	57.8	6.1
Japanese Market	81.8	211.6	257.0	210.0	200.7	25.2
European Market	40.6	54.6	35.0	35.0	43.5	1.7
Asia/Pacific-ROW Market	17.9	43.1	74.4	46.6	41.2	23.2
Total Implantation	185.9	377.4	456.6	369.8	343.2	16.6
Optical CD						
North American Market	15.9	33.4	25.4	22.9	19.8	5.6
Japanese Market	15.0	27.6	20.5	15.3	19.3	6.5
European Market	8.0	12.8	12.9	16.5	13.2	13.3
Asia/Pacific-ROW Market	3.4	5.6	10.8	4.2	7.0	19.8
Total Optical CD	42.3	79.4	69.6	58.9	59.3	8.8
CD SEM						
North American Market	19.0	26.5	26.2	23.2	17.9	(1.5)
Japanese Market	22.7	37.7	41.4	54.5	59.0	27.0
European Market	3.4	5.5	9.5	6.8	5.4	12.3
Asia/Pacific-ROW Market	1.3	1.9	3.5	3.1	12.0	74.3
Total CD SEM	46.4	71.6	80.6	87.6	94.3	19.4
Wafer Inspection						
North American Market	23.2	35.7	40.1	27.7	26.4	3.3
Japanese Market	21.8	39.3	42.9	40.2	41.1	17.2
European Market	8.5	12.9	23.4	18.3	15.6	16.4
Asia/Pacific-ROW Market	4.2	12.6	10.8	4.6	6.6	12.0
Total Wafer Inspection	57.7	100.5	117.2	90.8	89.7	11.7
Other Process Control						
North American Market	104.4	116.5	129.6	120.0	121.0	3.8
Japanese Market	112.3	153.4	176.8	171.0	181.0	12.7
European Market	41.1	48.2	48.8	45.0	42.0	.5
Asia/Pacific-ROW Market	27.9	37.3	49.2	32.0	54.0	17.9
Total Other Process Control	285.7	355.4	404.4	368.0	398.0	8.6
Total Process Control						
North American Market	162.5	212.1	221.3	193.8	185.1	3.3
Japanese Market	171.8	258.0	281.6	281.0	300.4	15.0
European Market	61.0	79.4	94.6	86.6	76.2	5.7
Asia/Pacific-ROW Market	36.8	57.4	74.3	43.9	79.6	21.3
Total Process Control	432.1	606.9	671.8	605.3	641.3	10.4

(Continued)

Table 2.1 (Continued)
Revenue from Shipments of Wafer Fab Equipment into Each Region
(End User Revenue in Millions of U.S. Dollars)

Company:	All
Product:	Each
Region Of Consumption:	Each

	1987	1988	1989	1990	1991	CAGR (%) 1987-1991
Factory Automation						
North American Market	24.0	26.0	37.0	40.0	36.0	10.7
Japanese Market	54.0	76.0	112.0	121.0	132.0	25.0
European Market	17.0	17.0	25.0	27.0	23.0	7.8
Asia/Pacific-ROW Market	4.0	11.0	21.0	28.0	36.0	73.2
Total Automation	99.0	130.0	195.0	216.0	227.0	23.1
Other Equipment						
North American Market	39.7	55.1	58.2	50.8	49.1	5.5
Japanese Market	45.6	80.5	97.9	97.1	96.5	20.6
European Market	18.6	23.5	25.2	24.8	20.3	2.2
Asia/Pacific-ROW Market	8.0	18.2	28.5	16.7	27.2	35.8
Total Other Equipment	111.9	177.3	209.8	189.4	193.1	14.6
Total Wafer Fab Equipment						
North American Market	1,105.8	1,535.7	1,665.9	1,597.1	1,536.3	8.6
Japanese Market	1,277.5	2,270.3	2,806.0	2,986.5	3,016.7	24.0
European Market	527.5	662.7	725.4	767.6	634.2	4.7
Asia/Pacific-ROW Market	229.8	519.1	820.1	520.1	852.3	38.8
Total Fab Equipment	3,140.6	4,987.8	6,017.4	5,871.3	6,039.5	17.8

NM = Not Meaningful

The category of Optical CD includes dedicated overlay tools, in addition to joint linewidth/overlay measurement systems.

Ref: SUMMREG

Source: Dataquest (April 1992)

Table 2.2
Each Regional Company Base's Revenue from Shipments of Wafer Fab Equipment to the World (End User Revenue in Millions of U.S. Dollars)

Company: Each Regional Company Base
Product: Each
Region Of Consumption: The World

	1987	1988	1989	1990	1991	CAGR (%) 1987-1991
World Fab Equipment Market	3,140.6	4,987.8	6,017.4	5,871.3	6,039.5	17.8
Lithography						
Contact/Proximity						
North American Companies	.0	.0	.0	.0	.0	NM
Japanese Companies	11.0	8.6	6.3	10.5	7.9	(7.9)
European Companies	13.6	13.7	16.3	13.5	12.9	(1.3)
Joint Venture Companies	.0	.0	.0	.0	.0	NM
Total Contact/Proximity	24.6	22.3	22.6	24.0	20.8	(4.1)
Projection Aligners						
North American Companies	88.0	78.6	44.9	37.0	21.2	(29.9)
Japanese Companies	40.6	69.1	49.4	56.4	47.2	3.8
European Companies	.0	.0	.0	.0	.0	NM
Joint Venture Companies	.0	.0	.0	.0	.0	NM
Total Projection	128.6	147.7	94.3	93.4	68.4	(14.6)
Steppers						
North American Companies	124.5	198.0	145.4	136.8	113.2	(2.4)
Japanese Companies	341.9	664.4	912.1	824.4	844.6	25.4
European Companies	36.7	58.6	123.2	91.0	71.3	18.1
Joint Venture Companies	.0	.0	.0	.0	.0	NM
Total Steppers	503.1	921.0	1,180.7	1,052.2	1,029.1	19.6
Direct-Write Lithography						
North American Companies	9.6	12.8	9.9	10.5	.0	(100.0)
Japanese Companies	39.5	40.7	41.0	54.9	44.6	3.1
European Companies	18.0	15.2	19.2	10.8	10.7	(12.2)
Joint Venture Companies	.0	.0	.0	.0	.0	NM
Total Direct-Write	67.1	68.7	70.1	76.2	55.3	(4.7)
Maskmaking Lithography						
North American Companies	28.6	38.2	34.7	28.0	25.5	(2.8)
Japanese Companies	35.0	16.5	29.6	16.6	17.8	(15.6)
European Companies	4.0	7.4	4.9	2.5	2.5	NM
Joint Venture Companies	.0	.0	.0	.0	.0	NM
Total Maskmaking	67.6	62.1	69.2	47.1	45.8	NM
X-Ray						
North American Companies	.0	1.8	2.0	.0	2.4	NM
Japanese Companies	.0	.0	.0	.0	.0	NM
European Companies	.0	4.6	2.8	1.6	1.8	NM
Joint Venture Companies	.0	.0	.0	.0	.0	NM
Total X-Ray	.0	6.4	4.8	1.6	4.2	ERR

(Continued)

Table 2.2 (Continued)
Each Regional Company Base's Revenue from Shipments of Wafer Fab Equipment to the World (End User Revenue in Millions of U.S. Dollars)

Company: Each Regional Company Base
Product: Each
Region Of Consumption: The World

	1987	1988	1989	1990	1991	CAGR (%) 1987-1991
Total Lithography						
North American Companies	250.7	329.4	236.9	212.3	162.3	(10.3)
Japanese Companies	468.0	799.3	1,038.4	962.8	962.1	19.7
European Companies	72.3	99.5	166.4	119.4	99.2	8.2
Joint Venture Companies	.0	.0	.0	.0	.0	NM
Total Lithography	791.0	1,228.2	1,441.7	1,294.5	1,223.6	11.5
Automatic Photoresist Processing Equipment						
North American Companies	80.2	93.4	106.8	98.5	103.5	6.6
Japanese Companies	76.6	146.2	195.2	198.3	229.1	31.5
European Companies	10.9	13.8	12.2	15.4	18.9	14.8
Joint Venture Companies	.0	.0	19.4	13.8	17.1	NM
Total Track	167.7	253.4	333.6	326.0	368.6	21.8
Wet Process						
North American Companies	95.2	106.5	114.5	96.2	122.7	6.5
Japanese Companies	67.7	165.7	248.6	291.6	271.0	41.4
European Companies	4.3	4.7	13.7	12.2	11.3	27.3
Joint Venture Companies	.0	.0	.0	.0	.0	NM
Total Wet Process	167.2	276.9	376.8	400.0	405.0	24.8
Dry Strip						
North American Companies	25.4	38.6	39.8	37.8	38.8	11.2
Japanese Companies	27.5	51.6	68.3	68.2	59.4	21.2
European Companies	.0	.0	.0	.0	.0	NM
Joint Venture Companies	5.0	10.2	13.1	11.7	20.9	43.0
Total Dry Strip	57.9	100.4	121.2	117.7	119.1	19.8
Dry Etch						
North American Companies	210.3	364.0	388.0	358.7	356.2	14.1
Japanese Companies	72.5	153.5	258.3	294.6	313.7	44.2
European Companies	7.2	15.7	17.0	23.0	18.3	26.3
Joint Venture Companies	17.4	.0	6.2	14.1	16.5	(1.3)
Total Dry Etch	307.4	533.2	669.5	690.4	704.7	23.0
Deposition						
CVD						
North American Companies	138.0	258.2	372.3	416.4	418.5	32.0
Japanese Companies	35.3	104.6	143.6	170.6	195.4	53.4
European Companies	78.0	100.1	91.3	101.9	97.1	5.6
Joint Venture Companies	8.8	3.5	4.0	27.6	36.4	42.6
Total CVD	260.1	466.4	611.2	716.5	747.4	30.2

(Continued)

Table 2.2 (Continued)
Each Regional Company Base's Revenue from Shipments of Wafer Fab Equipment to the World (End User Revenue in Millions of U.S. Dollars)

Company:	Each Regional Company Base
Product:	Each
Region Of Consumption:	The World

	1987	1988	1989	1990	1991	CAGR (%) 1987-1991
PVD						
North American Companies	102.0	132.4	157.7	123.0	173.5	14.2
Japanese Companies	102.7	129.7	161.1	236.1	271.3	27.5
European Companies	46.2	39.9	49.6	49.4	29.2	(10.8)
Joint Venture Companies	.0	.0	.0	.0	.0	NM
Total PVD	250.9	302.0	368.4	408.5	474.0	17.2
Silicon Epitaxy						
North American Companies	33.4	67.2	46.9	36.8	35.3	1.4
Japanese Companies	2.1	6.2	12.2	6.7	18.4	72.0
European Companies	.0	12.1	15.9	24.7	34.9	NM
Joint Venture Companies	.0	.0	.0	.0	.0	NM
Total Silicon Epitaxy	35.5	85.5	75.0	68.2	88.6	25.7
Metalorganic CVD						
North American Companies	10.2	13.1	15.7	17.0	18.5	16.0
Japanese Companies	10.5	13.7	14.5	11.2	16.9	12.6
European Companies	11.0	13.5	14.4	16.1	16.0	9.8
Joint Venture Companies	2.9	1.7	.0	.0	.0	NM
Total MOCVD	34.6	42.0	44.6	44.3	51.4	10.4
Molecular Beam Epitaxy						
North American Companies	17.1	20.3	17.2	4.7	5.2	(25.7)
Japanese Companies	16.6	21.6	15.5	15.6	24.7	10.4
European Companies	34.3	39.0	41.3	37.7	29.0	(4.1)
Joint Venture Companies	.0	.0	.0	.0	.0	NM
Total MBE	68.0	80.9	74.0	58.0	58.9	(3.5)
Total Deposition						
North American Companies	300.7	491.2	609.8	597.9	651.0	21.3
Japanese Companies	167.2	275.8	346.9	440.2	526.7	33.2
European Companies	169.5	204.6	212.5	229.8	206.2	5.0
Joint Venture Companies	11.7	5.2	4.0	27.6	36.4	32.8
Total Deposition	649.1	976.8	1,173.2	1,295.5	1,420.3	21.6
Diffusion						
North American Companies	65.3	115.9	117.2	100.3	88.6	7.9
Japanese Companies	33.3	141.2	159.5	167.9	203.8	57.3
European Companies	21.5	26.9	35.3	33.0	28.9	7.7
Joint Venture Companies	25.3	11.5	18.6	22.8	13.8	(14.1)
Total Diffusion	145.4	295.5	330.6	324.0	335.1	23.2

(Continued)

Table 2.2 (Continued)
Each Regional Company Base's Revenue from Shipments of Wafer Fab Equipment to the World (End User Revenue in Millions of U.S. Dollars)

Company: Each Regional Company Base
Product: Each
Region Of Consumption: The World

	1987	1988	1989	1990	1991	CAGR (%) 1987-1991
Rapid Thermal Processing						
North American Companies	16.3	19.3	21.2	25.0	35.6	21.6
Japanese Companies	1.2	1.8	2.4	3.0	2.9	24.7
European Companies	.7	1.2	1.5	1.7	3.3	47.4
Joint Venture Companies	.0	.0	.0	.0	.0	NM
Total RTP	18.2	22.3	25.1	29.7	41.8	23.1
Ion Implantation						
North American Companies	107.0	197.6	223.7	199.7	191.6	15.7
Japanese Companies	26.8	53.3	82.9	64.8	63.5	24.1
European Companies	2.8	4.2	1.6	.0	.0	NM
Joint Venture Companies	49.3	122.3	148.4	105.3	88.1	15.6
Total Ion Impantation	185.9	377.4	456.6	369.8	343.2	16.6
Optical CD						
North American Companies	10.4	28.7	37.6	34.4	38.5	38.7
Japanese Companies	15.1	27.7	19.1	11.8	12.5	(4.6)
European Companies	16.8	23.0	12.9	12.7	8.3	(16.2)
Joint Venture Companies	.0	.0	.0	.0	.0	NM
Total Optical CD	42.3	79.4	69.6	58.9	59.3	8.8
CD SEM						
North American Companies	3.9	6.4	16.0	11.5	12.9	34.9
Japanese Companies	32.9	53.2	64.6	76.1	81.4	25.4
European Companies	9.6	12.0	.0	.0	.0	NM
Joint Venture Companies	.0	.0	.0	.0	.0	NM
Total CD SEM	46.4	71.6	80.6	87.6	94.3	19.4
Wafer Inspection						
North American Companies	35.4	62.1	74.6	55.2	40.6	3.5
Japanese Companies	15.5	26.1	28.8	22.3	37.3	24.6
European Companies	6.8	12.3	13.8	13.3	11.8	14.8
Joint Venture Companies	.0	.0	.0	.0	.0	NM
Total Wafer Insp.	57.7	100.5	117.2	90.8	89.7	11.7
Subtotal Fab Equipment*						
North American Companies	1,200.8	1,853.1	1,986.1	1,827.5	1,842.3	11.3
Japanese Companies	1,004.3	1,895.4	2,513.0	2,601.6	2,763.4	28.8
European Companies	322.4	417.9	486.9	460.5	406.2	5.9
Joint Venture Companies	108.7	149.2	209.7	195.3	192.8	15.4
Subtotal Fab Equipment	2,636.2	4,315.6	5,195.7	5,084.9	5,204.7	18.5

(Continued)

Table 2.2 (Continued)
Each Regional Company Base's Revenue from Shipments of Wafer Fab Equipment to the World (End User Revenue in Millions of U.S. Dollars)

Company: Each Regional Company Base
Product: Each
Region Of Consumption: The World

	1987	1988	1989	1990	1991	CAGR (%) 1987-1991
Ion Milling						
All Companies	7.8	9.5	12.5	13.0	16.7	21.0
Other Process Control						
All Companies	285.7	355.4	404.4	368.0	398.0	8.6
Factory Automation						
All Companies	99.0	130.0	195.0	216.0	227.0	23.1
Other Equipment						
All Companies	111.9	177.3	209.8	189.4	193.1	14.6
Total Fab Equip.	3,140.6	4,987.8	6,017.4	5,871.3	6,039.5	17.8

*Subtotal Fab Equipment does not include Ion Milling, Other Process Control, Factory Automation, and Other Equipment categories as detailed company data is not complete for these categories. Aggregate data for these categories are added to provide a consistent total for the worldwide wafer fab equipment market.

The category of Optical CD includes dedicated overlay tools, in addition to joint linewidth/overlay measurement systems.

NM = Not Meaningful

Ref: SUMMSHR

Source: Dataquest (April 1992)

Chapter 3

Wafer Fab Equipment—Import/Export Data

This section of the equipment database consists of two summary tables that provide information on the import/export markets for the worldwide wafer fab equipment market. In both Table 3.1 and Table 3.2, the worldwide fab equipment market total in millions of U.S. dollars is listed at the beginning of the table and followed by the subtotal for fab equipment. The subtotal fab equipment line item includes all of the front-end equipment categories for which detailed company analysis has been made and accounts for 86 percent of all front-end equipment for 1991. For some equipment categories (Ion Milling, Other Process Control, Factory Automation, and Other Equipment), detailed company analysis is not yet complete. For these categories, which account for the remaining 14 percent of wafer fab equipment, a top-down estimate has been made and included in Tables 3.1 and 3.2 so that worldwide fab equipment sales are consistent across all tables.

The subtotal fab equipment market includes all of the major wafer fab equipment categories and accounts for the majority of all import/export activity in the worldwide fab equipment market. Relatively little import/export activity exists for the remaining 14 percent of wafer fab equipment for which detailed company data are not yet complete. These equipment markets are largely supplied by domestic suppliers. Significant import/export analysis of the fab equipment market can be done, however, with the aid of the data in Tables 3.1 and 3.2.

Table 3.1
Each Regional Company Base's Revenue from Shipments of Wafer Fab Equipment to Each Region of the World (End User Revenue in Millions of U.S. Dollars)

Company: Each Regional Company Base
Product: All
Region Of Consumption: Each

	1987	1988	1989	1990	1991	CAGR (%) 1987-1991
World Fab Equipment Market	3,140.6	4,987.8	6,017.4	5,871.3	6,039.5	17.8
Subtotal Fab Equip.*	2,636.2	4,315.6	5,195.7	5,084.9	5,204.7	18.5
Subtotal Percent (%)	83.9	86.5	86.3	86.6	86.2	
Subtotal Fab Equipment						
North America						
N. American Co. Sales	697.6	1,000.2	1,001.7	954.7	854.2	5.2
Japanese Co. Sales	123.7	177.1	230.1	261.6	301.0	24.9
European Co. Sales	112.7	156.8	180.9	149.7	137.7	5.1
Joint Venture Co. Sales	.0	.0	25.4	17.3	33.5	NM
Subtotal N. America Market	934.0	1,334.1	1,438.1	1,383.3	1,326.4	9.2
Japan						
N. American Co. Sales	149.7	322.0	355.1	381.7	455.3	32.1
Japanese Co. Sales	767.9	1,443.9	1,838.0	1,984.9	1,950.7	26.2
European Co. Sales	37.8	44.3	44.9	70.6	64.7	14.4
Joint Venture Co. Sales	108.7	148.2	176.3	155.2	129.5	4.5
Subtotal Japan Market	1,064.1	1,958.4	2,414.3	2,592.4	2,600.2	25.0
Europe						
N. American Co. Sales	241.9	304.1	314.5	288.6	265.8	2.4
Japanese Co. Sales	54.5	82.4	99.9	166.8	122.7	22.5
European Co. Sales	152.8	184.5	201.0	189.6	132.8	-3.4
Joint Venture Co. Sales	.0	1.0	8.0	22.8	25.5	NM
Subtotal Europe Market	449.2	572.0	623.4	667.8	546.8	5.0
Asia/Pacific-ROW						
N. American Co. Sales	111.6	226.8	314.8	202.5	267.0	24.4
Japanese Co. Sales	58.2	192.0	345.0	188.3	389.0	60.8
European Co. Sales	19.1	32.3	60.1	50.6	71.0	38.9
Joint Venture Co. Sales	.0	.0	.0	.0	4.3	NM
Subtotal Asia/Pacific-ROW Market	188.9	451.1	719.9	441.4	731.3	40.3
Worldwide						
N. American Co. Sales	1,200.8	1,853.1	1,986.1	1,827.5	1,842.3	11.3
Japanese Co. Sales	1,004.3	1,895.4	2,513.0	2,601.6	2,763.4	28.8
European Co. Sales	322.4	417.9	486.9	460.5	406.2	5.9
Joint Venture Co. Sales	108.7	149.2	209.7	195.3	192.8	15.4
Subtotal Fab Equip.	2,636.2	4,315.6	5,195.7	5,084.9	5,204.7	18.5

(Continued)

Table 3.1 (Continued)
Each Regional Company Base's Revenue from Shipments of Wafer Fab Equipment to Each Region of the World (End User Revenue in Millions of U.S. Dollars)

Company: Each Regional Company Base
Product: All
Region Of Consumption: Each

	1987	1988	1989	1990	1991	CAGR (%) 1987-1991
Ion Milling						
All Companies	7.8	9.5	12.5	13.0	16.7	21.0
Other Process Control						
All Companies	285.7	355.4	404.4	368.0	398.0	8.6
Factory Automation						
All Companies	99.0	130.0	195.0	216.0	227.0	23.1
Other Equipment						
All Companies	111.9	177.3	209.8	189.4	193.1	14.6
Total Fab Equipment	3,140.6	4,987.8	6,017.4	5,871.3	6,039.5	17.8

*Subtotal Fab Equipment does not include Ion Milling, Other Process Control, Factory Automation, and Other Equipment categories, as detailed company data are not complete for these categories. Aggregate data for these categories are added to provide a consistent total for the worldwide wafer fab equipment market.

NM = Not Meaningful

Ref: IMEXSHR

Source: Dataquest (April 1992)

Table 3.2
Each Regional Company Base's Revenue from Shipments of Wafer Fab Equipment into Each Region of the World
(End User Revenue in Millions of U.S. Dollars)

Company: All
Product: All
Region Of Consumption: All

	1987	1988	1989	1990	1991	CAGR (%) 1987-1991
World Fab Equipment Market	3140.6	4987.8	6017.4	5871.3	6039.5	17.8
Subtotal Fab Equipment*	2636.2	4315.6	5195.7	5084.9	5204.7	18.5
Subtotal Percent (%)	83.9	86.5	86.3	86.6	86.2	
Subtotal Fab Equipment						
N. American Equipment Companies						
Sales in North America	697.6	1000.2	1001.7	954.7	854.2	5.2
Sales in Japan	149.7	322.0	355.1	381.7	455.3	32.1
Sales in Europe	241.9	304.1	314.5	288.6	265.8	2.4
Sales in Asia/Pacific-ROW	111.6	226.8	314.8	202.5	267.0	24.4
Total N. American Companies	1200.8	1853.1	1986.1	1827.5	1842.3	11.3
Japanese Equipment Companies						
Sales in North America	123.7	177.1	230.1	261.6	301.0	24.9
Sales in Japan	767.9	1443.9	1838.0	1984.9	1950.7	26.2
Sales in Europe	54.5	82.4	99.9	166.8	122.7	22.5
Sales in Asia/Pacific-ROW	58.2	192.0	345.0	188.3	389.0	60.8
Total Japanese Companies	1004.3	1895.4	2513.0	2601.6	2763.4	28.8
European Equipment Companies						
Sales in North America	112.7	156.8	180.9	149.7	137.7	5.1
Sales in Japan	37.8	44.3	44.9	70.6	64.7	14.4
Sales in Europe	152.8	184.5	201.0	189.6	132.8	-3.4
Sales in Asia/Pacific-ROW	19.1	32.3	60.1	50.6	71.0	38.9
Total European Companies	322.4	417.9	486.9	460.5	406.2	5.9
Joint Venture Equipment Companies						
Sales in North America	.0	.0	25.4	17.3	33.5	NM
Sales in Japan	108.7	148.2	176.3	155.2	129.5	4.5
Sales in Europe	.0	1.0	8.0	22.8	25.5	NM
Sales in Asia/Pacific-ROW	.0	.0	.0	.0	4.3	NM
Total JV Companies	108.7	149.2	209.7	195.3	192.8	15.4
Subtotal Fab Equip.	2636.2	4315.6	5195.7	5084.9	5204.7	18.5

(Continued)

Table 3.2 (Continued)
Each Regional Company Base's Revenue from Shipments of Wafer Fab Equipment into Each Region of the World
(End User Revenue in Millions of U.S. Dollars)

Company:	All
Product:	All
Region Of Consumption:	All

	1987	1988	1989	1990	1991	CAGR (%) 1987-1991
Ion Milling						
All Companies	7.8	9.5	12.5	13.0	16.7	21.0
Other Process Control						
All Companies	285.7	355.4	404.4	368.0	398.0	8.6
Factory Automation						
All Companies	99.0	130.0	195.0	216.0	227.0	23.1
Other Equipment						
All Companies	111.9	177.3	209.8	189.4	193.1	14.6
Total Fab Equipment	3140.6	4987.8	6017.4	5871.3	6039.5	17.8

*Subtotal Fab Equipment does not include Ion Milling, Other Process Control, Factory Automation, and Other Equipment categories as detailed company data is not complete for these categories. Aggregate data for these categories are added to provide a consistent total for the worldwide wafer fab equipment market.

Ref: IMEXSHR

Source: Dataquest (April 1992)

Chapter 4

Wafer Fab Equipment—Company Shares by Category

This section of the equipment database contains detailed company market share data by region for the major front-end equipment categories as shown in Tables 4.1 through 4.63. All of the companies that participate in an equipment segment are listed for each region, regardless of whether or not they have sales in a particular region. Although this approach results in a large number of zeros in the tables, it also indicates that Dataquest has not recorded any sales for the company in that region. We believe that this format gives more positive information than eliminating a company with no sales in a given region.

At the beginning of each table, the total world market for a particular equipment category is presented. This total is the same for each category as the total listed in Tables 2.1 and 2.2 in Chapter 2 entitled "Wafer Fab Equipment—Summary Data by Category." Thus, all tables are completely consistent as one proceeds from the summary tables to the detailed tables presented here in this section.

Table 4.1
Each Company's Revenue from Shipments of Lithography Equipment to the World By Equipment Category (End User Revenue in Millions of U.S. Dollars)

Company: Each
Product: Lithography
Region Of Consumption: Worldwide

	1987	1988	1989	1990	1991	CAGR (%) 1987-1991
World Lithography Market	791.0	1,228.2	1,441.7	1,294.5	1,223.6	11.5
Contact/Proximity						
Canon	11.0	8.6	6.3	10.5	7.9	
Karl Suss	13.6	13.7	16.3	13.5	12.9	
Total Cont./Prox.	24.6	22.3	22.6	24.0	20.8	-4.1
Projection Aligners						
Canon	40.6	69.1	49.4	56.4	47.2	
Perkin-Elmer	88.0	78.6	44.9	.0	.0	
SVG Lithography	.0	.0	.0	37.0	21.2	
Total Projection	128.6	147.7	94.3	93.4	68.4	-14.6
Steppers						
ASET	11.3	16.0	4.0	.0	.0	
ASM Lithography	36.7	58.6	123.2	91.0	71.3	
Canon	89.8	125.0	182.9	202.2	219.7	
GCA	47.4	104.0	68.9	78.2	46.8	
Hitachi	33.3	49.2	75.5	103.8	86.7	
Nikon	218.8	490.2	653.7	518.4	538.2	
Perkin-Elmer	25.2	5.0	10.2	.0	.0	
SVG Lithography	.0	.0	.0	30.6	30.4	
Ultratech	40.6	73.0	62.3	28.0	36.0	
Total Steppers	503.1	921.0	1,180.7	1,052.2	1,029.1	19.6
Direct-Write Lithography						
ASM Lithography	8.0	7.2	7.2	.0	.0	
Ateq	.0	.0	.0	.0	.0	
Cambridge	10.0	8.0	12.0	.0	.0	
Etec	.0	.0	.0	10.5	.0	
Hitachi	8.7	9.6	9.4	19.5	17.8	
JEOL	30.8	31.1	31.6	35.4	26.8	
Leica	.0	.0	.0	10.8	10.7	
Perkin-Elmer	9.6	12.8	9.9	.0	.0	
Total Direct-Write	67.1	68.7	70.1	76.2	55.3	-4.7

(Continued)

Table 4.1 (Continued)
Each Company's Revenue from Shipments of Lithography Equipment to the World By Equipment Category (End User Revenue in Millions of U.S. Dollars)

Company: Each
Product: Lithography
Region Of Consumption: Worldwide

	1987	1988	1989	1990	1991	CAGR (%) 1987-1991
Maskmaking Lithography						
ASM Lithography	4.0	2.4	2.4	.0	.0	
Ateq	1.6	11.2	13.7	14.0	15.0	
Cambridge	.0	5.0	2.5	.0	.0	
Etec	.0	.0	.0	14.0	10.5	
Hitachi	13.4	3.8	6.6	6.2	6.7	
JEOL	18.1	5.0	15.8	10.4	11.1	
Leica	.0	.0	.0	2.5	2.5	
Perkin-Elmer	27.0	27.0	21.0	.0	.0	
Toshiba	3.5	7.7	7.2	.0	.0	
Total Maskmaking	67.6	62.1	69.2	47.1	45.8	-9.3
X-Ray						
Hampshire Instruments	.0	1.8	.0	.0	2.4	
Perkin-Elmer	.0	.0	2.0	.0	.0	
Karl Suss	.0	4.6	2.8	1.6	1.8	
Total X-Ray	.0	6.4	4.8	1.6	4.2	NM
Total Lithography	791.0	1,228.2	1,441.7	1,294.5	1,223.6	11.5

Ref: LITHSHR
NM = Not Meaningful
Source: Dataquest (April 1992)

Table 4.2
Each Company's Revenue from Shipments of Contact/Proximity Equipment to Each Region (End User Revenue in Millions of U.S. Dollars)

Company: Each
Product: Contact/Proximity
Region Of Consumption: Each

	1987	1988	1989	1990	1991	CAGR (%) 1987-1991
World Cont./Prox. Market	24.6	22.3	22.6	24.0	20.8	-4.1
North America						
Canon	4.5	3.0	1.4	1.1	.5	
Karl Suss	5.5	5.9	5.9	5.1	2.1	
Total North America	10.0	8.9	7.3	6.2	2.6	-28.6
Japan						
Canon	3.6	2.7	2.7	6.2	6.2	
Karl Suss	1.6	1.3	3.0	2.4	1.7	
Total Japan	5.2	4.0	5.7	8.6	7.9	11.0
Europe						
Canon	1.5	1.5	.8	1.1	.5	
Karl Suss	3.5	3.9	5.2	4.2	6.5	
Total Europe	5.0	5.4	6.0	5.3	7.0	8.8
Asia-Pacific/ROW						
Canon	1.4	1.4	1.4	2.1	.7	
Karl Suss	3.0	2.6	2.2	1.8	2.6	
Total A/P-ROW	4.4	4.0	3.6	3.9	3.3	-6.9
Worldwide						
Canon	11.0	8.6	6.3	10.5	7.9	
Karl Suss	13.6	13.7	16.3	13.5	12.9	
Total Worldwide	24.6	22.3	22.6	24.0	20.8	-4.1

Ref: CONTSHR
Source: Dataquest (April 1992)

Table 4.3
Each Company's Revenue from Shipments of Projection Aligner Equipment to Each Region (End User Revenue in Millions of U.S. Dollars)

Company: Each
Product: Projection Aligner
Region Of Consumption: Each

	1987	1988	1989	1990	1991	CAGR (%) 1987-1991
World Projection Market	128.6	147.7	94.3	93.4	68.4	-14.6
North America						
Canon	8.4	12.0	8.4	14.6	6.2	
Perkin-Elmer	58.0	48.7	14.0	.0	.0	
SVG Lithography	.0	.0	.0	10.2	8.6	
Total North America	66.4	60.7	22.4	24.8	14.8	-31.3
Japan						
Canon	21.7	52.3	36.0	27.7	25.2	
Perkin-Elmer	15.0	11.0	7.9	.0	.0	
SVG Lithography	.0	.0	.0	9.2	5.5	
Total Japan	36.7	63.3	43.9	36.9	30.7	-4.4
Europe						
Canon	6.3	3.2	2.5	4.9	2.1	
Perkin-Elmer	11.0	13.1	10.5	.0	.0	
SVG Lithography	.0	.0	.0	10.2	5.5	
Total Europe	17.3	16.3	13.0	15.1	7.6	-18.6
Asia-Pacific/ROW						
Canon	4.2	1.6	2.5	9.2	13.7	
Perkin-Elmer	4.0	5.8	12.5	.0	.0	
SVG Lithography	.0	.0	.0	7.4	1.6	
Total A/P-ROW	8.2	7.4	15.0	16.6	15.3	16.9
Worldwide						
Canon	40.6	69.1	49.4	56.4	47.2	
Perkin-Elmer	88.0	78.6	44.9	.0	.0	
SVG Lithography	.0	.0	.0	37.0	21.2	
Total Worldwide	128.6	147.7	94.3	93.4	68.4	-14.6

Ref: PROJSHR
Source: Dataquest (April 1992)

Table 4.4
Each Company's Revenue from Shipments of Stepper Equipment to Each Region (End User Revenue in Millions of U.S. Dollars)

Company: Each
Product: Steppers
Region Of Consumption: Each

	1987	1988	1989	1990	1991	CAGR (%) 1987-1991
World Stepper Market	503.1	921.0	1,180.7	1,052.2	1,029.1	19.6
North America						
ASET	10.4	14.0	4.0	.0	.0	
ASM Lithography	19.6	39.0	82.6	49.7	40.7	
Canon	25.2	25.0	31.2	41.7	47.7	
GCA	36.7	80.6	53.0	68.2	38.2	
Hitachi	.0	.0	.0	6.2	.0	
Nikon	44.0	71.5	112.0	75.6	117.8	
Perkin-Elmer	18.0	5.0	10.2	.0	.0	
SVG Lithography	.0	.0	.0	30.6	15.0	
Ultratech	30.1	44.9	43.4	17.0	18.1	
Total North America	184.0	280.0	336.4	289.0	277.5	10.8
Japan						
ASET	.0	.0	.0	.0	.0	
ASM Lithography	.0	.0	.0	.0	.0	
Canon	24.1	45.0	64.7	92.4	99.5	
GCA	4.4	3.9	.0	.0	1.7	
Hitachi	33.3	49.2	75.5	96.4	50.7	
Nikon	151.0	336.2	390.5	344.2	334.9	
Perkin-Elmer	.0	.0	.0	.0	.0	
SVG Lithography	.0	.0	.0	.0	7.8	
Ultratech	.0	2.3	1.7	2.5	7.5	
Total Japan	212.8	436.6	532.4	535.5	502.1	23.9
Europe						
ASET	.9	.0	.0	.0	.0	
ASM Lithography	17.1	16.9	23.2	27.1	9.0	
Canon	18.0	20.0	37.5	41.7	29.0	
GCA	6.3	18.2	15.9	4.5	5.2	
Hitachi	.0	.0	.0	.0	.0	
Nikon	6.2	22.0	25.2	54.0	39.1	
Perkin-Elmer	2.7	.0	.0	.0	.0	
SVG Lithography	.0	.0	.0	.0	7.6	
Ultratech	7.3	12.9	8.8	4.5	4.2	
Total Europe	58.5	90.0	110.6	131.8	94.1	12.6

(Continued)

Table 4.4 (Continued)
Each Company's Revenue from Shipments of Stepper Equipment to Each Region
(End User Revenue in Millions of U.S. Dollars)

Company: Each
Product: Steppers
Region Of Consumption: Each

	1987	1988	1989	1990	1991	CAGR (%) 1987-1991
Asia/Pacific-ROW						
ASET	.0	2.0	.0	.0	.0	
ASM Lithography	.0	2.7	17.4	14.2	21.6	
Canon	22.5	35.0	49.5	26.4	43.5	
GCA	.0	1.3	.0	5.5	1.7	
Hitachi	.0	.0	.0	1.2	36.0	
Nikon	17.6	60.5	126.0	44.6	46.4	
Perkin-Elmer	4.5	.0	.0	.0	.0	
SVG Lithography	.0	.0	.0	.0	.0	
Ultratech	3.2	12.9	8.4	4.0	6.2	
Total A/P-ROW	47.8	114.4	201.3	95.9	155.4	34.3
Worldwide						
ASET	11.3	16.0	4.0	.0	.0	
ASM Lithography	36.7	58.6	123.2	91.0	71.3	
Canon	89.8	125.0	182.9	202.2	219.7	
GCA	47.4	104.0	68.9	78.2	46.8	
Hitachi	33.3	49.2	75.5	103.8	86.7	
Nikon	218.8	490.2	653.7	518.4	538.2	
Perkin-Elmer	25.2	5.0	10.2	.0	.0	
SVG Lithography	.0	.0	.0	30.6	30.4	
Ultratech	40.6	73.0	62.3	28.0	36.0	
Total Worldwide	503.1	921.0	1,180.7	1,052.2	1,029.1	19.6

Ref: STEPSHR
Source: Dataquest (April 1992)

Table 4.5
Each Company's Unit Shipments of Stepper Equipment to Each Region
(Units)

Company: Each
Product: Steppers
Region Of Consumption: Each

	1987	1988	1989	1990	1991	CAGR (%) 1987-1991
World Stepper Market	520	833	954	771	679	6.9
North America						
ASET	11	14	4	0	0	
ASM Lithography	16	30	57	33	23	
Canon	28	25	25	30	30	
GCA	41	62	40	44	26	
Hitachi	0	0	0	5	0	
Nikon	50	65	80	56	80	
Perkin-Elmer	20	5	3	0	0	
SVG Lithography	0	0	0	9	4	
Ultratech	37	41	45	20	19	
Total North America	203	242	254	197	182	-2.7
Japan						
ASET	0	0	0	0	0	
ASM Lithography	0	0	0	0	0	
Canon	20	45	60	70	65	
GCA	4	3	0	0	1	
Hitachi	30	40	70	78	38	
Nikon	148	310	325	255	215	
Perkin-Elmer	0	0	0	0	0	
SVG Lithography	0	0	0	0	2	
Ultratech	0	3	2	3	9	
Total Japan	202	401	457	406	330	13.1
Europe						
ASET	1	0	0	0	0	
ASM Lithography	14	13	16	15	5	
Canon	20	20	30	30	20	
GCA	7	14	12	4	3	
Hitachi	0	0	0	0	0	
Nikon	7	20	18	40	25	
Perkin-Elmer	3	0	0	0	0	
SVG Lithography	0	0	0	0	2	
Ultratech	9	14	10	6	5	
Total Europe	61	81	86	95	60	-.4

(Continued)

Table 4.5 (Continued)
Each Company's Unit Shipments of Stepper Equipment to Each Region (Units)

Company:	Each
Product:	Steppers
Region Of Consumption:	Each

	1987	1988	1989	1990	1991	CAGR (%) 1987-1991
Asia/Pacific-ROW						
ASET	0	2	0	0	0	
ASM Lithography	0	2	12	10	12	
Canon	25	35	45	20	30	
GCA	0	1	0	4	1	
Hitachi	0	0	0	1	27	
Nikon	20	55	90	33	30	
Perkin-Elmer	5	0	0	0	0	
SVG Lithography	0	0	0	0	0	
Ultratech	4	14	10	5	7	
Total Asia/Pacific-ROW	54	109	157	73	107	18.6
Worldwide						
ASET	12	16	4	0	0	
ASM Lithography	30	45	85	58	40	
Canon	93	125	160	150	145	
GCA	52	80	52	52	31	
Hitachi	30	40	70	84	65	
Nikon	225	450	513	384	350	
Perkin-Elmer	28	5	3	0	0	
SVG Lithography	0	0	0	9	8	
Ultratech	50	72	67	34	40	
Total Worldwide	520	833	954	771	679	6.9

Ref: STEPUNIT
Source: Dataquest (April 1992)

Table 4.6
Each Company's Revenue from Shipments of Direct-Write Lithography Equipment Each Region (End User Revenue in Millions of U.S. Dollars)

Company: Each
Product: Direct-Write Lithography
Region Of Consumption: Each

	1987	1988	1989	1990	1991	CAGR (%) 1987-1991
World Direct-Write Market	67.1	68.7	70.1	76.2	55.3	-4.7
North America						
ASM Lithography	4.0	2.4	.0	.0	.0	
Ateq	.0	.0	.0	.0	.0	
Cambridge Instruments	4.0	2.0	4.0	.0	.0	
Etec	.0	.0	.0	.0	.0	
Hitachi	.0	.0	.0	5.6	.0	
JEOL	6.0	6.0	6.0	8.3	3.0	
Leica	.0	.0	.0	2.0	4.3	
Perkin-Elmer	3.2	3.2	.0	.0	.0	
Total North America	17.2	13.6	10.0	15.9	7.3	-19.3
Japan						
ASM Lithography	.0	.0	.0	.0	.0	
Ateq	.0	.0	.0	.0	.0	
Cambridge Instruments	.0	.0	.0	.0	.0	
Etec	.0	.0	.0	.0	.0	
Hitachi	8.7	9.6	9.4	8.3	17.8	
Leica	.0	.0	.0	.0	.0	
JEOL	20.8	23.1	21.6	18.8	17.8	
Perkin-Elmer	3.2	3.2	3.5	.0	.0	
Total Japan	32.7	35.9	34.5	27.1	35.6	2.1
Europe						
ASM Lithography	4.0	4.8	7.2	.0	.0	
Ateq	.0	.0	.0	.0	.0	
Cambridge Instruments	4.0	4.0	6.0	.0	.0	
Etec	.0	.0	.0	7.0	.0	
Hitachi	.0	.0	.0	.0	.0	
JEOL	4.0	2.0	4.0	8.3	3.0	
Leica	.0	.0	.0	8.8	4.3	
Perkin-Elmer	3.2	6.4	3.2	.0	.0	
Total Europe	15.2	17.2	20.4	24.1	7.3	-16.8

(Continued)

Table 4.6 (Continued)
Each Company's Revenue from Shipments of Direct-Write Lithography Equipment Each Region (End User Revenue in Millions of U.S. Dollars)

Company: Each
Product: Direct-Write Lithography
Region Of Consumption: Each

	1987	1988	1989	1990	1991	CAGR (%) 1987-1991
Asia/Pacific-ROW						
ASM Lithography	.0	.0	.0	.0	.0	
Ateq	.0	.0	.0	.0	.0	
Cambridge Instruments	2.0	2.0	2.0	.0	.0	
Etec	.0	.0	.0	3.5	.0	
Hitachi	.0	.0	.0	5.6	.0	
JEOL	.0	.0	.0	.0	3.0	
Leica	.0	.0	.0	.0	2.1	
Perkin-Elmer	.0	.0	3.2	.0	.0	
Total Asia/Pacific-ROW	2.0	2.0	5.2	9.1	5.1	26.4
Worldwide						
ASM Lithography	8.0	7.2	7.2	.0	.0	
Ateq	.0	.0	.0	.0	.0	
Cambridge Instruments	10.0	8.0	12.0	.0	.0	
Etec	.0	.0	.0	10.5	.0	
Hitachi	8.7	9.6	9.4	19.5	17.8	
JEOL	30.8	31.1	31.6	35.4	26.8	
Leica	.0	.0	.0	10.8	10.7	
Perkin-Elmer	9.6	12.8	9.9	.0	.0	
Total Worldwide	67.1	68.7	70.1	76.2	55.3	-4.7

Ref: DWLTHSHR
Source: Dataquest (April 1992)

Table 4.7
Each Company's Revenue from Shipments of Maskmaking Lithography Equipment to Each Region (End User Revenue in Millions of U.S. Dollars)

Company:	Each
Product:	Maskmaking Lithography
Region Of Consumption:	Each

	1987	1988	1989	1990	1991	CAGR (%) 1987-1991
World Maskmaking Market	67.6	62.1	69.2	47.1	45.8	-9.3
North America						
ASM Lithography	.0	2.4	2.4	.0	.0	
Ateq	1.6	1.6	4.0	11.2	6.0	
Cambridge Instruments	.0	.0	.0	.0	.0	
Etec Systems	.0	.0	.0	3.5	3.5	
Hitachi	.0	.0	.0	.0	.0	
JEOL	.0	.0	.0	.0	.0	
Leica	.0	.0	.0	.0	.0	
Perkin-Elmer	12.0	12.0	9.0	.0	.0	
Toshiba	.0	.0	.0	.0	.0	
Total North America	13.6	16.0	15.4	14.7	9.5	-8.6
Japan						
ASM Lithography	.0	.0	.0	.0	.0	
Ateq	.0	8.0	7.5	2.8	6.0	
Cambridge Instruments	.0	.0	.0	.0	.0	
Etec Systems	.0	.0	.0	3.5	3.5	
Hitachi	10.4	3.8	6.6	6.2	6.7	
JEOL	18.1	5.0	15.8	10.4	11.1	
Leica	.0	.0	.0	.0	2.5	
Perkin-Elmer	6.0	3.0	3.0	.0	.0	
Toshiba	3.5	7.7	7.2	.0	.0	
Total Japan	38.0	27.5	40.1	22.9	29.8	-5.9
Europe						
ASM Lithography	4.0	.0	.0	.0	.0	
Ateq	.0	1.6	2.2	.0	3.0	
Cambridge Instruments	.0	.0	.0	.0	.0	
Etec Systems	.0	.0	.0	3.5	.0	
Hitachi	3.0	.0	.0	.0	.0	
JEOL	.0	.0	.0	.0	.0	
Leica	.0	.0	.0	.0	.0	
Perkin-Elmer	6.0	6.0	6.0	.0	.0	
Toshiba	.0	.0	.0	.0	.0	
Total Europe	13.0	7.6	8.2	3.5	3.0	-30.7

(Continued)

Table 4.7 (Continued)
Each Company's Revenue from Shipments of Maskmaking Lithography Equipment to Each Region
(End User Revenue in Millions of U.S. Dollars)

Company: Each
Product: Maskmaking Lithography
Region Of Consumption: Each

	1987	1988	1989	1990	1991	CAGR (%) 1987-1991
Asia/Pacific-ROW						
ASM Lithography	.0	.0	.0	.0	.0	
Ateq	.0	.0	.0	.0	.0	
Cambridge Instruments	.0	5.0	2.5	.0	.0	
Etec Systems	.0	.0	.0	3.5	3.5	
Hitachi	.0	.0	.0	.0	.0	
JEOL	.0	.0	.0	.0	.0	
Leica	.0	.0	.0	2.5	.0	
Perkin-Elmer	3.0	6.0	3.0	.0	.0	
Toshiba	.0	.0	.0	.0	.0	
Total Asia/Pacific-ROW	3.0	11.0	5.5	6.0	3.5	3.9
Worldwide						
ASM Lithography	4.0	2.4	2.4	.0	.0	
Ateq	1.6	11.2	13.7	14.0	15.0	
Cambridge Instruments	.0	5.0	2.5	.0	.0	
Etec Systems	.0	.0	.0	14.0	10.5	
Hitachi	13.4	3.8	6.6	6.2	6.7	
JEOL	18.1	5.0	15.8	10.4	11.1	
Leica	.0	.0	.0	2.5	2.5	
Perkin-Elmer	27.0	27.0	21.0	.0	.0	
Toshiba	3.5	7.7	7.2	.0	.0	
Total Worldwide	67.6	62.1	69.2	47.1	45.8	-9.3

Ref: MMLITHSHR
Source: Dataquest (April 1992)

Table 4.8
Each Company's Revenue from Shipments of Direct-Write and Maskmaking Lithography Equipment to Each Region
(End User Revenue in Millions of U.S. Dollars)

Company: Each
Product: Direct-Write and Maskmaking Lithography
Region Of Consumption: Each

	1987	1988	1989	1990	1991	CAGR (%) 1987-1991
World Direct-Write and Maskmaking Lithography Market	134.7	130.8	139.3	123.3	101.1	-6.9
North America						
ASM Lithography	4.0	4.8	2.4	.0	.0	
Ateq	1.6	1.6	4.0	11.2	6.0	
Cambridge Instruments	4.0	2.0	4.0	.0	.0	
Etec	.0	.0	.0	3.5	3.5	
Hitachi	.0	.0	.0	5.6	.0	
JEOL	6.0	6.0	6.0	8.3	3.0	
Leica	.0	.0	.0	2.0	4.3	
Perkin-Elmer	15.2	15.2	9.0	.0	.0	
Toshiba	.0	.0	.0	.0	.0	
Total North America	30.8	29.6	25.4	30.6	16.8	-14.1
Japan						
ASM Lithography	.0	.0	.0	.0	.0	
Ateq	.0	8.0	7.5	2.8	6.0	
Cambridge Instruments	.0	.0	.0	.0	.0	
Etec	.0	.0	.0	3.5	3.5	
Hitachi	19.1	13.4	16.0	14.5	24.5	
JEOL	38.9	28.1	37.4	29.2	28.9	
Leica	.0	.0	.0	.0	2.5	
Perkin-Elmer	9.2	6.2	6.5	.0	.0	
Toshiba	3.5	7.7	7.2	.0	.0	
Total Japan	70.7	63.4	74.6	50.0	65.4	-1.9
Europe						
ASM Lithography	8.0	4.8	7.2	.0	.0	
Ateq	.0	1.6	2.2	.0	3.0	
Cambridge Instruments	4.0	4.0	6.0	.0	.0	
Etec	.0	.0	.0	10.5	.0	
Hitachi	3.0	.0	.0	.0	.0	
JEOL	4.0	2.0	4.0	8.3	3.0	
Leica	.0	.0	.0	8.8	4.3	
Perkin-Elmer	9.2	12.4	9.2	.0	.0	
Toshiba	.0	.0	.0	.0	.0	
Total Europe	28.2	24.8	28.6	27.6	10.3	-22.3

(Continued)

Table 4.8 (Continued)
Each Company's Revenue from Shipments of Direct-Write and Maskmaking Lithography Equipment to Each Region
(End User Revenue in Millions of U.S. Dollars)

Company: Each
Product: Direct-Write and Maskmaking Lithography
Region Of Consumption: Each

	1987	1988	1989	1990	1991	CAGR (%) 1987-1991
Asia/Pacific-ROW						
ASM Lithography	.0	.0	.0	.0	.0	
Ateq	.0	.0	.0	.0	.0	
Cambridge Instruments	2.0	7.0	4.5	.0	.0	
Etec	.0	.0	.0	7.0	3.5	
Hitachi	.0	.0	.0	5.6	.0	
JEOL	.0	.0	.0	.0	3.0	
Leica	.0	.0	.0	2.5	2.1	
Perkin-Elmer	3.0	6.0	6.2	.0	.0	
Toshiba	.0	.0	.0	.0	.0	
Total Asia/Pacific-ROW	5.0	13.0	10.7	15.1	8.6	14.5
Worldwide						
ASM Lithography	12.0	9.6	9.6	.0	.0	
Ateq	1.6	11.2	13.7	14.0	15.0	
Cambridge Instruments	10.0	13.0	14.5	.0	.0	
Etec	.0	.0	.0	24.5	10.5	
Hitachi	22.1	13.4	16.0	25.7	24.5	
JEOL	48.9	36.1	47.4	45.8	37.9	
Leica	.0	.0	.0	13.3	13.2	
Perkin-Elmer	36.6	39.8	30.9	.0	.0	
Toshiba	3.5	7.7	7.2	.0	.0	
Total Worldwide	134.7	130.8	139.3	123.3	101.1	-6.9

Ref: DWMMSHR
Source: Dataquest (April 1992)

Table 4.9
Each Company's Revenue from Shipments of X-Ray Aligner Equipment to Each Region (End User Revenue in Millions of U.S. Dollars)

Company: Each
Product: X-Ray Aligner
Region Of Consumption: Each

	1987	1988	1989	1990	1991	CAGR (%) 1987-1991
World X-Ray Market	.0	6.4	4.8	1.6	4.2	NM
North America						
Hampshire Instruments	.0	1.8	.0	.0	2.4	
Perkin-Elmer	.0	.0	2.0	.0	.0	
Karl Suss	.0	1.6	.0	.0	.0	
Total North America	.0	3.4	2.0	.0	2.4	NM
Japan						
Hampshire Instruments	.0	.0	.0	.0	.0	
Perkin-Elmer	.0	.0	.0	.0	.0	
Karl Suss	.0	1.6	.0	.0	1.8	
Total Japan	.0	1.6	.0	.0	1.8	NM
Europe						
Hampshire Instruments	.0	.0	.0	.0	.0	
Perkin-Elmer	.0	.0	.0	.0	.0	
Kark Suss	.0	1.4	2.8	1.6	.0	
Total Europe	.0	1.4	2.8	1.6	.0	NM
Asia/Pacific-ROW						
Hampshire Instruments	.0	.0	.0	.0	.0	
Perkin-Elmer	.0	.0	.0	.0	.0	
Karl Suss	.0	.0	.0	.0	.0	
Total Asia/Pacific-ROW	.0	.0	.0	.0	.0	NM
Worldwide						
Hampshire Instruments	.0	1.8	.0	.0	2.4	
Perkin-Elmer	.0	.0	2.0	.0	.0	
Karl Suss	.0	4.6	2.8	1.6	1.8	
Total Worldwide	.0	6.4	4.8	1.6	4.2	NM

Ref: XRAYSHR
NM = Not Meaningful
Source: Dataquest (April 1992)

Table 4.10
Each Company's Revenue from Shipments of Automatic Photoresist Processing Equipment (Track) to Each Region
(End User Revenue in Millions of U.S. Dollars)

Company: Each
Product: Track
Region Of Consumption: Each

	1987	1988	1989	1990	1991	CAGR (%) 1987-1991
World Track Market	167.7	253.4	333.6	326.0	368.6	21.8
North America						
Canon	.0	.0	.0	1.1	.0	
Convac	4.0	5.9	6.4	7.1	8.3	
Dainippon Screen	.5	3.1	5.7	6.2	11.1	
Eaton	3.7	1.1	1.0	1.5	1.4	
FSI International	.0	.0	.0	.0	4.8	
GCA	2.8	2.2	.0	.0	.0	
Machine Technology	10.1	7.9	10.0	17.5	18.5	
Semiconductor Systems	9.6	19.8	18.7	20.0	14.0	
Silicon Valley Group	20.8	25.4	27.0	23.7	37.0	
Solitec	5.3	5.6	7.0	5.0	3.0	
Tazmo	2.0	2.0	1.7	1.7	1.5	
Tokyo Electron Ltd	2.1	5.0	.0	.0	.0	
Varian/TEL	.0	.0	13.6	6.9	9.3	
Yuasa	.0	.0	.0	.0	1.5	
Total North America	60.9	78.0	91.1	90.7	110.4	16.0
Japan						
Canon	.7	3.8	10.1	6.2	12.3	
Convac	.0	.0	.0	.0	.0	
Dainippon Screen	27.8	31.7	51.8	48.1	51.3	
Eaton	.0	.0	.0	.0	.0	
FSI International	.0	.0	.0	.0	.0	
GCA	.3	.2	.0	.0	.0	
Machine Technology	.3	.5	.5	.0	1.6	
Semiconductor Systems	.0	.0	.0	.0	.0	
Silicon Valley Group	.0	.0	.5	.5	.0	
Solitec	.0	.0	.0	.0	.0	
Tazmo	2.1	2.9	6.8	15.3	11.9	
Tokyo Electron Ltd.	30.6	68.5	77.7	95.5	97.8	
Varian/TEL	.0	.0	.0	.0	.0	
Yuasa	3.6	6.0	8.8	5.8	4.4	
Total Japan	65.4	113.6	156.2	171.4	179.3	28.7

(Continued)

Table 4.10 (Continued)
Each Company's Revenue from Shipments of Automatic Photoresist Processing Equipment (Track) to Each Region
(End User Revenue in Millions of U.S. Dollars)

Company: Each
Product: Track
Region Of Consumption: Each

	1987	1988	1989	1990	1991	CAGR (%) 1987-1991
Europe						
Canon	.3	.0	.0	.0	.0	
Convac	6.9	7.9	5.8	8.3	7.7	
Dainippon Screen	1.9	2.7	5.1	2.1	4.8	
Eaton	5.2	6.6	6.3	1.0	.9	
FSI International	.0	.0	.0	.0	.0	
GCA	3.2	2.5	.0	.0	.0	
Machine Technology	1.0	1.3	.6	3.5	6.5	
Semiconductor Systems	1.2	2.2	3.3	3.0	.0	
Silicon Valley Group	6.9	6.4	10.8	8.8	5.3	
Solitec	.1	.4	.5	.4	1.5	
Tazmo	.3	.3	.4	.0	.0	
Tokyo Electron Ltd.	1.5	6.2	.0	.0	.0	
Varian/TEL	.0	.0	5.8	6.9	7.8	
Yuasa	.0	.0	.0	1.5	.0	
Total Europe	28.5	36.5	38.6	35.5	34.5	4.9
Asia/Pacific-ROW						
Canon	.0	.0	.0	1.1	.0	
Convac	.0	.0	.0	.0	2.9	
Dainippon Screen	1.0	2.7	5.1	2.8	2.3	
Eaton	1.6	3.3	3.2	2.2	2.0	
FSI International	.0	.0	.0	.0	.0	
GCA	.7	.6	.0	.0	.0	
Machine Technology	1.3	.3	.2	.0	.0	
Semiconductor Systems	.0	.0	.0	.0	.0	
Silicon Valley Group	5.3	5.6	15.7	11.0	6.6	
Solitec	.8	1.5	1.5	.4	.4	
Tazmo	.2	.5	.4	.5	1.8	
Tokyo Electron Ltd.	2.0	10.8	21.6	10.4	28.4	
Varian/TEL	.0	.0	.0	.0	.0	
Yuasa	.0	.0	.0	.0	.0	
Total Asia/Pacific-ROW	12.9	25.3	47.7	28.4	44.4	36.2

(Continued)

Table 4.10 (Continued)
Each Company's Revenue from Shipments of Automatic Photoresist Processing Equipment (Track) to Each Region
(End User Revenue in Millions of U.S. Dollars)

Company: Each
Product: Track
Region Of Consumption: Each

	1987	1988	1989	1990	1991	CAGR (%) 1987-1991
Worldwide						
Canon	1.0	3.8	10.1	8.4	12.3	
Convac	10.9	13.8	12.2	15.4	18.9	
Dainippon Screen	31.2	40.2	67.7	59.2	69.5	
Eaton	10.5	11.0	10.5	4.7	4.3	
FSI International	.0	.0	.0	.0	4.8	
GCA	7.0	5.5	.0	.0	.0	
Machine Technology	12.7	10.0	11.3	21.0	26.6	
Semiconductor Systems	10.8	22.0	22.0	23.0	14.0	
Silicon Valley Group	33.0	37.4	54.0	44.0	48.9	
Solitec	6.2	7.5	9.0	5.8	4.9	
Tazmo	4.6	5.7	9.3	17.5	15.2	
Tokyo Electron Ltd.	36.2	90.5	99.3	105.9	126.2	
Varian/TEL	.0	.0	19.4	13.8	17.1	
Yuasa	3.6	6.0	8.8	7.3	5.9	
Total Worldwide	167.7	253.4	333.6	326.0	368.6	22.3

Ref: TRACKSHR
Source: Dataquest (April 1992)

Table 4.11
Each Company's Revenue from Shipments of Wet Process Equipment to North America (End User Revenue in Millions of U.S. Dollars)

Company: Each
Product: Wet Process
Region Of Consumption: North America

	1987	1988	1989	1990	1991	CAGR (%) 1987-1991
World Wet Process Market	167.2	276.9	376.8	400.0	405.0	24.8
Integrated Wet Systems						
CFM Technology	.0	1.0	.3	2.1	2.9	
Dainippon Screen	.0	2.2	4.3	.0	4.5	
Dalton Corporation	.0	.0	.0	.0	.0	
Dan Science Co., Ltd.	.0	.0	.0	.0	.0	
Dexon	.7	3.1	4.1	.5	.0	
ETE Company, Ltd.	.0	.0	.0	.0	.0	
Enya	.0	.0	.0	1.4	.0	
Fuji Electric	.0	.0	.0	.0	.0	
Integrated Air Systems	2.3	1.8	.0	.0	.0	
Kaijo Denki	.6	3.1	3.0	.0	6.7	
Kuwano Electric	.0	.9	2.1	2.0	.0	
Maruwa	.0	.0	.0	.0	.0	
Musashi	.0	.0	.0	.0	.0	
Pokorny	.0	.0	.0	.0	.0	
Poly-Flow Engineering	.1	.0	.0	.0	.0	
Pure-Aire	1.5	1.7	2.5	1.0	1.1	
Sankyo Engineering	1.2	.0	.0	.0	.0	
Santa Clara Plastics	6.0	6.0	7.2	5.8	15.0	
Sapi Equipements	.0	.0	2.5	3.0	2.0	
SCI Manufacturing	2.8	1.0	1.1	.4	4.8	
Semifab	2.6	5.0	6.2	3.5	3.0	
Shimada	.0	.0	.0	.0	.0	
Submicron Systems, Inc.	.0	.0	2.0	10.0	12.0	
Sugai	.0	.0	.0	.0	.0	
S&K Products International	1.5	2.0	4.2	1.0	.0	
Tohokasei	.0	.0	.0	.0	.0	
Toyoko Chemical	.0	.0	.0	.0	.0	
Tokyo Electron	.0	.0	.0	.0	.0	
Universal Plastics	1.6	3.1	5.5	4.5	5.5	
Verteq	.8	1.8	.9	1.1	1.7	
Other Companies	.0	.0	.0	.0	.0	
Total Integr. Systems	21.7	32.7	45.9	36.3	59.2	28.5

(Continued)

Table 4.11 (Continued)
Each Company's Revenue from Shipments of Wet Process Equipment to North America
(End User Revenue in Millions of U.S. Dollars)

Company: Each
Product: Wet Process
Region Of Consumption: North America

	1987	1988	1989	1990	1991	CAGR (%) 1987-1991
Manual Wet Benches						
Dainippon Screen	.0	.4	.5	.0	.0	
Dan Science Co., Ltd.	.0	.0	.0	.0	.0	
Dexon	2.1	2.3	1.6	.5	.0	
Dalton Corporation	.0	.0	.0	.0	.0	
Enya	.0	.0	.0	.0	.0	
ETE Company, Ltd.	.0	.0	.0	.0	.0	
Integrated Air Systems	.7	.2	.0	.0	.0	
Kaijo Denki	.0	.0	.0	.0	.0	
Kyoritsu	.0	.0	.0	.0	.0	
Maruwa	.0	.0	.0	.0	.1	
Musashi	.0	.0	.0	.0	.0	
Pokorny	.0	.0	.0	.0	.0	
Pure-Aire	.6	.5	.2	.1	.1	
Sankyo Engineering	.0	.0	.7	.0	.0	
Santa Clara Plastics	3.0	1.8	1.2	.6	.5	
Sapi Equipements	.0	.0	.0	.0	.0	
SCI Manufacturing	1.7	.9	1.3	.0	.0	
Semifab	4.3	1.2	.9	2.0	2.4	
Shimada	.0	.0	.0	.0	.0	
Sugai	.0	.0	.0	.0	.0	
Tohokasei	.0	.0	.0	.0	.0	
Toyoko Chemical	.0	.0	.0	.0	.0	
Universal Plastics	1.9	4.6	3.0	3.0	3.6	
Verteq	.0	.4	.0	.0	.0	
Other Companies	.0	.0	.0	.0	.0	
Total Man. Benches	14.3	12.3	9.4	6.2	6.7	-17.3
Rinsers/Dryers						
Dainippon Screen	.0	.0	.0	.0	.0	
Dan Science Co., Ltd.	.0	.0	.0	.0	.0	
Enya	.0	.0	.0	.0	.0	
Estek	.8	.8	.0	.0	.0	
FSI International	.7	1.1	.7	1.3	1.4	
Kaijo Denki	.0	.3	.2	.1	.0	
Kuwano	.0	.2	.0	.0	.0	
Poly-Flow Engineering	.2	.1	.2	.0	.2	
Sankyo Engineering	.0	.2	.1	.0	.0	

(Continued)

Table 4.11 (Continued)
Each Company's Revenue from Shipments of Wet Process Equipment to North America
(End User Revenue in Millions of U.S. Dollars)

Company:	Each
Product:	Wet Process
Region Of Consumption:	North America

	1987	1988	1989	1990	1991	CAGR (%) 1987-1991
Semitool	10.9	9.7	4.6	5.8	6.1	
Shimada	.0	.0	.0	.0	.0	
S&K Products International	.6	.9	2.2	4.0	6.0	
Sugai	.0	.0	.0	.0	.0	
Tohokasei	.0	.0	.0	.0	.0	
Verteq	2.7	4.0	4.1	3.9	4.2	
Other Companies	.0	.0	.0	.0	.0	
Total Rinser/Dryers	15.9	17.3	12.1	15.1	17.9	3.0
Acid Processors						
Advantage Production Technology	.0	.0	.0	.0	2.6	
Alameda Instruments	.0	.0	.0	1.2	.8	
Athens	1.0	4.0	2.0	2.4	1.2	
Dainippon Screen	.0	.0	.9	.6	.9	
FSI International	7.5	8.8	10.7	7.4	6.9	
Musashi	.0	.0	.0	.0	.0	
Poly-Flow Engineering	.1	.0	.0	.1	.0	
Semitool	2.2	2.9	1.3	1.6	1.5	
Total Acid Process.	10.8	15.7	14.9	13.3	13.9	6.5
Megasonic Cleaners						
Dainippon Screen	.0	.8	.7	.0	.9	
Enya	.0	.0	.0	.0	.0	
FSI International	1.2	1.3	.9	.5	.8	
Kaijo Denki	.0	.0	.0	.0	.0	
S&K Products	.0	.0	.0	.0	1.0	
Shimada	.0	.0	.0	.0	.0	
Verteq	1.7	3.2	3.9	3.5	5.2	
Total Megasonics	2.9	5.3	5.5	4.0	7.9	28.5
Total N.A. Wet Process	65.6	83.3	87.8	74.9	105.6	12.6

Ref: WETSHR
Source: Dataquest (April 1992)

Table 4.12
Each Company's Revenue from Shipments of Wet Process Equipment to Japan (End User Revenue in Millions of U.S. Dollars)

Company:	Each
Product:	Wet Process
Region Of Consumption:	Japan

	1987	1988	1989	1990	1991	CAGR (%) 1987-1991
World Wet Process Market	167.2	276.9	376.8	400.0	405.0	24.8
Integrated Wet Systems						
CFM Technology	.0	.0	.0	.0	.0	
Dainippon Screen	18.7	25.7	28.9	41.3	19.3	
Dalton Corporation	.0	.0	1.7	1.7	1.2	
Dan Science Co., Ltd.	.0	.9	5.1	4.2	5.8	
Dexon	.0	.0	.0	.0	.0	
ETE Company, Ltd.	.0	1.5	2.9	7.6	10.4	
Enya	4.9	5.4	6.5	5.6	10.7	
Fuji Electric	.0	2.6	2.4	2.0	1.6	
Integrated Air Systems	.0	.0	.0	.0	.0	
Kaijo Denki	6.2	7.7	19.4	27.3	13.5	
Kuwano Electric	5.6	8.5	4.0	5.6	7.1	
Maruwa	.0	1.8	4.0	5.9	5.9	
Musashi	.0	.0	1.2	3.9	3.1	
Pokorny	.0	.0	.0	.0	.0	
Poly-Flow Engineering	.0	.0	.0	.0	.0	
Pure-Aire	.0	.0	.0	.0	.0	
Sankyo Engineering	3.1	5.3	25.1	25.0	23.8	
Santa Clara Plastics	.0	.0	.0	.0	.0	
Sapi Equipements	.0	.0	.0	.0	.0	
SCI Manufacturing	.0	.0	.0	.0	.0	
Semifab	.0	.0	.0	.0	.0	
Shimada	3.4	4.9	8.6	13.9	13.4	
Submicron Systems, Inc.	.0	.0	.0	.0	.0	
Sugai	2.8	15.0	24.4	28.0	23.4	
S&K Products International	2.0	.0	.0	.0	.0	
Tohokasei	.0	1.8	2.0	3.4	5.2	
Toyoko Chemical	.0	1.2	1.7	3.8	.9	
Tokyo Electron	.0	.0	.0	.0	5.6	
Universal Plastics	.0	.0	.0	.0	.0	
Verteq	.0	.0	.0	.0	.0	
Other Companies	4.2	6.2	8.2	.0	.0	
Total Integr. Systems	50.9	88.5	146.1	179.2	150.9	31.2

(Continued)

Table 4.12 (Continued)
Each Company's Revenue from Shipments of Wet Process Equipment to Japan
(End User Revenue in Millions of U.S. Dollars)

Company: Each
Product: Wet Process
Region Of Consumption: Japan

	1987	1988	1989	1990	1991	CAGR (%) 1987-1991
Manual Wet Benches						
Dainippon Screen	1.8	2.7	1.1	.0	.0	
Dan Science Co., Ltd.	.0	1.5	2.2	3.6	3.3	
Dexon	.0	.0	.0	.0	.0	
Dalton Corporation	.0	.0	.9	.9	.7	
Enya	.8	1.3	4.0	2.6	.9	
ETE Company, Ltd.	.0	.5	1.1	2.1	.5	
Integrated Air Systems	.0	.0	.0	.0	.0	
Kaijo Denki	.8	1.9	1.1	1.6	.0	
Kyoritsu	.0	2.7	2.5	3.1	.0	
Maruwa	.0	1.8	1.4	6.4	5.6	
Musashi	.0	.5	.7	.9	.7	
Pokorny	.0	.0	.0	.0	.0	
Pure-Aire	.0	.0	.0	.0	.0	
Sankyo Engineering	.9	1.9	2.3	3.4	2.6	
Santa Clara Plastics	.0	.0	.0	.0	.0	
Sapi Equipements	.0	.0	.0	.0	.0	
SCI Manufacturing	.0	.0	.0	.0	.0	
Semifab	.0	.0	.0	.0	.0	
Shimada	.3	.4	.0	.0	.0	
Sugai	.3	.9	1.1	1.4	1.2	
Tohokasei	.0	1.1	1.1	1.4	1.2	
Toyoko Chemical	.0	1.2	1.1	1.3	.0	
Universal Plastics	.0	.0	.0	.0	.0	
Verteq	.0	.0	.0	.0	.0	
Other Companies	2.4	3.7	4.5	.0	.0	
Total Man. Benches	7.3	22.1	25.1	28.7	16.7	23.0
Rinsers/Dryers						
Dainippon Screen	1.2	.0	.0	.0	.0	
Dan Science Co., Ltd.	.0	.5	.5	.2	.3	
Enya	.5	.9	.0	.0	.0	
Estek	.0	.0	.0	.0	.0	
FSI International	.0	.0	.0	1.7	.9	
Kaijo Denki	.6	1.3	1.4	2.4	.9	
Kuwano	.7	.8	.0	.0	.0	
Poly-Flow Engineering	.0	.0	.0	.0	.0	
Sankyo Engineering	.6	1.2	1.8	1.7	2.3	

(Continued)

Table 4.12 (Continued)
Each Company's Revenue from Shipments of Wet Process Equipment to Japan
(End User Revenue in Millions of U.S. Dollars)

Company: Each
Product: Wet Process
Region Of Consumption: Japan

	1987	1988	1989	1990	1991	CAGR (%) 1987-1991
Semitool	.0	.4	.4	.4	.6	
Shimada	.2	.2	.0	.0	.0	
S&K Products International	3.8	4.5	1.2	.0	.0	
Sugai	1.4	1.9	.0	.0	.0	
Tohokasei	.0	.4	.4	.5	.7	
Verteq	.1	.4	1.6	1.9	.5	
Other Companies	.3	.5	.5	.0	.0	
Total Rinser/Dryers	9.4	13.0	7.8	8.8	6.2	-9.9
Acid Processors						
Advantage Production Technology	.0	.0	.0	.0	.0	
Alameda Instruments	.0	.0	.0	.0	.0	
Athens	.0	.0	.0	1.2	.0	
Dainippon Screen	.0	.0	5.4	10.8	10.0	
FSI International	1.2	1.3	1.1	.5	2.4	
Musashi	.0	.0	.0	.0	.7	
Poly-Flow Engineering	.0	.0	.0	.0	.0	
Semitool	.0	.3	.4	.2	.3	
Total Acid Process.	1.2	1.6	6.9	12.7	13.4	82.8
Megasonic Cleaners						
Dainippon Screen	.0	13.1	14.4	8.4	10.3	
Enya	.0	.0	1.1	.0	.0	
FSI International	.2	.1	.1	.0	.0	
Kaijo Denki	.1	.1	.1	2.1	1.9	
S&K Products	.0	.0	.0	.0	.0	
Shimada	.0	.0	.0	5.8	5.2	
Verteq	.1	.3	.1	.1	.2	
Total Megasonics	.4	13.6	15.8	16.4	17.6	157.6
Total Japan Wet Process	69.2	138.8	201.7	245.8	204.8	31.2

Ref: WETSHR
Source: Dataquest (April 1992)

Table 4.13
Each Company's Revenue from Shipments of Wet Process Equipment to Europe (End User Revenue in Millions of U.S. Dollars)

Company:	Each
Product:	Wet Process
Region Of Consumption:	Europe

	1987	1988	1989	1990	1991	CAGR (%) 1987-1991
World Wet Process Market	167.2	276.9	376.8	400.0	405.0	24.8
Integrated Wet Systems						
CFM Technology	.0	.0	.0	.0	2.4	
Dainippon Screen	.0	.0	.0	.7	4.5	
Dalton Corporation	.0	.0	.0	.0	.0	
Dan Science Co., Ltd.	.0	.0	.0	.0	.0	
Dexon	.0	.0	.0	.0	.0	
ETE Company, Ltd.	.0	.0	.0	.0	.0	
Enya	.0	.0	.0	.0	.0	
Fuji Electric	.0	.0	.0	.0	.0	
Integrated Air Systems	.0	.0	.0	.0	.0	
Kaijo Denki	1.8	.0	.0	3.6	.0	
Kuwano Electric	.0	2.3	1.0	.0	.0	
Maruwa	.0	.0	.0	.0	.0	
Musashi	.0	.0	.0	.0	.0	
Pokorny	2.3	2.5	4.7	6.2	6.6	
Poly-Flow Engineering	.0	.0	.0	.0	.0	
Pure-Aire	.0	.0	.0	.0	.0	
Sankyo Engineering	1.2	3.1	2.2	6.9	2.4	
Santa Clara Plastics	3.0	3.0	4.2	1.4	2.0	
Sapi Equipements	.0	.0	.0	.0	.0	
SCI Manufacturing	.0	.0	.0	.0	.0	
Semifab	.0	.0	.0	.0	.0	
Shimada	.0	.0	.0	.0	.0	
Submicron Systems, Inc.	.0	.0	.0	.0	.0	
Sugai	.0	.0	.0	.0	.0	
S&K Products International	.0	1.5	3.5	2.0	.0	
Tohokasei	.0	.0	.0	4.6	.0	
Toyoko Chemical	.0	.0	.0	.0	.0	
Tokyo Electron	.0	.0	.0	.0	.0	
Universal Plastics	.0	.0	.0	.0	.0	
Verteq	.0	.0	.0	.6	.0	
Other Companies	.0	.0	.0	.0	.0	
Total Integr. Systems	8.3	12.4	15.6	26.0	17.9	21.2

(Continued)

Table 4.13 (Continued)
Each Company's Revenue from Shipments of Wet Process Equipment to Europe
(End User Revenue in Millions of U.S. Dollars)

Company: Each
Product: Wet Process
Region Of Consumption: Europe

	1987	1988	1989	1990	1991	CAGR (%) 1987-1991
Manual Wet Benches						
Dainippon Screen	.0	.4	.5	.0	.0	
Dan Science Co., Ltd.	.0	.0	.0	.0	.0	
Dexon	.3	.1	.4	.0	.0	
Dalton Corporation	.0	.0	.0	.0	.0	
Enya	.0	.0	.0	2.1	.0	
ETE Company, Ltd.	.0	.0	.0	.0	.0	
Integrated Air Systems	.0	.0	.0	.0	.0	
Kaijo Denki	.0	.0	.0	.0	.0	
Kyoritsu	.0	.0	.0	.0	.0	
Maruwa	.0	.0	.0	.0	.8	
Musashi	.0	.0	.0	.0	.0	
Pokorny	2.0	2.2	3.5	1.2	1.2	
Pure-Aire	.0	.0	.0	.0	.0	
Sankyo Engineering	.0	3.2	.0	.0	.0	
Santa Clara Plastics	1.0	.8	.6	.1	.1	
Sapi Equipements	.0	.0	3.0	1.8	1.5	
SCI Manufacturing	.0	.0	.0	.0	.0	
Semifab	.1	.0	.0	.0	.0	
Shimada	.0	.0	.0	.0	.0	
Sugai	.0	.0	.0	.0	.0	
Tohokasei	.0	.0	.0	1.0	.0	
Toyoko Chemical	.0	.0	.0	.0	.0	
Universal Plastics	.1	.0	.0	.0	.0	
Verteq	.0	.0	.0	.0	.0	
Other Companies	.0	.0	.0	.0	.0	
Total Man. Benches	3.5	6.7	8.0	6.2	3.6	.7
Rinsers/Dryers						
Dainippon Screen	.0	.0	.0	.0	.0	
Dan Science Co., Ltd.	.0	.0	.0	.0	.2	
Enya	.0	.0	.0	.0	.0	
Estek	.4	.3	.0	.0	.0	
FSI International	.2	.4	.2	.9	1.2	
Kaijo Denki	.0	.2	.0	.0	.0	
Kuwano	.0	.0	.0	.0	.0	
Poly-Flow Engineering	.0	.0	.1	.2	.0	
Sankyo Engineering	.0	.2	.2	.2	.3	

(Continued)

Table 4.13 (Continued)
Each Company's Revenue from Shipments of Wet Process Equipment to Europe
(End User Revenue in Millions of U.S. Dollars)

Company: Each
Product: Wet Process
Region Of Consumption: Europe

	1987	1988	1989	1990	1991	CAGR (%) 1987-1991
Semitool	2.1	1.6	2.5	2.1	2.3	
Shimada	.0	.0	.0	.0	.0	
S&K Products International	.6	.5	.5	.5	1.2	
Sugai	.0	.0	.0	.0	.0	
Tohokasei	.0	.0	.0	.0	.0	
Verteq	.3	.5	.6	.9	.9	
Other Companies	.0	.0	.0	.0	.0	
Total Rinser/Dryers	3.6	3.7	4.1	4.8	6.1	14.1
Acid Processors						
Advantage Production Technology	.0	.0	.0	.0	.0	
Alameda Instruments	.0	.0	.0	.0	.0	
Athens	.0	.0	.0	.0	.0	
Dainippon Screen	.0	.0	.9	.4	.6	
FSI International	5.1	4.2	7.4	3.3	3.5	
Musashi	.0	.0	.0	.0	.0	
Poly-Flow Engineering	.0	.1	4.1	.2	.0	
Semitool	.8	.4	1.5	1.1	.7	
Total Acid Process.	5.9	4.7	13.9	5.0	4.8	-5.0
Megasonic Cleaners						
Dainippon Screen	.0	.8	.7	1.4	.9	
Enya	.0	.0	.0	.0	.0	
FSI International	.5	.4	.2	.2	.4	
Kaijo Denki	.0	.0	.0	.0	.0	
S&K Products	.0	.0	.0	.0	.0	
Shimada	.0	.0	.0	.0	.0	
Verteq	.3	.5	.8	.4	1.0	
Total Megasonics	.8	1.7	1.7	2.0	2.3	30.2
Total Europe Wet Process	22.1	29.2	43.3	44.0	34.7	11.9

Ref: WETSHR
Source: Dataquest (April 1992)

Table 4.14
Each Company's Revenue from Shipments of Wet Process Equipment to Asia/Pacific-ROW (End User Revenue in Millions of U.S. Dollars)

Company: Each
Product: Wet Process
Region Of Consumption: Asia/Pacific-ROW

	1987	1988	1989	1990	1991	CAGR (%) 1987-1991
World Wet Process Market	167.2	276.9	376.8	400.0	405.0	24.8
Integrated Wet Systems						
CFM Technology	.0	.0	.0	.0	.0	
Dainippon Screen	.0	2.2	8.6	1.4	12.6	
Dalton Corporation	.0	.0	.0	.0	.0	
Dan Science Co., Ltd.	.0	.0	4.9	8.5	9.1	
Dexon	.0	.0	.3	.0	.0	
ETE Company, Ltd.	.0	.0	.0	.0	.0	
Enya	.0	.0	.0	.0	.0	
Fuji Electric	.0	.0	8.3	.0	.5	
Integrated Air Systems	.0	.0	.0	.0	.0	
Kaijo Denki	.0	.0	.0	.0	9.7	
Kuwano Electric	.0	.9	2.3	2.0	.0	
Maruwa	.0	.0	.0	.0	2.2	
Musashi	.0	.0	.0	1.9	1.0	
Pokorny	.0	.0	.0	.0	.0	
Poly-Flow Engineering	.0	.0	.0	.0	.0	
Pure-Aire	.2	.2	.1	.1	.1	
Sankyo Engineering	1.1	1.8	2.4	1.7	1.2	
Santa Clara Plastics	2.0	2.0	2.9	2.0	2.5	
Sapi Equipements	.0	.0	.0	.0	.0	
SCI Manufacturing	.0	.0	.0	.0	.0	
Semifab	.1	.0	.0	.0	.0	
Shimada	.0	.0	.0	2.4	.0	
Submicron Systems, Inc.	.0	.0	.0	.0	.0	
Sugai	.0	2.9	5.4	6.3	8.0	
S&K Products International	.0	.0	.0	.0	.0	
Tohokasei	.0	.0	.0	.0	.0	
Toyoko Chemical	.0	.0	.0	.0	.0	
Tokyo Electron	.0	.0	.0	.0	.0	
Universal Plastics	.0	.0	.0	.0	.0	
Verteq	.0	.2	.2	.0	.0	
Other Companies	.0	.0	.0	.0	.0	
Total Integr. Systems	3.4	10.2	35.4	26.3	46.9	92.7

(Continued)

Table 4.14 (Continued)
Each Company's Revenue from Shipments of Wet Process Equipment to Asia/Pacific-ROW
(End User Revenue in Millions of U.S. Dollars)

Company: Each
Product: Wet Process
Region Of Consumption: Asia/Pacific-ROW

	1987	1988	1989	1990	1991	CAGR (%) 1987-1991
Manual Wet Benches						
Dainippon Screen	.0	.4	.2	.0	.0	
Dan Science Co., Ltd.	.0	.0	.0	1.6	1.1	
Dexon	.0	.0	.0	.0	.0	
Dalton Corporation	.0	.0	.0	.0	.0	
Enya	.0	.0	.0	.0	.0	
ETE Company, Ltd.	.0	.0	.0	.0	.0	
Integrated Air Systems	.0	.0	.0	.0	.0	
Kaijo Denki	.0	.0	.0	.0	.0	
Kyoritsu	.0	.0	.0	.0	.0	
Maruwa	.0	.0	.0	.0	.4	
Musashi	.0	.0	.0	.0	.0	
Pokorny	.0	.0	.0	.0	.0	
Pure-Aire	.1	.4	.2	.1	.1	
Sankyo Engineering	.0	6.5	.0	.0	.0	
Santa Clara Plastics	1.0	1.0	.5	.2	.1	
Sapi Equipements	.0	.0	.0	.0	.0	
SCI Manufacturing	.0	.0	.0	.0	.0	
Semifab	.6	.8	.5	1.0	1.1	
Shimada	.0	.0	.0	.0	.0	
Sugai	.0	.0	.0	.0	.0	
Tohokasei	.0	.0	.0	.0	.0	
Toyoko Chemical	.0	.0	.0	.0	.0	
Universal Plastics	.1	.8	.9	.5	.0	
Verteq	.2	.1	.0	.0	.0	
Other Companies	.0	.0	.0	.0	.0	
Total Man. Benches	2.0	10.0	2.3	3.4	2.8	8.8
Rinsers/Dryers						
Dainippon Screen	.0	.0	.0	.0	.0	
Dan Science Co., Ltd.	.0	.0	.0	.1	.0	
Enya	.0	.0	.0	.0	.0	
Estek	.0	.0	.0	.0	.0	
FSI International	.3	.3	.3	.4	.2	
Kaijo Denki	.0	.0	.0	.0	.0	
Kuwano	.0	.0	.0	.0	.0	
Poly-Flow Engineering	.1	.0	.0	.0	.0	
Sankyo Engineering	.0	.4	.3	.2	.1	

(Continued)

Table 4.14 (Continued)
Each Company's Revenue from Shipments of Wet Process Equipment to Asia/Pacific-ROW
(End User Revenue in Millions of U.S. Dollars)

Company: Each
Product: Wet Process
Region Of Consumption: Asia/Pacific-ROW

	1987	1988	1989	1990	1991	CAGR (%) 1987-1991
Semitool	2.5	.1	.2	.3	.4	
Shimada	.0	.0	.0	.0	.0	
S&K Products International	.0	.0	.0	.5	.0	
Sugai	.0	.0	.0	.0	.0	
Tohokasei	.0	.0	.0	.0	.0	
Verteq	.2	.4	.3	.3	.4	
Other Companies	.0	.0	.0	.0	.0	
Total Rinser/Dryers	3.1	1.2	1.1	1.8	1.1	-22.8
Acid Processors						
Advantage Production Technology	.0	.0	.0	.0	.8	
Alameda Instruments	.0	.0	.0	.0	.8	
Athens	.0	.0	.0	.6	.0	
Dainippon Screen	.0	.0	.7	.0	.0	
FSI International	1.2	2.9	3.3	1.5	4.0	
Musashi	.0	.0	.0	.0	.0	
Poly-Flow Engineering	.0	.0	.0	.0	.0	
Semitool	.3	.0	.0	.0	.2	
Total Acid Process.	1.5	2.9	4.0	2.1	5.8	40.2
Megasonic Cleaners						
Dainippon Screen	.0	.8	.7	.7	2.0	
Enya	.0	.0	.0	.0	.0	
FSI International	.2	.5	.3	.2	.1	
Kaijo Denki	.0	.0	.0	.0	.4	
S&K Products	.0	.0	.0	.0	.0	
Shimada	.0	.0	.0	.0	.0	
Verteq	.1	.0	.2	.8	.8	
Total Megasonics	.3	1.3	1.2	1.7	3.3	82.1
Total A/P-ROW Wet Process	10.3	25.6	44.0	35.3	59.9	55.3

Ref: WETSHR
Source: Dataquest (April 1992)

Table 4.15
Each Company's Revenue from Shipments of Wet Process Equipment to the World
(End User Revenue in Millions of U.S. Dollars)

Company: Each
Product: Wet Process
Region Of Consumption: World

	1987	1988	1989	1990	1991	CAGR (%) 1987-1991
World Wet Process Market	167.2	276.9	376.8	400.0	405.0	24.8
Integrated Wet Systems						
CFM Technology	.0	1.0	.3	2.1	5.3	
Dainippon Screen	18.7	30.1	41.8	43.4	40.9	
Dalton Corporation	.0	.0	1.7	1.7	1.2	
Dan Science Co., Ltd.	.0	.9	10.0	12.7	14.9	
Dexon	.7	3.1	4.4	.5	.0	
ETE Company, Ltd.	.0	1.5	2.9	7.6	10.4	
Enya	4.9	5.4	6.5	7.0	10.7	
Fuji Electric	.0	2.6	10.7	2.0	2.1	
Integrated Air Systems	2.3	1.8	.0	.0	.0	
Kaijo Denki	8.6	10.8	22.4	30.9	29.9	
Kuwano Electric	5.6	12.6	9.4	9.6	7.1	
Maruwa	.0	1.8	4.0	5.9	8.1	
Musashi	.0	.0	1.2	5.8	4.1	
Pokorny	2.3	2.5	4.7	6.2	6.6	
Poly-Flow Engineering	.1	.0	.0	.0	.0	
Pure-Aire	1.7	1.9	2.6	1.1	1.2	
Sankyo Engineering	6.6	10.2	29.7	33.6	27.4	
Santa Clara Plastics	11.0	11.0	14.3	9.2	19.5	
Sapi Equipements	.0	.0	2.5	3.0	2.0	
SCI Manufacturing	2.8	1.0	1.1	.4	4.8	
Semifab	2.7	5.0	6.2	3.5	3.0	
Shimada	3.4	4.9	8.6	16.3	13.4	
Submicron Systems, Inc.	.0	.0	2.0	10.0	12.0	
Sugai	2.8	17.9	29.8	34.3	31.4	
S&K Products International	3.5	3.5	7.7	3.0	.0	
Tohokasei	.0	1.8	2.0	8.0	5.2	
Toyoko Chemical	.0	1.2	1.7	3.8	.9	
Tokyo Electron	.0	.0	.0	.0	5.6	
Universal Plastics	1.6	3.1	5.5	4.5	5.5	
Verteq	.8	2.0	1.1	1.7	1.7	
Other Companies	4.2	6.2	8.2	.0	.0	
Total Integr. Systems	84.3	143.8	243.0	267.8	274.9	34.4

(Continued)

Table 4.15 (Continued)
Each Company's Revenue from Shipments of Wet Process Equipment to the World
(End User Revenue in Millions of U.S. Dollars)

Company:	Each
Product:	Wet Process
Region Of Consumption:	World

	1987	1988	1989	1990	1991	CAGR (%) 1987-1991
Manual Wet Benches						
Dainippon Screen	1.8	3.9	2.3	.0	.0	
Dan Science Co., Ltd.	.0	1.5	2.2	5.2	4.4	
Dexon	2.4	2.4	2.0	.5	.0	
Dalton Corporation	.0	.0	.9	.9	.7	
Enya	.8	1.3	4.0	4.7	.9	
ETE Company, Ltd.	.0	.5	1.1	2.1	.5	
Integrated Air Systems	.7	.2	.0	.0	.0	
Kaijo Denki	.8	1.9	1.1	1.6	.0	
Kyoritsu	.0	2.7	2.5	3.1	.0	
Maruwa	.0	1.8	1.4	6.4	6.9	
Musashi	.0	.5	.7	.9	.7	
Pokorny	2.0	2.2	3.5	1.2	1.2	
Pure-Aire	.7	.9	.4	.2	.2	
Sankyo Engineering	.9	11.6	3.0	3.4	2.6	
Santa Clara Plastics	5.0	3.6	2.3	.9	.7	
Sapi Equipements	.0	.0	3.0	1.8	1.5	
SCI Manufacturing	1.7	.9	1.3	.0	.0	
Semifab	5.0	2.0	1.4	3.0	3.5	
Shimada	.3	.4	.0	.0	.0	
Sugai	.3	.9	1.1	1.4	1.2	
Tohokasei	.0	1.1	1.1	2.4	1.2	
Toyoko Chemical	.0	1.2	1.1	1.3	.0	
Universal Plastics	2.1	5.4	3.9	3.5	3.6	
Verteq	.2	.5	.0	.0	.0	
Other Companies	2.4	3.7	4.5	.0	.0	
Total Man. Benches	27.1	51.1	44.8	44.5	29.8	2.4
Rinsers/Dryers						
Dainippon Screen	1.2	.0	.0	.0	.0	
Dan Science Co., Ltd.	.0	.5	.5	.3	.5	
Enya	.5	.9	.0	.0	.0	
Estek	1.2	1.1	.0	.0	.0	
FSI International	1.2	1.8	1.2	4.3	3.7	
Kaijo Denki	.6	1.8	1.6	2.5	.9	
Kuwano	.7	1.0	.0	.0	.0	
Poly-Flow Engineering	.3	.1	.3	.2	.2	
Sankyo Engineering	.6	2.0	2.4	2.1	2.7	

(Continued)

Table 4.15 (Continued)
Each Company's Revenue from Shipments of Wet Process Equipment to the World
(End User Revenue in Millions of U.S. Dollars)

Company: Each
Product: Wet Process
Region Of Consumption: World

	1987	1988	1989	1990	1991	CAGR (%) 1987-1991
Semitool	15.5	11.8	7.7	8.6	9.4	
Shimada	.2	.2	.0	.0	.0	
S&K Products International	5.0	5.9	3.9	5.0	7.2	
Sugai	1.4	1.9	.0	.0	.0	
Tohokasei	.0	.4	.4	.5	.7	
Verteq	3.3	5.3	6.6	7.0	6.0	
Other Companies	.3	.5	.5	.0	.0	
Total Rinser/Dryers	32.0	35.2	25.1	30.5	31.3	-.6
Acid Processors						
Advantage Production Technology	.0	.0	.0	.0	3.4	
Alameda Instruments	.0	.0	.0	1.2	1.6	
Athens	1.0	4.0	2.0	4.2	1.2	
Dainippon Screen	.0	.0	7.9	11.8	11.5	
FSI International	15.0	17.2	22.5	12.7	16.8	
Musashi	.0	.0	.0	.0	.7	
Poly-Flow Engineering	.1	.1	4.1	.3	.0	
Semitool	3.3	3.6	3.2	2.9	2.7	
Total Acid Process.	19.4	24.9	39.7	33.1	37.9	18.2
Megasonic Cleaners						
Dainippon Screen	.0	15.5	16.5	10.5	14.1	
Enya	.0	.0	1.1	.0	.0	
FSI International	2.1	2.3	1.5	.9	1.3	
Kaijo Denki	.1	.1	.1	2.1	2.3	
S&K Products	.0	.0	.0	.0	1.0	
Shimada	.0	.0	.0	5.8	5.2	
Verteq	2.2	4.0	5.0	4.8	7.2	
Total Megasonics	4.4	21.9	24.2	24.1	31.1	63.1
Total W.W. Wet Process	167.2	276.9	376.8	400.0	405.0	24.8

Ref: WETSHR
Source: Dataquest (April 1992)

Table 4.16
Each Company's Revenue from Shipments of Dry Strip Market Equipment to North America (End User Revenue in Millions of U.S. Dollars)

Company:	Each
Product:	Dry Strip
Region Of Consumption:	North America

	1987	1988	1989	1990	1991	CAGR (%) 1987-1991
World Dry Strip Market	57.9	100.4	121.2	117.7	119.1	19.8
North America						
Alcan Tech	.0	.0	.0	.0	4.0	
Branson/IPC	3.8	8.0	6.4	6.0	.0	
Chemitronics	.0	.0	.0	.0	.0	
Chlorine Engineers	.0	.0	.0	.0	.0	
Drytek	.8	.8	1.0	.0	.0	
Fusion Semiconductor Systems	.5	1.0	1.5	1.5	.8	
Gasonics	1.6	2.1	5.3	6.8	14.9	
Hitachi	.0	.0	.0	.0	.0	
LFE	1.0	.8	1.2	1.0	1.1	
Lam Research	.0	.0	.0	.0	.0	
m.FSI	.0	.0	.0	.0	.0	
Machine Technology	2.0	3.0	1.0	.0	.0	
Matrix	4.5	4.7	5.5	6.0	4.1	
Mattson Technologies	.0	.0	.0	.0	1.5	
Plasma Systems	.0	.0	.0	1.1	1.2	
Plasma-Therm	.0	.0	1.0	.0	.0	
Ramco	.0	.0	.0	.0	2.1	
Samco	.0	.1	.1	.1	.2	
Shinko Seiki	.0	.0	.0	.0	.0	
Sumitomo Metals	.0	.0	.0	.0	.0	
Tegal	2.5	2.5	2.0	2.0	1.6	
Tokyo Ohka Kogyo	.0	.0	2.0	.6	.7	
Ulvac	.0	.0	.0	.0	.0	
Total North America	16.7	23.0	27.0	25.1	32.2	17.8

Source: Dataquest (April 1992)

Table 4.17
Each Company's Revenue from Shipments of Dry Strip Equipment to Japan
(End User Revenue in Millions of U.S. Dollars)

Company: Each
Product: Dry Strip
Region Of Consumption: Japan

	1987	1988	1989	1990	1991	CAGR (%) 1987-1991
World Dry Strip Market	57.9	100.4	121.2	117.7	119.1	19.8
Japan						
Alcan Tech	5.0	9.2	11.6	9.7	12.7	
Branson/IPC	1.4	1.0	1.5	1.0	.0	
Chemitronics	.0	1.4	.0	.0	.0	
Chlorine Engineers	.6	.0	2.8	2.7	.0	
Drytek	.0	.0	.0	.0	.0	
Fusion Semiconductor Systems	.0	.0	.0	.0	.0	
Gasonics	.0	.0	.1	1.0	1.0	
Hitachi	.0	4.6	5.0	2.7	4.5	
LFE	.0	.0	.0	.0	.0	
Lam Research	.0	.0	.0	.0	.0	
m.FSI	.0	.0	.0	.0	1.7	
Machine Technology	.7	1.5	.0	.0	.0	
Matrix	.2	.5	.5	1.0	.3	
Mattson Technologies	.0	.0	.0	.0	.0	
Plasma Systems	4.3	10.4	15.0	21.0	16.7	
Plasma-Therm	.0	.0	.0	.0	.0	
Ramco	8.7	9.6	11.0	16.0	5.6	
Samco	.0	.7	.9	.8	.9	
Shinko Seiki	.0	.0	.0	.0	1.1	
Sumitomo Metals	.0	.0	.0	.0	2.1	
Tegal	.5	.5	.0	.0	.7	
Tokyo Ohka Kogyo	8.7	19.9	22.0	17.3	12.5	
Ulvac	3.6	4.9	5.5	2.3	2.3	
Total Japan	33.7	64.2	75.9	75.5	62.1	16.5

Source: Dataquest (April 1992)

Table 4.18
Each Company's Revenue from Shipments of Dry Strip Equipment to Europe
(End User Revenue in Millions of U.S. Dollars)

Company: Each
Product: Dry Strip
Region Of Consumption: Europe

	1987	1988	1989	1990	1991	CAGR (%) 1987-1991
World Dry Strip Market	57.9	100.4	121.2	117.7	119.1	19.8
Europe						
Alcan Tech	.0	1.0	1.5	2.0	.9	
Branson/IPC	1.4	2.0	3.2	4.5	.0	
Chemitronics	.0	.0	.0	.0	.0	
Chlorine Engineers	.0	.0	.0	.0	.0	
Drytek	.0	.0	.0	.0	.0	
Fusion Semiconductor Systems	.0	.0	.0	.0	.5	
Gasonics	.4	.6	.1	.4	2.0	
Hitachi	.0	.0	.0	.0	.0	
LFE	.0	.5	.1	.0	.0	
Lam Research	.0	.0	.0	.0	.0	
m.FSI	.0	.0	.0	.0	.0	
Machine Technology	.0	.0	.0	.2	.0	
Matrix	.1	.6	.5	1.5	2.4	
Mattson Technologies	.0	.0	.0	.0	.0	
Plasma Systems	.0	.0	.0	.0	.0	
Plasma-Therm	.0	.0	.0	.0	.0	
Ramco	.0	.0	.0	.0	1.6	
Samco	.0	.0	.0	.0	.0	
Shinko Seiki	.0	.0	.0	.0	.0	
Sumitomo Metals	.0	.0	.0	.0	.0	
Tegal	1.0	1.2	.5	.5	.8	
Tokyo Ohka Kogyo	.0	.0	1.0	.2	1.0	
Ulvac	.0	.0	.0	.0	.0	
Total Europe	2.9	5.9	6.9	9.3	9.2	33.5

Source: Dataquest (April 1992)

Table 4.19
Each Company's Revenue from Shipments of Dry Strip Equipment to Asia/Pacific-ROW
(End User Revenue in Millions of U.S. Dollars)

Company: Each
Product: Dry Strip
Region Of Consumption: Asia/Pacific-ROW

	1987	1988	1989	1990	1991	CAGR (%) 1987-1991
World Dry Strip Market	57.9	100.4	121.2	117.7	119.1	19.8
Asia/Pacific-ROW						
Alcan Tech	.0	.0	.0	.0	1.6	
Branson/IPC	1.2	4.0	4.9	3.0	.0	
Chemitronics	.0	.0	.0	.0	.0	
Chlorine Engineers	.0	.0	.0	.0	.0	
Drytek	.2	.4	.4	.0	.0	
Fusion Semiconductor Systems	.0	.0	.0	.0	.6	
Gasonics	.0	.3	.7	.0	5.0	
Hitachi	.0	.0	.0	.0	1.1	
LFE	.0	.2	.4	.4	.4	
Lam Research	.0	.0	.0	.0	.0	
m.FSI	.0	.0	.0	.0	.0	
Machine Technology	.0	.0	.5	.0	.0	
Matrix	.4	1.4	.5	.5	.7	
Mattson Technologies	.0	.0	.0	.0	.0	
Plasma Systems	1.1	.0	2.0	2.8	3.3	
Plasma-Therm	.0	.0	.0	.0	.0	
Ramco	.0	.0	.0	.0	1.0	
Samco	.0	.0	.0	.0	.0	
Shinko Seiki	.0	.0	.0	.0	.0	
Sumitomo Metals	.0	.0	.0	.0	.0	
Tegal	1.2	1.0	1.0	.5	.4	
Tokyo Ohka Kogyo	.5	.0	1.0	.6	1.5	
Ulvac	.0	.0	.0	.0	.0	
Total A/P-ROW	4.6	7.3	11.4	7.8	15.6	35.7

Source: Dataquest (April 1992)

Table 4.20
Each Company's Revenue from Shipments of Dry Strip Equipment to the World (End User Revenue in Millions of U.S. Dollars)

Company: Each
Product: Dry Strip
Region Of Consumption: World

	1987	1988	1989	1990	1991	CAGR (%) 1987-1991
World Dry Strip Market	57.9	100.4	121.2	117.7	119.1	19.8
Worldwide						
Alcan Tech	5.0	10.2	13.1	11.7	19.2	
Branson/IPC	7.8	15.0	16.0	14.5	.0	
Chemitronics	.0	1.4	.0	.0	.0	
Chlorine Engineers	.6	.0	2.8	2.7	.0	
Drytek	1.0	1.2	1.4	.0	.0	
Fusion Semiconductor Systems	.5	1.0	1.5	1.5	1.9	
Gasonics	2.0	3.0	6.2	8.2	22.9	
Hitachi	.0	4.6	5.0	2.7	5.6	
LFE	1.0	1.5	1.7	1.4	1.5	
Lam Research	.0	.0	.0	.0	.0	
m.FSI	.0	.0	.0	.0	1.7	
Machine Technology	2.7	4.5	1.5	.2	.0	
Matrix	5.2	7.2	7.0	9.0	7.5	
Mattson Technologies	.0	.0	.0	.0	1.5	
Plasma Systems	5.4	10.4	17.0	24.9	21.2	
Plasma-Therm	.0	.0	1.0	.0	.0	
Ramco	8.7	9.6	11.0	16.0	10.3	
Samco	.0	.8	1.0	.9	1.1	
Shinko Seiki	.0	.0	.0	.0	1.1	
Sumitomo Metals	.0	.0	.0	.0	2.1	
Tegal	5.2	5.2	3.5	3.0	3.5	
Tokyo Ohka Kogyo	9.2	19.9	26.0	18.7	15.7	
Ulvac	3.6	4.9	5.5	2.3	2.3	
Total Worldwide	57.9	100.4	121.2	117.7	119.1	19.8

Source: Dataquest (April 1992)

Table 4.21
Each Company's Revenue from Shipments of Dry Etch Equipment to North America
(End User Revenue in Millions of U.S. Dollars)

Company: Each
Product: Dry Etch
Region Of Consumption: North America

	1987	1988	1989	1990	1991	CAGR (%) 1987-1991
World Dry Etch Market	307.4	533.2	669.5	690.4	704.7	23.0
North America						
Alcan Technology	.0	.0	.0	.0	.0	
Anelva	.0	.0	.0	.0	.0	
Applied Materials	48.1	72.9	77.0	78.0	60.0	
Branson/IPC	.0	.0	1.2	2.0	.0	
Drytek	11.0	23.0	18.0	13.0	15.0	
Elionix	.0	.0	.0	.0	.0	
E.T. Electrotech	1.0	4.2	4.0	4.0	4.8	
GCA	3.0	4.0	.0	.0	.0	
Gasonics	.0	.0	.0	.0	3.5	
Hitachi	.0	.0	.0	7.0	3.3	
Kokusai	.0	.0	.0	.0	.0	
Lam Research	20.0	29.0	44.0	48.0	63.0	
Materials Research	2.5	6.0	4.0	.0	.0	
Matrix	.0	.0	.0	.0	2.1	
MRC (Sony)	.0	.0	.0	.8	2.6	
Plasma Systems	.0	.0	.0	.0	.0	
Plasma Technology	.0	.8	1.0	2.5	2.7	
Plasma-Therm	11.4	10.2	12.0	10.0	.7	
Samco	.0	.0	.0	.0	.0	
Shibaura	.0	.0	.0	.0	.0	
Sumitomo Metals	.0	.0	.0	.7	.0	
Tegal	20.0	21.0	18.0	13.0	11.0	
Tokyo Electron	.0	.0	.0	.0	.0	
Tokuda	1.1	.0	.7	.5	.0	
Tokyo Ohka	.0	.0	.0	.3	.0	
TEL/LAM	.0	.0	.0	.0	.0	
Ulvac	.0	.0	.0	.0	.0	
Varian/TEL	.0	.0	6.2	4.7	4.4	
Total North America	118.1	171.1	186.1	184.5	173.1	10.0

DETCHSHR
Source: Dataquest (April 1992)

Table 4.22
Each Company's Revenue from Shipments of Dry Etch Equipment to Japan
(End User Revenue in Millions of U.S. Dollars)

Company:	Each
Product:	Dry Etch
Region Of Consumption:	Japan

	1987	1988	1989	1990	1991	CAGR (%) 1987-1991
World Dry Etch Market	307.4	533.2	669.5	690.4	704.7	23.0
Japan						
Alcan Technology	.0	.0	.0	2.5	5.6	
Anelva	22.3	41.6	39.1	27.3	20.3	
Applied Materials	24.8	76.1	79.0	52.0	47.0	
Branson/IPC	.6	.0	.7	.0	.0	
Drytek	.0	.0	5.0	3.0	3.0	
Elionix	.3	.3	.3	1.2	.7	
E.T. Electrotech	.0	1.5	1.5	2.5	.0	
GCA	.0	.0	.0	.0	.0	
Gasonics	.0	.0	.0	.0	.0	
Hitachi	18.8	34.6	47.6	79.5	95.1	
Kokusai	1.4	1.5	1.0	1.1	.0	
Lam Research	.0	.0	2.2	24.2	21.1	
Materials Research	1.0	5.0	2.2	.0	.0	
Matrix	.0	.0	.0	.0	.0	
MRC (Sony)	.0	.0	.0	3.9	5.2	
Plasma Systems	1.9	3.2	3.3	1.7	1.5	
Plasma Technology	.0	.0	.0	.0	.0	
Plasma-Therm	1.2	1.2	1.6	5.0	11.0	
Samco	.0	.0	2.2	2.8	3.4	
Shibaura	.0	.0	.0	.0	14.1	
Sumitomo Metals	5.6	6.2	12.0	15.0	15.4	
Tegal	.0	3.0	3.0	5.0	7.0	
Tokyo Electron	.0	44.6	70.5	96.8	86.0	
Tokuda	5.0	3.2	28.3	22.3	.0	
Tokyo Ohka	7.1	10.0	21.7	13.5	14.0	
TEL/LAM	17.4	.0	.0	.0	.0	
Ulvac	5.6	8.1	8.7	6.6	6.2	
Varian/TEL	.0	.0	.0	.0	.0	
Total Japan	113.0	240.1	329.9	365.9	356.6	33.3

DETCHSHR
Source: Dataquest (April 1992)

Table 4.23
Each Company's Revenue from Shipments of Dry Etch Equipment to Europe (End User Revenue in Millions of U.S. Dollars)

Company: Each
Product: Dry Etch
Region Of Consumption: Europe

	1987	1988	1989	1990	1991	CAGR (%) 1987-1991
World Dry Etch Market	307.4	533.2	669.5	690.4	704.7	23.0
Europe						
Alcan Technology	.0	.0	.0	.0	.0	
Anelva	.0	.0	.0	.0	.0	
Applied Materials	22.0	28.3	31.0	35.0	28.0	
Branson/IPC	.0	.0	.8	1.0	.0	
Drytek	2.0	.0	3.0	4.0	5.0	
Elionix	.0	.0	.0	.0	.0	
E.T. Electrotech	6.2	7.7	8.0	10.0	4.8	
GCA	1.0	1.0	.0	.0	.0	
Gasonics	.0	.0	.0	.0	1.5	
Hitachi	.0	.0	.0	5.0	4.5	
Kokusai	.0	.0	.0	.0	.0	
Lam Research	7.0	13.0	11.0	17.0	12.0	
Materials Research	.9	1.5	1.2	.0	.0	
Matrix	.0	.0	.0	.0	.0	
MRC (Sony)	.0	.0	.0	.0	1.8	
Plasma Systems	.0	.0	.0	.0	.0	
Plasma Technology	.0	.8	1.0	3.0	3.6	
Plasma-Therm	.8	1.2	1.2	2.0	2.1	
Samco	.0	.0	.0	.0	.0	
Shibaura	.0	.0	.0	.0	.0	
Sumitomo Metals	.0	.0	.0	.0	.0	
Tegal	15.6	19.4	16.0	11.0	8.0	
Tokyo Electron	.0	.0	.0	.0	.0	
Tokuda	2.8	.0	1.3	.7	.0	
Tokyo Ohka	.0	.0	.0	.0	.0	
TEL/LAM	.0	.0	.0	.0	.0	
Ulvac	.0	.0	.0	.0	.0	
Varian/TEL	.0	.0	.0	6.9	6.5	
Total Europe	58.3	72.9	74.5	95.6	77.8	7.5

DETCH5HR
Source: Dataquest (April 1992)

Table 4.24
Each Company's Revenue from Shipments of Dry Etch Equipment to Asia/Pacific-ROW
(End User Revenue in Millions of U.S. Dollars)

Company: Each
Product: Dry Etch
Region Of Consumption: Asia/Pacific-ROW

	1987	1988	1989	1990	1991	CAGR (%) 1987-1991
World Dry Etch Market	307.4	533.2	669.5	690.4	704.7	23.0
Asia/Pacific-ROW						
Alcan Technology	.0	.0	.0	.0	.0	
Anelva	.0	.0	9.4	2.1	2.0	
Applied Materials	7.1	19.4	21.0	10.0	19.0	
Branson/IPC	1.0	.0	.5	.5	.0	
Drytek	4.0	2.0	4.0	2.0	2.0	
Elionix	.0	.0	.0	.0	.0	
E.T. Electrotech	.0	.7	1.5	1.0	2.4	
GCA	.0	.0	.0	.0	.0	
Gasonics	.0	.0	.0	.0	.0	
Hitachi	.0	.0	.0	.0	12.3	
Kokusai	.0	.0	.0	.0	.0	
Lam Research	5.0	23.0	26.0	20.0	31.0	
Materials Research	.0	.5	.0	.0	.0	
Matrix	.0	.0	.0	.0	.2	
MRC (Sony)	.0	.0	.0	.0	.0	
Plasma Systems	.0	.0	.0	.0	.0	
Plasma Technology	.0	.0	.0	.0	.0	
Plasma-Therm	.3	.3	.4	1.0	.0	
Samco	.0	.0	.0	.0	.0	
Shibaura	.0	.0	.0	.0	.0	
Sumitomo Metals	.0	.0	.0	.0	.0	
Tegal	.0	3.0	4.0	2.0	3.0	
Tokyo Electron	.0	.0	10.1	2.4	24.0	
Tokuda	.5	.0	2.1	.6	.0	
Tokyo Ohka	.0	.0	.0	2.8	1.3	
TEL/LAM	.0	.0	.0	.0	.0	
Ulvac	.1	.2	.0	.0	.0	
Varian/TEL	.0	.0	.0	.0	.0	
Total A/P-ROW	18.0	49.1	79.0	44.4	97.2	52.4

DETCHSHR
Source: Dataquest (April 1992)

Table 4.25
Each Company's Revenue from Shipments of Dry Etch Equipment to the World (End User Revenue in Millions of U.S. Dollars)

Company: Each
Product: Dry Etch
Region Of Consumption: World

	1987	1988	1989	1990	1991	CAGR (%) 1987-1991
World Dry Etch Market	307.4	533.2	669.5	690.4	704.7	23.0
Worldwide						
Alcan Technology	.0	.0	.0	2.5	5.6	
Anelva	22.3	41.6	48.5	29.4	22.3	
Applied Materials	102.0	196.7	208.0	175.0	154.0	
Branson/IPC	1.6	.0	3.2	3.5	.0	
Drytek	17.0	25.0	30.0	22.0	25.0	
Elionix	.3	.3	.3	1.2	.7	
E.T. Electrotech	7.2	14.1	15.0	17.5	12.0	
GCA	4.0	5.0	.0	.0	.0	
Gasonics	.0	.0	.0	.0	5.0	
Hitachi	18.8	34.6	47.6	91.5	115.2	
Kokusai	1.4	1.5	1.0	1.1	.0	
Lam Research	32.0	65.0	83.2	109.2	127.1	
Materials Research	4.4	13.0	7.4	.0	.0	
Matrix	.0	.0	.0	.0	2.3	
MRC (Sony)	.0	.0	.0	4.7	9.6	
Plasma Systems	1.9	3.2	3.3	1.7	1.5	
Plasma Technology	.0	1.6	2.0	5.5	6.3	
Plasma-Therm	13.7	12.9	15.2	18.0	13.8	
Samco	.0	.0	2.2	2.8	3.4	
Shibaura	.0	.0	.0	.0	14.1	
Sumitomo Metals	5.6	6.2	12.0	15.7	15.4	
Tegal	35.6	46.4	41.0	31.0	29.0	
Tokyo Electron	.0	44.6	80.6	99.2	110.0	
Tokuda	9.4	3.2	32.4	24.1	.0	
Tokyo Ohka	7.1	10.0	21.7	16.6	15.3	
TEL/LAM	17.4	.0	.0	.0	.0	
Ulvac	5.7	8.3	8.7	6.6	6.2	
Varian/TEL	.0	.0	6.2	11.6	10.9	
Total Worldwide	307.4	533.2	669.5	690.4	704.7	23.0

DETCHSHR
Source: Dataquest (April 1992)

Table 4.26
Each Company's Revenue from Shipments of Chemical Vapor Deposition Equipment to North America (End User Revenue in Millions of U.S. Dollars)

Company: Each
Product: Chemical Vapor Deposition
Region Of Consumption: North America

	1987	1988	1989	1990	1991	CAGR (%) 1987-1991
World CVD Market	260.1	466.4	611.2	716.5	747.4	30.2
Tube CVD						
Horizontal Tube LPCVD						
ASM International	1.7	2.6	2.0	2.5	2.0	
BTU International	3.4	7.4	9.0	4.0	2.5	
Centrotherm	.0	.0	2.5	2.8	1.6	
Enya	.0	.0	.0	.0	.0	
General Signal Thinfilm	.0	3.0	3.0	2.0	.0	
Kokusai Electric	.0	.8	.0	.0	.0	
Koyo Lindberg	.0	.0	.0	.0	.0	
Process Technology	3.8	4.0	2.2	2.5	1.2	
Silicon Valley Group	.0	.0	7.0	6.0	4.0	
Solitec	2.0	4.8	4.0	4.0	.0	
TEL/Thermco	.0	.0	.0	.0	.0	
Thermco	3.0	3.5	.0	.0	.0	
Tokyo Electron Ltd.	.0	.0	.0	.0	.0	
Tylan	1.0	1.5	.0	.0	.0	
Tystar	.0	.0	.6	.2	.0	
Ulvac	.0	.0	.0	.0	.0	
Ulvac/BTU	.0	.0	.0	.0	.0	
Varian/TEL	.0	.0	.0	.0	.0	
Wellman	.0	.0	.0	.0	.0	
Total Horizontal LPCVD	14.9	27.6	30.3	24.0	11.3	-6.7
Vertical Tube LPCVD						
ASM International	.0	.0	.6	1.2	2.0	
BTU International	.0	.0	.0	2.0	3.5	
Denko	.0	.0	.0	.0	.0	
Disco	.0	.0	.0	.0	.0	
General Signal Thinfilm	.0	.0	2.0	4.0	3.0	
Helmut Seier	.0	.0	.0	.0	.0	
Koyo Lindberg	.0	.0	.0	.0	.0	
Kokusai Electric	.0	2.5	2.2	2.5	5.5	
Semitherm	.0	.5	1.0	1.5	1.5	
Shinko Electric	.0	.0	.0	.0	.0	
Silicon Valley Group	1.6	1.6	3.0	8.0	12.0	
Toyoko Chemical	.0	.0	.0	.0	.0	
Tokyo Electron Ltd.	.0	.0	.0	.0	.0	
Ulvac	.0	.0	.0	.0	.0	
Varian/TEL	.0	.0	.0	2.0	5.3	
Total Vertical LPCVD	1.6	4.6	8.8	21.2	32.8	112.8

(Continued)

Table 4.26 (Continued)
Each Company's Revenue from Shipments of Chemical Vapor Deposition Equipment to North America (End User Revenue in Millions of U.S. Dollars)

Company: Each
Product: Chemical Vapor Deposition
Region Of Consumption: North America

	1987	1988	1989	1990	1991	CAGR (%) 1987-1991
Horizontal Tube PECVD						
ASM International	23.1	20.6	16.0	16.0	10.0	
Pacific Western	3.7	2.7	1.8	1.5	1.0	
Total Horizontal Tube PECVD	26.8	23.3	17.8	17.5	11.0	-20.0
Total N.A. Tube CVD	43.3	55.5	56.9	62.7	55.1	6.2
Non-Tube CVD Reactors						
APCVD Reactors						
Alcan (Canon)	.0	.0	.0	.0	2.7	
Amaya	.0	.0	.0	.0	.0	
Applied Materials	3.0	3.0	2.0	.0	.0	
General Signal Thinfilm	.0	.5	.5	.5	.5	
Hitachi	.0	.0	.0	.0	.0	
Kokusai Electric	.0	.0	.0	.0	.0	
Koyo Lindberg	.0	.0	.0	.0	.0	
Pacific Western	.0	.0	.0	.0	.0	
Tempress	.0	.5	.5	.5	.0	
Toshiba Machine	.0	.0	.0	.0	.0	
Watkins-Johnson	7.3	10.5	10.0	10.0	13.2	
Total APCVD Reactors	10.3	14.5	13.0	11.0	16.4	12.3
LPCVD Reactors						
Anicon	1.4	1.5	.6	.6	.0	
Anelva	.0	.0	.0	.0	.0	
Applied Materials	.0	.0	.0	12.0	12.0	
BCT Spectrum	.0	.0	.0	.0	2.0	
BTU/Ulvac	.0	.0	.0	1.6	.0	
Enya	.0	.0	.0	.0	.0	
Focus Semiconductor	1.0	1.6	.0	.0	.0	
Genus	7.1	11.7	22.0	14.0	12.0	
Kokusai Electric	.0	.0	.0	.0	.0	
LAM Research	.0	.0	.0	1.3	.0	
Novellus	.0	.0	.0	1.0	5.7	
Silicon Valley Group	1.4	1.5	.6	.6	.0	
Spectrum CVD	2.3	1.1	3.0	2.0	.0	
Tokyo Electron, Ltd.	.0	.0	.0	.0	.0	
Ulvac	.0	.0	.0	.0	.6	
Varian	2.5	2.0	.7	.0	.0	
Total LPCVD Reactors	15.7	19.4	26.9	33.1	32.3	19.8

(Continued)

Table 4.26 (Continued)
Each Company's Revenue from Shipments of Chemical Vapor Deposition Equipment to North America (End User Revenue in Millions of U.S. Dollars)

Company:	Each
Product:	Chemical Vapor Deposition
Region Of Consumption:	North America

	1987	1988	1989	1990	1991	CAGR (%) 1987-1991
PECVD Reactors						
Anelva	.0	.0	.0	.0	.0	
Applied Materials	15.5	37.0	56.0	67.0	54.0	
Enya	.0	.0	.0	.0	.0	
E.T. Electrotech	1.0	4.2	2.5	3.5	3.4	
Japan Production	.0	.0	.0	.0	.0	
LAM Research	.0	.0	.0	.0	.0	
Novellus	3.1	16.9	35.0	42.0	23.0	
Plasma-Therm	3.8	4.0	2.0	2.0	1.2	
Samco	.0	.0	.0	.0	.0	
Total PECVD Reactors	23.4	62.1	95.5	114.5	81.6	36.7
ECR CVD						
Anelva	.0	.0	.0	.0	.0	
Fuji Electric	.0	.0	.0	.0	.0	
Plasma Technology	.0	.8	1.0	.6	.5	
Sumitomo Metals	.0	.0	.0	2.5	2.7	
Total ECR CVD Reactors	.0	.8	1.0	3.1	3.2	
Total N.A. Non-Tube CVD	49.4	96.8	136.4	161.7	133.5	28.2
Total N.A. CVD	92.7	152.3	193.3	224.4	188.6	19.4

Ref: CVDSHR
Source: Dataquest (April 1992)

Table 4.27
Each Company's Revenue from Shipments of Chemical Vapor Deposition Equipment to Japan (End User Revenue in Millions of U.S. Dollars)

Company:	Each
Product:	Chemical Vapor Deposition
Region Of Consumption:	Japan

	1987	1988	1989	1990	1991	CAGR (%) 1987-1991
World CVD Market	260.1	466.4	611.2	716.5	747.4	30.2
Tube CVD						
Horizontal Tube LPCVD						
ASM International	2.0	3.9	2.0	1.5	.9	
BTU International	.0	.0	.0	.0	.0	
Centrotherm	.0	.0	.0	.0	.0	
Enya	.6	1.8	1.7	.0	.0	
General Signal Thinfilm	.0	.0	.0	.0	.0	
Kokusai Electric	7.6	6.4	2.2	2.5	.0	
Koyo Lindberg	1.0	1.8	3.0	1.0	.0	
Process Technology	.0	.0	.0	.0	.0	
Silicon Valley Group	.0	.0	.0	.0	.0	
Solitec	.0	.0	.0	.0	.0	
TEL/Thermco	8.3	.0	.0	.0	.0	
Thermco	.0	.0	.0	.0	.0	
Tokyo Electron Ltd.	.0	8.5	8.7	3.6	7.1	
Tylan	.0	.0	.0	.0	.0	
Tystar	.0	.0	.0	.0	.0	
Ulvac	.0	.0	.0	.0	5.3	
Ulvac/BTU	.5	3.5	4.0	6.2	.0	
Varian/TEL	.0	.0	.0	.0	.0	
Wellman	.0	.0	.0	.0	.0	
Total Horizontal LPCVD	20.0	25.9	21.6	14.8	13.3	-9.7
Vertical Tube LPCVD						
ASM International	.0	.0	.6	13.9	14.1	
BTU International	.0	.0	.0	.0	.0	
Denko	2.1	2.3	3.5	3.8	.0	
Disco	.0	.0	.0	.0	2.7	
General Signal Thinfilm	.0	.0	.0	.0	.0	
Helmut Seier	.3	.3	.0	.0	.0	
Koyo Lindberg	1.0	2.7	1.1	2.1	1.9	
Kokusai Electric	2.8	12.3	23.6	39.2	32.3	
Semitherm	.0	.0	.0	.0	.0	
Shinko Electric	.0	.0	.0	.0	4.0	
Silicon Valley Group	.0	.8	.0	.0	.0	
Toyoko Chemical	.0	.0	5.8	5.2	5.0	
Tokyo Electron Ltd.	.0	3.8	15.9	34.0	45.0	
Ulvac	.0	.0	.0	.0	5.0	
Varian/TEL	.0	.0	.0	.0	.0	
Total Vertical LPCVD	6.2	22.2	50.5	98.2	110.0	105.2

(Continued)

Table 4.27 (Continued)
Each Company's Revenue from Shipments of Chemical Vapor Deposition Equipment to Japan
(End User Revenue in Millions of U.S. Dollars)

Company: Each
Product: Chemical Vapor Deposition
Region Of Consumption: Japan

	1987	1988	1989	1990	1991	CAGR (%) 1987-1991
Horizontal Tube PECVD						
ASM International	9.8	15.5	17.0	23.6	19.0	
Pacific Western	2.8	2.1	.0	.0	.0	
Total Horizontal Tube PECVD	12.6	17.6	17.0	23.6	19.0	10.8
Total Japan Tube CVD	38.8	65.7	89.1	136.6	142.3	38.4
Non-Tube CVD Reactors						
APCVD Reactors						
Alcan (Canon)	.0	.0	.0	15.0	21.4	
Amaya	5.5	17.5	19.0	15.3	12.3	
Applied Materials	8.5	8.7	4.0	3.0	.0	
General Signal Thinfilm	.0	.5	.0	.0	.0	
Hitachi	.0	.5	1.1	.0	.0	
Kokusai Electric	.0	.7	.0	.0	.0	
Koyo Lindberg	.2	1.3	.6	.8	.6	
Pacific Western	.2	.0	.0	.0	.0	
Tempress	.0	.5	.0	.0	.0	
Toshiba Machine	5.0	6.0	4.2	3.2	3.2	
Watkins-Johnson	2.0	15.0	20.0	20.0	15.4	
Total APCVD Reactors	21.4	50.7	48.9	57.3	52.9	25.4
LPCVD Reactors						
Anicon	.8	1.5	.7	.0	.0	
Anelva	.7	2.3	1.1	1.4	2.8	
Applied Materials	.0	.0	.0	8.0	17.0	
BCT Spectrum	.0	.0	.0	.0	.0	
BTU/Ulvac	.0	.0	.0	.0	.0	
Enya	.0	1.8	1.7	3.5	.0	
Focus Semiconductor	.0	.9	.0	.0	.0	
Genus	3.3	12.7	23.0	19.0	12.3	
Kokusai Electric	.0	.0	.0	3.1	.0	
LAM Research	.0	.0	.0	1.4	.0	
Novellus	.0	.0	.0	.0	.0	
Silicon Valley Group	.8	1.5	.7	.0	.0	
Spectrum CVD	.0	.3	.6	.6	.0	
Tokyo Electron, Ltd.	.0	.0	.0	4.9	2.7	
Ulvac	1.4	3.8	4.2	4.5	7.4	
Varian	2.4	2.3	4.3	.0	.0	
Total LPCVD Reactors	9.4	27.1	36.3	46.4	42.2	45.6

(Continued)

Table 4.27 (Continued)
Each Company's Revenue from Shipments of Chemical Vapor Deposition Equipment to Japan (End User Revenue in Millions of U.S. Dollars)

Company: Each
Product: Chemical Vapor Deposition
Region Of Consumption: Japan

	1987	1988	1989	1990	1991	CAGR (%) 1987-1991
PECVD Reactors						
Anelva	.0	1.4	.4	.0	.0	
Applied Materials	10.0	25.0	59.0	70.0	85.4	
Enya	1.9	4.2	3.5	3.8	1.6	
E.T. Electrotech	5.2	4.9	4.0	4.5	7.6	
Japan Production	4.5	6.5	7.0	8.0	5.6	
LAM Research	.0	.0	.0	.0	.0	
Novellus	.5	3.4	5.6	11.0	26.0	
Plasma-Therm	.3	.5	.6	.5	.0	
Samco	.0	.0	1.0	2.3	3.0	
Total PECVD Reactors	22.4	45.9	81.1	100.1	129.2	55.0
ECR CVD						
Anelva	1.0	.8	1.0	.4	2.2	
Fuji Electric	.0	.0	.0	.0	.9	
Plasma Technology	.0	.0	.0	.0	.0	
Sumitomo Metals	.0	.0	6.0	2.9	.0	
Total ECR CVD Reactors	1.0	.8	7.0	3.3	3.1	
Total Japan Non-Tube CVD	54.2	124.5	173.3	207.1	227.4	43.1
Total Japan CVD	93.0	190.2	262.4	343.7	369.7	41.2

Ref: CVDSHR
Source: Dataquest (April 1992)

Table 4.28
Each Company's Revenue from Shipments of Chemical Vapor Deposition Equipment to Europe (End User Revenue in Millions of U.S. Dollars)

Company: Each
Product: Chemical Vapor Deposition
Region Of Consumption: Europe

	1987	1988	1989	1990	1991	CAGR (%) 1987-1991
World CVD Market	260.1	466.4	611.2	716.5	747.4	30.2
Tube CVD						
Horizontal Tube LPCVD						
ASM International	16.2	16.7	10.0	5.0	3.5	
BTU International	3.0	3.5	3.5	2.0	1.5	
Centrotherm	.0	.0	2.0	2.0	1.5	
Enya	.0	.0	.0	.0	.0	
General Signal Thinfilm	.0	.8	1.0	1.0	.0	
Kokusai Electric	.0	.0	.0	2.0	.0	
Koyo Lindberg	.0	.0	.0	.0	.0	
Process Technology	.5	.0	.3	.5	.2	
Silicon Valley Group	.0	.0	1.0	2.0	1.8	
Solitec	.3	.6	.0	.0	.0	
TEL/Thermco	.0	.0	.0	.0	.0	
Thermco	2.2	1.0	.0	.0	.0	
Tokyo Electron Ltd.	.0	2.3	.0	.0	.0	
Tylan	2.0	.0	.0	.0	.0	
Tystar	.0	.0	.0	.0	.0	
Ulvac	.0	.0	.0	.0	.0	
Ulvac/BTU	.0	.0	.0	.0	.0	
Varian/TEL	.0	.0	.0	2.1	1.9	
Wellman	.0	.5	.3	.0	.0	
Total Horizontal LPCVD	24.2	25.4	18.1	16.6	10.4	-19.0
Vertical Tube LPCVD						
ASM International	.0	.0	1.2	1.8	3.5	
BTU International	.0	.0	.0	1.5	1.0	
Denko	.0	.0	.0	.0	.0	
Disco	.0	.0	.0	.0	.0	
General Signal Thinfilm	.0	.0	.0	.0	.0	
Helmut Seier	.0	.0	.0	.0	.0	
Koyo Lindberg	.0	.0	.0	.0	.0	
Kokusai Electric	.0	.0	.3	.0	2.2	
Semitherm	.0	.0	.0	.0	.0	
Shinko Electric	.0	.0	.0	.0	.0	
Silicon Valley Group	.0	.8	.5	1.6	1.5	

(Continued)

Table 4.28 (Continued)
Each Company's Revenue from Shipments of Chemical Vapor Deposition Equipment to Europe (End User Revenue in Millions of U.S. Dollars)

Company:	Each
Product:	Chemical Vapor Deposition
Region Of Consumption:	Europe

	1987	1988	1989	1990	1991	CAGR (%) 1987-1991
Toyoko Chemical	.0	.0	.0	.7	.0	
Tokyo Electron Ltd.	.0	.0	.0	.0	.0	
Ulvac	.0	.0	.0	.0	.0	
Varian/TEL	.0	.0	.0	.7	2.4	
Total Vertical LPCVD	.0	.8	2.0	6.3	10.6	ERR
Horizontal Tube PECVD						
ASM International	5.8	10.3	9.0	5.0	4.0	
Pacific Western	1.4	.9	1.0	1.0	.0	
Total Horizontal Tube PECVD	7.2	11.2	10.0	6.0	4.0	-13.7
Total Europe Tube CVD	31.4	37.4	30.1	28.9	25.0	-5.5
Non-Tube CVD Reactors						
APCVD Reactors						
Alcan (Canon)	.0	.0	.0	.0	.0	
Amaya	.0	.0	.0	.0	.0	
Applied Materials	3.0	3.0	1.0	1.0	.0	
General Signal Thinfilm	.0	.3	.3	.3	.0	
Hitachi	.0	.0	.0	.0	.0	
Kokusai Electric	.0	.0	.0	.0	.0	
Koyo Lindberg	.0	.0	.0	.0	.0	
Pacific Western	.0	.0	.0	.0	.0	
Tempress	.0	.3	.3	.3	.0	
Toshiba Machine	.0	.0	.0	.0	.0	
Watkins-Johnson	6.7	6.0	5.0	8.0	4.9	
Total APCVD Reactors	9.7	9.6	6.6	9.6	4.9	-15.7
LPCVD Reactors						
Anicon	1.1	.5	.7	.7	.0	
Anelva	.0	.0	.0	.0	.0	
Applied Materials	.0	.0	.0	5.0	2.0	
BCT Spectrum	.0	.0	.0	.0	.0	
BTU/Ulvac	.0	.0	.0	.0	.0	
Enya	.0	.0	.0	.0	.0	
Focus Semiconductor	.0	.0	.0	.0	.0	
Genus	1.7	3.7	7.0	7.0	4.5	
Kokusai Electric	.0	.0	.0	.0	.0	

(Continued)

Table 4.28 (Continued)
Each Company's Revenue from Shipments of Chemical Vapor Deposition Equipment to Europe (End User Revenue in Millions of U.S. Dollars)

Company:	Each
Product:	Chemical Vapor Deposition
Region Of Consumption:	Europe

	1987	1988	1989	1990	1991	CAGR (%) 1987-1991
LAM Research	.0	.0	.0	.0	.0	
Novellus	.0	.0	.0	.0	.0	
Silicon Valley Group	1.1	.5	.7	.7	.0	
Spectrum CVD	.0	.0	.0	.6	.0	
Tokyo Electron, Ltd.	.0	.0	.0	.0	.0	
Ulvac	.0	.0	.0	.0	.0	
Varian	1.5	1.4	.0	.0	.0	
Total LPCVD Reactors	5.4	6.1	8.4	14.0	6.5	4.7
PECVD Reactors						
Anelva	.0	.0	.0	.0	.0	
Applied Materials	3.9	8.9	16.0	24.0	22.0	
Enya	.0	.0	.0	.0	.0	
E.T. Electrotech	7.1	9.8	7.0	8.0	8.0	
Japan Production	.0	.0	.0	.0	.0	
LAM Research	.0	.0	.0	.0	.0	
Novellus	.0	1.1	3.7	6.0	9.0	
Plasma-Therm	.5	1.0	.4	.5	.0	
Samco	.0	.0	.0	.0	.0	
Total PECVD Reactors	11.5	20.8	27.1	38.5	39.0	35.7
ECR CVD						
Anelva	.0	.0	.0	.0	.0	
Fuji Electric	.0	.0	.0	.0	.0	
Plasma Technology	.0	.8	1.0	1.9	1.0	
Sumitomo Metals	.0	.0	.0	.0	.0	
Total ECR CVD Reactors	.0	.8	1.0	1.9	1.0	
Total Europe Non-Tube CVD	26.6	37.3	43.1	64.0	51.4	17.9
Total Europe CVD	58.0	74.7	73.2	92.9	76.4	7.1

Ref: CVDSHR
Source: Dataquest (April 1992)

Table 4.29
Each Company's Revenue from Shipments of Chemical Vapor Deposition Equipment to Asia/Pacific-ROW (End User Revenue in Millions of U.S. Dollars)

Company:	Each
Product:	Chemical Vapor Deposition
Region Of Consumption:	Asia/Pacific-ROW

	1987	1988	1989	1990	1991	CAGR (%) 1987-1991
World CVD Market	260.1	466.4	611.2	716.5	747.4	30.2
Tube CVD						
Horizontal Tube LPCVD						
ASM International	.0	2.6	1.0	1.0	1.5	
BTU International	1.5	3.6	5.0	1.2	2.0	
Centrotherm	.0	.0	.0	.0	.0	
Enya	.0	.0	.0	.0	.0	
General Signal Thinfilm	.0	.0	.0	.0	.0	
Kokusai Electric	.0	2.0	.0	.0	1.6	
Koyo Lindberg	.0	.0	.0	.0	.0	
Process Technology	.0	.0	.0	.0	.0	
Silicon Valley Group	.0	.0	2.0	2.0	3.5	
Solitec	1.3	.6	1.0	1.0	.0	
TEL/Thermco	.0	.0	.0	.0	.0	
Thermco	1.8	2.0	.0	.0	.0	
Tokyo Electron Ltd.	.0	3.8	6.0	3.3	.0	
Tylan	1.0	.0	.0	.0	.0	
Tystar	.0	.0	.2	.2	.3	
Ulvac	.0	.0	.0	.0	.0	
Ulvac/BTU	.0	.0	.0	.0	.0	
Varian/TEL	.0	.0	.0	.0	.0	
Wellman	.0	.0	.0	.0	.0	
Total Horizontal LPCVD	5.6	14.6	15.2	8.7	8.9	12.3
Vertical Tube LPCVD						
ASM International	.0	.0	.6	.6	3.0	
BTU International	.0	.0	.0	1.5	.0	
Denko	.0	.0	.0	.0	.0	
Disco	.0	.0	.0	.0	.0	
General Signal Thinfilm	.0	.0	.0	.0	.0	
Helmut Seier	.0	.0	.0	.0	.0	
Koyo Lindberg	.0	.0	.0	.0	.0	
Kokusai Electric	.0	6.8	18.8	13.4	22.0	
Semitherm	.0	.0	.0	.0	.0	
Shinko Electric	.0	.0	.0	.0	2.2	

(Continued)

Table 4.29 (Continued)
Each Company's Revenue from Shipments of Chemical Vapor Deposition Equipment to Asia/Pacific-ROW (End User Revenue in Millions of U.S. Dollars)

Company: Each
Product: Chemical Vapor Deposition
Region Of Consumption: Asia/Pacific-ROW

	1987	1988	1989	1990	1991	CAGR (%) 1987-1991
Silicon Valley Group	.0	.4	.5	1.6	3.0	
Toyoko Chemical	.0	.0	.0	.0	.0	
Tokyo Electron Ltd.	.0	.0	.0	.0	8.0	
Ulvac	.0	.0	.0	.0	.0	
Varian/TEL	.0	.0	.0	.0	.0	
Total Vertical LPCVD	.0	7.2	19.9	17.1	38.2	N/M
Horizontal Tube PECVD						
ASM International	5.8	5.2	9.0	5.0	7.0	
Pacific Western	.0	.5	.0	.0	.0	
Total Horizontal Tube PECVD	5.8	5.7	9.0	5.0	7.0	4.8
Total A/P-ROW Tube CVD	11.4	27.5	44.1	30.8	54.1	47.6
Non-Tube CVD Reactors						
APCVD Reactors						
Alcan (Canon)	.0	.0	.0	.0	2.7	
Amaya	.0	.0	.0	.7	.0	
Applied Materials	.0	1.0	2.0	1.0	.0	
General Signal Thinfilm	.0	.0	.0	.0	.0	
Hitachi	.0	.0	.0	.0	.0	
Kokusai Electric	.0	.0	.0	.0	.0	
Koyo Lindberg	.0	.0	.0	.0	.0	
Pacific Western	.0	.0	.0	.0	.0	
Tempress	.0	.5	.5	.5	.0	
Toshiba Machine	.0	.0	.0	.0	.0	
Watkins-Johnson	.0	4.5	7.0	3.0	15.0	
Total APCVD Reactors	.0	6.0	9.5	5.2	17.7	ERR
LPCVD Reactors						
Anicon	.4	.5	.0	.0	.0	
Anelva	.0	.0	.0	.0	.0	
Applied Materials	.0	.0	.0	1.0	1.0	
BCT Spectrum	.0	.0	.0	.0	.0	
BTU/Ulvac	.0	.0	.0	.0	.0	
Enya	.0	.0	.0	.0	.0	
Focus Semiconductor	.0	.0	.0	.0	.0	
Genus	1.1	5.3	10.0	4.0	6.0	

(Continued)

Table 4.29 (Continued)
Each Company's Revenue from Shipments of Chemical Vapor Deposition Equipment to Asia/Pacific-ROW (End User Revenue in Millions of U.S. Dollars)

Company: Each
Product: Chemical Vapor Deposition
Region Of Consumption: Asia/Pacific-ROW

	1987	1988	1989	1990	1991	CAGR (%) 1987-1991
Kokusai Electric	.0	.0	.0	.0	.0	
LAM Research	.0	.0	.0	.0	1.9	
Novellus	.0	.0	.0	.0	.0	
Silicon Valley Group	.4	.5	.0	.0	.0	
Spectrum CVD	.0	.0	.0	.0	.0	
Tokyo Electron, Ltd.	.0	.0	.0	.0	.0	
Ulvac	.0	.0	.0	.0	.0	
Varian	1.5	.7	.0	.0	.0	
Total LPCVD Reactors	3.4	7.0	10.0	5.0	8.9	27.2
PECVD Reactors						
Anelva	.0	.0	.0	.0	.0	
Applied Materials	1.6	4.5	12.0	9.0	25.0	
Enya	.0	.0	.0	.0	.0	
E.T. Electrotech	.0	1.4	2.0	1.5	1.0	
Japan Production	.0	.0	.0	.0	.0	
LAM Research	.0	.0	.0	.0	.0	
Novellus	.0	2.3	4.7	4.0	6.0	
Plasma-Therm	.0	.5	.0	.0	.0	
Samco	.0	.0	.0	.0	.0	
Total PECVD Reactors	1.6	8.7	18.7	14.5	32.0	111.5
ECR CVD						
Anelva	.0	.0	.0	.0	.0	
Fuji Electric	.0	.0	.0	.0	.0	
Plasma Technology	.0	.0	.0	.0	.0	
Sumitomo Metals	.0	.0	.0	.0	.0	
Total ECR CVD Reactors	.0	.0	.0	.0	.0	
Total A/P-ROW Non-Tube CVD	5.0	21.7	38.2	24.7	58.6	85.0
Total A/P-ROW CVD	16.4	49.2	82.3	55.5	112.7	61.9

Ref: CVDSHR
Source: Dataquest (April 1992)

Table 4.30
Each Company's Revenue from Shipments of Chemical Vapor Deposition Equipment to the World (End User Revenue in Millions of U.S. Dollars)

Company: Each
Product: Chemical Vapor Deposition
Region Of Consumption: World

	1987	1988	1989	1990	1991	CAGR (%) 1987-1991
World CVD Market	260.1	466.4	611.2	716.5	747.4	30.2
Tube CVD						
Horizontal Tube LPCVD						
ASM International	19.9	25.8	15.0	10.0	7.9	
BTU International	7.9	14.5	17.5	7.2	6.0	
Centrotherm	.0	.0	4.5	4.8	3.1	
Enya	.6	1.8	1.7	.0	.0	
General Signal Thinfilm	.0	3.8	4.0	3.0	.0	
Kokusai Electric	7.6	9.2	2.2	4.5	1.6	
Koyo Lindberg	1.0	1.8	3.0	1.0	.0	
Process Technology	4.3	4.0	2.5	3.0	1.4	
Silicon Valley Group	.0	.0	10.0	10.0	9.3	
Solitec	3.6	6.0	5.0	5.0	.0	
TEL/Thermco	8.3	.0	.0	.0	.0	
Thermco	7.0	6.5	.0	.0	.0	
Tokyo Electron Ltd.	.0	14.6	14.7	6.9	7.1	
Tylan	4.0	1.5	.0	.0	.0	
Tystar	.0	.0	.8	.4	.3	
Ulvac	.0	.0	.0	.0	5.3	
Ulvac/BTU	.5	3.5	4.0	6.2	.0	
Varian/TEL	.0	.0	.0	2.1	1.9	
Wellman	.0	.5	.3	.0	.0	
Total Horizontal LPCVD	64.7	93.5	85.2	64.1	43.9	-9.2
Vertical Tube LPCVD						
ASM International	.0	.0	3.0	17.5	22.6	
BTU International	.0	.0	.0	5.0	4.5	
Denko	2.1	2.3	3.5	3.8	.0	
Disco	.0	.0	.0	.0	2.7	
General Signal Thinfilm	.0	.0	2.0	4.0	3.0	
Helmut Seier	.3	.3	.0	.0	.0	
Koyo Lindberg	1.0	2.7	1.1	2.1	1.9	
Kokusai Electric	2.8	21.6	44.9	55.1	62.0	
Semitherm	.0	.5	1.0	1.5	1.5	
Shinko Electric	.0	.0	.0	.0	6.2	

(Continued)

Table 4.30 (Continued)
Each Company's Revenue from Shipments of Chemical Vapor Deposition Equipment to the World
(End User Revenue in Millions of U.S. Dollars)

Company:	Each
Product:	Chemical Vapor Deposition
Region Of Consumption:	World

	1987	1988	1989	1990	1991	CAGR (%) 1987-1991
Silicon Valley Group	1.6	3.6	4.0	11.2	16.5	
Toyoko Chemical	.0	.0	5.8	5.9	5.0	
Tokyo Electron Ltd.	.0	3.8	15.9	34.0	53.0	
Ulvac	.0	.0	.0	.0	5.0	
Varian/TEL	.0	.0	.0	2.7	7.7	
Total Vertical LPCVD	7.8	34.8	81.2	142.8	191.6	122.6
Horizontal Tube PECVD						
ASM International	44.5	51.6	51.0	49.6	40.0	
Pacific Western	7.9	6.2	2.8	2.5	1.0	
Total Horizontal Tube PECVD	52.4	57.8	53.8	52.1	41.0	-5.9
Total Worldwide Tube CVD	124.9	186.1	220.2	259.0	276.5	22.0
Non-Tube CVD Reactors						
APCVD Reactors						
Alcan (Canon)	.0	.0	.0	15.0	26.8	
Amaya	5.5	17.5	19.0	16.0	12.3	
Applied Materials	14.5	15.7	9.0	5.0	.0	
General Signal Thinfilm	.0	1.3	.8	.8	.5	
Hitachi	.0	.5	1.1	.0	.0	
Kokusai Electric	.0	.7	.0	.0	.0	
Koyo Lindberg	.2	1.3	.6	.8	.6	
Pacific Western	.2	.0	.0	.0	.0	
Tempress	.0	1.8	1.3	1.3	.0	
Toshiba Machine	5.0	6.0	4.2	3.2	3.2	
Watkins-Johnson	16.0	36.0	42.0	41.0	48.5	
Total APCVD Reactors	41.4	80.8	78.0	83.1	91.9	22.1
LPCVD Reactors						
Anicon	3.7	4.0	2.0	1.3	.0	
Anelva	.7	2.3	1.1	1.4	2.8	
Applied Materials	.0	.0	.0	26.0	32.0	
BCT Spectrum	.0	.0	.0	.0	2.0	
BTU/Ulvac	.0	.0	.0	1.6	.0	

(Continued)

Table 4.30 (Continued)
Each Company's Revenue from Shipments of Chemical Vapor Deposition Equipment to the World (End User Revenue in Millions of U.S. Dollars)

Company: Each
Product: Chemical Vapor Deposition
Region Of Consumption: World

	1987	1988	1989	1990	1991	CAGR (%) 1987-1991
Enya	.0	1.8	1.7	3.5	.0	
Focus Semiconductor	1.0	2.5	.0	.0	.0	
Genus	13.2	33.4	62.0	44.0	34.8	
Kokusai Electric	.0	.0	.0	3.1	.0	
LAM Research	.0	.0	.0	2.7	1.9	
Novellus	.0	.0	.0	1.0	5.7	
Silicon Valley Group	3.7	4.0	2.0	1.3	.0	
Spectrum CVD	2.3	1.4	3.6	3.2	.0	
Tokyo Electron, Ltd.	.0	.0	.0	4.9	2.7	
Ulvac	1.4	3.8	4.2	4.5	8.0	
Varian	7.9	6.4	5.0	.0	.0	
Total LPCVD Reactors	33.9	59.6	81.6	98.5	89.9	27.6
PECVD Reactors						
Anelva	.0	1.4	.4	.0	.0	
Applied Materials	31.0	75.4	143.0	170.0	186.4	
Enya	1.9	4.2	3.5	3.8	1.6	
E.T. Electrotech	13.3	20.3	15.5	17.5	20.0	
Japan Production	4.5	6.5	7.0	8.0	5.6	
LAM Research	.0	.0	.0	.0	.0	
Novellus	3.6	23.7	49.0	63.0	64.0	
Plasma-Therm	4.6	6.0	3.0	3.0	1.2	
Samco	.0	.0	1.0	2.3	3.0	
Total PECVD Reactors	58.9	137.5	222.4	267.6	281.8	47.9
ECR CVD						
Anelva	1.0	.8	1.0	.4	2.2	
Fuji Electric	.0	.0	.0	.0	.9	
Plasma Technology	.0	1.6	2.0	2.5	1.5	
Sumitomo Metals	.0	.0	6.0	5.4	2.7	
Total ECR CVD Reactors	1.0	2.4	9.0	8.3	7.3	
Total Worldwide Non-Tube CVD	135.2	280.3	391.0	457.5	470.9	36.6
Total Worldwide CVD	260.1	466.4	611.2	716.5	747.4	30.2

Ref: CVDSHR
Source: Dataquest (April 1992)

Table 4.31
Each Company's Revenue from Shipments of Physical Vapor Deposition Equipment to North America (End User Revenue in Millions of U.S. Dollars)

Company:	Each
Product:	Physical Vapor Deposition
Region Of Consumption:	North America

	1987	1988	1989	1990	1991	CAGR (%) 1987-1991
World PVD Market	250.9	302.0	368.4	408.5	474.0	17.2
Sputtering						
Advanced Film Tech.	.0	.0	.0	.0	.0	
Anelva	10.0	10.0	10.8	17.8	20.8	
Applied Materials	.0	.0	.0	6.5	20.0	
Balzers	5.0	5.0	4.0	2.0	.0	
CHA Industries	.3	.7	.1	.4	.4	
Circuit Processing	2.0	.0	.0	.0	.0	
CPA	.0	.0	.0	1.0	2.0	
CVC Products	6.8	7.5	9.0	5.0	6.0	
E.T. Electrotech	1.4	1.8	3.0	3.0	3.0	
GSTC	.0	2.6	2.0	.0	.0	
Innotec	2.4	4.2	.5	.3	.2	
Ion Tech	.7	.5	.1	.1	.2	
Kurt J. Lesker	.8	.8	.8	1.0	.2	
Leybold-Heraeus	3.0	3.0	2.0	2.0	1.0	
Materials Research	13.0	15.0	24.0	.0	.0	
MRC Sony	.0	.0	.0	25.0	30.0	
Novellus	.0	.0	.0	.0	1.8	
Perkin-Elmer	2.1	.9	1.0	.0	.0	
Shibaura	.0	.0	.0	.0	.0	
Shinko Seiki	.0	.0	.0	.0	.0	
Sputtered Films	1.0	.6	1.2	1.0	1.5	
Temescal	.0	.0	.1	.1	.0	
Tokuda	.0	.0	.0	.0	.0	
Ulvac	6.3	6.4	6.2	12.6	4.5	
Varian	21.3	24.6	28.0	36.0	25.5	
Others	3.1	5.1	1.9	1.3	1.4	
Total Sputtering	79.2	88.7	94.7	115.1	118.5	10.6

(Continued)

Table 4.31 (Continued)
Each Company's Revenue from Shipments of Physical Vapor Deposition Equipment to North America (End User Revenue in Millions of U.S. Dollars)

Company: Each
Product: Physical Vapor Deposition
Region Of Consumption: North America

	1987	1988	1989	1990	1991	CAGR (%) 1987-1991
Evaporation						
Anelva	.0	.0	.0	.0	.0	
Balzers	1.1	1.1	1.5	2.0	.0	
CHA Industries	6.0	6.3	5.6	2.8	3.0	
CVC Products	.0	1.0	1.0	1.5	2.7	
Innotec	.0	1.0	.0	.0	.0	
Kurt J. Lesker	.3	.3	.4	.6	.2	
Leybold-Heraeus	.5	.5	.8	.0	.0	
Temescal	5.1	4.5	5.0	6.0	5.1	
Ulvac	1.4	1.5	1.6	1.5	.7	
Others	.2	.2	1.2	2.7	2.8	
Total Evaporation	14.6	16.4	17.1	17.1	14.5	-.2
Total North America	93.8	105.1	111.8	132.2	133.0	9.1

Ref: PVDSHR
Source: Dataquest (April 1992)

Table 4.32
Each Company's Revenue from Shipments of Physical Vapor Deposition Equipment to Japan (End User Revenue in Millions of U.S. Dollars)

Company: Each
Product: Physical Vapor Deposition
Region Of Consumption: Japan

	1987	1988	1989	1990	1991	CAGR (%) 1987-1991
World PVD Market	250.9	302.0	368.4	408.5	474.0	17.2
Sputtering						
Advanced Film Tech.	.0	.0	.0	.7	.8	
Anelva	34.7	43.8	65.0	64.5	80.0	
Applied Materials	.0	.0	.0	6.5	21.0	
Balzers	.0	.0	.0	.0	.0	
CHA Industries	.0	.0	.0	.0	.0	
Circuit Processing	1.0	.0	.0	.0	.0	
CPA	.0	.0	.0	.0	.0	
CVC Products	.0	.3	.0	.0	.5	
E.T. Electrotech	.6	.6	1.6	1.0	.0	
GSTC	.0	.0	.0	.0	.0	
Innotec	.0	.0	.0	.0	.0	
Ion Tech	.0	.0	.0	.0	.0	
Kurt J. Lesker	.0	.0	.0	.0	.0	
Leybold-Heraeus	.0	.0	.0	.0	.0	
Materials Research	1.9	7.5	13.0	.0	.0	
MRC Sony	.0	.0	.0	27.0	34.0	
Novellus	.0	.0	.0	.0	.0	
Perkin-Elmer	.0	.0	.0	.0	.0	
Shibaura	.0	.0	.0	.0	4.0	
Shinko Seiki	.0	.0	.0	.0	.4	
Sputtered Films	.0	.0	.0	.0	.0	
Temescal	.0	.0	.0	.0	.0	
Tokuda	11.1	7.0	5.6	5.8	.0	
Ulvac	24.7	40.1	43.6	46.0	50.0	
Varian	12.6	18.7	24.0	26.0	28.2	
Others	.0	.0	.0	.0	.0	
Total Sputtering	86.6	118.0	152.8	177.5	218.9	26.1

(Continued)

Table 4.32 (Continued)
Each Company's Revenue from Shipments of Physical Vapor Deposition Equipment to Japan (End User Revenue in Millions of U.S. Dollars)

Company: Each
Product: Physical Vapor Deposition
Region Of Consumption: Japan

	1987	1988	1989	1990	1991	CAGR (%) 1987-1991
Evaporation						
Anelva	4.9	6.2	4.3	4.1	4.1	
Balzers	.0	.0	1.4	2.0	.0	
CHA Industries	.0	.0	.0	.0	.0	
CVC Products	.0	.0	.0	.0	.0	
Innotec	.0	.0	.0	.0	.0	
Kurt J. Lesker	.0	.0	.0	.0	.0	
Leybold-Heraeus	.0	.0	.0	.0	.0	
Temescal	2.4	2.4	3.5	2.0	1.6	
Ulvac	5.9	11.5	13.0	12.0	7.8	
Others	.0	.0	.0	.0	.0	
Total Evaporation	13.2	20.1	22.2	20.1	13.5	.6
Total Japan	99.8	138.1	175.0	197.6	232.4	23.5

Ref: PVDSHR
Source: Dataquest (April 1992)

Table 4.33
Each Company's Revenue from Shipments of Physical Vapor Deposition Equipment to Europe (End User Revenue in Millions of U.S. Dollars)

Company:	Each
Product:	Physical Vapor Deposition
Region Of Consumption:	Europe

	1987	1988	1989	1990	1991	CAGR (%) 1987-1991
World PVD Market	250.9	302.0	368.4	408.5	474.0	17.2
Sputtering						
Advanced Film Tech.	.0	.0	.0	.0	.0	
Anelva	.0	.0	1.5	5.0	3.7	
Applied Materials	.0	.0	.0	2.0	2.0	
Balzers	8.9	6.0	4.2	5.0	.0	
CHA Industries	.0	.0	.0	.0	.0	
Circuit Processing	.0	.0	.0	.0	.0	
CPA	.0	.0	.0	.0	.0	
CVC Products	2.9	3.5	2.0	1.5	.0	
E.T. Electrotech	4.0	6.0	8.0	8.0	8.0	
GSTC	.0	.0	.0	.0	.0	
Innotec	.0	.0	.0	.0	.0	
Ion Tech	.0	.0	.0	.0	.0	
Kurt J. Lesker	.0	.0	.0	.0	.8	
Leybold-Heraeus	7.0	4.8	6.0	5.0	2.6	
Materials Research	4.0	4.0	5.0	.0	.0	
MRC Sony	.0	.0	.0	7.0	8.5	
Novellus	.0	.0	.0	.0	.0	
Perkin-Elmer	.3	.0	.0	.0	.0	
Shibaura	.0	.0	.0	.0	.0	
Shinko Seiki	.0	.0	.0	.0	.0	
Sputtered Films	.0	.0	.0	.0	.0	
Temescal	.0	.0	.0	.0	.0	
Tokuda	.0	.0	.0	.0	.0	
Ulvac	2.0	1.2	5.9	.0	.0	
Varian	6.3	6.0	7.0	10.0	12.7	
Others	.0	.0	.0	.0	.0	
Total Sputtering	35.4	31.5	39.6	43.5	38.3	2.0

(Continued)

Table 4.33 (Continued)
Each Company's Revenue from Shipments of Physical Vapor Deposition Equipment to Europe (End User Revenue in Millions of U.S. Dollars)

Company: Each
Product: Physical Vapor Deposition
Region Of Consumption: Europe

	1987	1988	1989	1990	1991	CAGR (%) 1987-1991
Evaporation						
Anelva	.0	.0	.0	.0	.0	
Balzers	1.8	1.8	1.5	2.0	.0	
CHA Industries	.0	.0	.0	.0	.0	
CVC Products	.0	.6	.6	.8	.0	
Innotec	.0	.0	.2	.4	.5	
Kurt J. Lesker	.0	.0	.0	.0	.6	
Leybold-Heraeus	1.0	.0	1.0	1.0	1.4	
Temescal	2.4	1.8	2.1	3.0	2.5	
Ulvac	.1	.3	.0	.0	.0	
Others	.0	.0	.0	.0	.0	
Total Evaporation	5.3	4.5	5.4	7.2	5.0	-1.4
Total Europe	40.7	36.0	45.0	50.7	43.3	1.6

Ref: PVDSHR
Source: Dataquest (April 1992)

Table 4.34
Each Company's Revenue from Shipments of Physical Vapor Deposition Equipment to Asia/Pacific-ROW (End User Revenue in Millions of U.S. Dollars)

Company:	Each
Product:	Physical Vapor Deposition
Region Of Consumption:	Asia/Pacific-ROW

	1987	1988	1989	1990	1991	CAGR (%) 1987-1991
World PVD Market	250.9	302.0	368.4	408.5	474.0	17.2
Sputtering						
Advanced Film Tech.	.0	.0	.0	.0	.0	
Anelva	.0	.0	3.6	3.5	10.0	
Applied Materials	.0	.0	.0	.0	12.0	
Balzers	.0	.0	.0	.0	.0	
CHA Industries	.0	.0	.0	.0	.3	
Circuit Processing	.0	.0	.0	.0	.0	
CPA	.0	.0	.0	.0	.0	
CVC Products	.0	1.0	1.0	1.0	.5	
E.T. Electrotech	.0	.6	1.5	1.5	1.0	
GSTC	.0	.0	.0	.0	.0	
Innotec	.0	.0	.0	.5	.5	
Ion Tech	.0	.0	.0	.0	.0	
Kurt J. Lesker	.0	.0	.0	.0	.0	
Leybold-Heraeus	2.0	.0	.8	.8	.8	
Materials Research	4.2	7.5	12.0	.0	.0	
MRC Sony	.0	.0	.0	3.6	12.0	
Novellus	.0	.0	.0	.0	.0	
Perkin-Elmer	.7	.0	.0	.0	.0	
Shibaura	.0	.0	.0	.0	.0	
Shinko Seiki	.0	.0	.0	.0	.0	
Sputtered Films	.0	.0	.0	.0	.0	
Temescal	.0	.0	.0	.0	.0	
Tokuda	.0	.0	.0	.0	.0	
Ulvac	1.0	1.0	.0	.0	.0	
Varian	8.1	12.0	14.0	12.0	24.5	
Others	.0	.0	.0	.2	.4	
Total Sputtering	16.0	22.1	32.9	23.1	62.0	40.3

(Continued)

Table 4.34 (Continued)
Each Company's Revenue from Shipments of Physical Vapor Deposition Equipment to Asia/Pacific-ROW (End User Revenue in Millions of U.S. Dollars)

Company: Each
Product: Physical Vapor Deposition
Region Of Consumption: Asia/Pacific-ROW

	1987	1988	1989	1990	1991	CAGR (%) 1987-1991
Evaporation						
Anelva	.0	.0	.0	.0	.0	
Balzers	.0	.0	1.0	.5	.0	
CHA Industries	.0	.0	1.5	1.2	.7	
CVC Products	.0	.0	.4	.4	.0	
Innotec	.0	.0	.0	.0	.0	
Kurt J. Lesker	.0	.0	.2	.0	.0	
Leybold-Heraeus	.0	.0	.0	.5	.6	
Temescal	.0	.0	.6	2.0	1.6	
Ulvac	.6	.7	.0	.0	.0	
Others	.0	.0	.0	.3	.4	
Total Evaporation	.6	.7	3.7	4.9	3.3	53.1
Total A/P-ROW	16.6	22.8	36.6	28.0	65.3	40.8

Ref: PVDSHR
Source: Dataquest (April 1992)

Table 4.35
Each Company's Revenue from Shipments of Physical Vapor Deposition Equipment to the World
(End User Revenue in Millions of U.S. Dollars)

Company: Each
Product: Physical Vapor Deposition
Region Of Consumption: World

	1987	1988	1989	1990	1991	CAGR (%) 1987-1991
World PVD Market	250.9	302.0	368.4	408.5	474.0	17.2
Sputtering						
Advanced Film Tech.	.0	.0	.0	.7	.8	
Anelva	44.7	53.8	80.9	90.8	114.5	
Applied Materials	.0	.0	.0	15.0	55.0	
Balzers	13.9	11.0	8.2	7.0	.0	
CHA Industries	.3	.7	.1	.4	.7	
Circuit Processing	3.0	.0	.0	.0	.0	
CPA	.0	.0	.0	1.0	2.0	
CVC Products	9.7	12.3	12.0	7.5	7.0	
E.T. Electrotech	6.0	9.0	14.1	13.5	12.0	
GSTC	.0	2.6	2.0	.0	.0	
Innotec	2.4	4.2	.5	.8	.7	
Ion Tech	.7	.5	.1	.1	.2	
Kurt J. Lesker	.8	.8	.8	1.0	1.0	
Leybold-Heraeus	12.0	7.8	8.8	7.8	4.4	
Materials Research	23.1	34.0	54.0	.0	.0	
MRC Sony	.0	.0	.0	62.6	84.5	
Novellus	.0	.0	.0	.0	1.8	
Perkin-Elmer	3.1	.9	1.0	.0	.0	
Shibaura	.0	.0	.0	.0	4.0	
Shinko Seiki	.0	.0	.0	.0	.4	
Sputtered Films	1.0	.6	1.2	1.0	1.5	
Temescal	.0	.0	.1	.1	.0	
Tokuda	11.1	7.0	5.6	5.8	.0	
Ulvac	34.0	48.7	55.7	58.6	54.5	
Varian	48.3	61.3	73.0	84.0	90.9	
Others	3.1	5.1	1.9	1.5	1.8	
Total Sputtering	217.2	260.3	320.0	359.2	437.7	19.1

(Continued)

Table 4.35 (Continued)
Each Company's Revenue from Shipments of Physical Vapor Deposition Equipment to the World (End User Revenue in Millions of U.S. Dollars)

Company: Each
Product: Physical Vapor Deposition
Region Of Consumption: World

	1987	1988	1989	1990	1991	CAGR (%) 1987-1991
Evaporation						
Anelva	4.9	6.2	4.3	4.1	4.1	
Balzers	2.9	2.9	5.4	6.5	.0	
CHA Industries	6.0	6.3	7.1	4.0	3.7	
CVC Products	.0	1.6	2.0	2.7	2.7	
Innotec	.0	1.0	.2	.4	.5	
Kurt J. Lesker	.3	.3	.6	.6	.8	
Leybold-Heraeus	1.5	.5	1.8	1.5	2.0	
Temescal	9.9	8.7	11.2	13.0	10.8	
Ulvac	8.0	14.0	14.6	13.5	8.5	
Others	.2	.2	1.2	3.0	3.2	
Total Evaporation	33.7	41.7	48.4	49.3	36.3	1.9
Total Worldwide	250.9	302.0	368.4	408.5	474.0	17.2

Ref: PVDSHR
Source: Dataquest (April 1992)

Table 4.36
Each Company's Revenue from Shipments of Silicon Epitaxy Equipment to Each Region (End User Revenue in Millions of U.S. Dollars)

Company: Each
Product: Silicon Epitaxy
Region Of Consumption: Each

	1987	1988	1989	1990	1991	CAGR (%) 1987-1991
Total Epitaxy Market	35.5	85.5	75.0	68.2	88.6	25.7
North America						
Applied Materials	6.4	25.5	13.0	12.5	7.0	
ASM Epitaxy	.0	1.5	3.8	12.6	15.0	
Kokusai Electric	.0	.0	.0	.0	.0	
Lam Research	7.0	15.0	12.8	7.9	.0	
LPE	.0	.0	.0	.0	.0	
Moore	.0	1.0	1.2	1.8	2.8	
Rapro	.0	.0	.9	.9	.0	
Sitesa	.0	.0	.0	.0	.0	
Toshiba Machine	.0	.0	.0	.0	.0	
Total North America	13.4	43.0	31.7	35.7	24.8	16.6
Japan						
Applied Materials	8.0	16.5	5.4	8.5	20.0	
ASM Epitaxy	.0	.8	.0	3.0	7.2	
Kokusai Electric	1.5	4.2	5.7	2.2	5.9	
Lam Research	2.9	.0	3.1	.0	.0	
LPE	.0	.0	.0	.0	.0	
Moore	.0	.0	.0	.0	.5	
Rapro	.0	.0	.0	.0	.0	
Sitesa	.0	.0	.0	.0	.0	
Toshiba Machine	.6	2.0	6.5	4.5	12.5	
Total Japan	13.0	23.5	20.7	18.2	46.1	37.2
Europe						
Applied Materials	3.6	4.4	3.0	3.1	3.0	
ASM Epitaxy	.0	.8	2.4	3.6	5.5	
Kokusai Electric	.0	.0	.0	.0	.0	
Lam Research	2.8	1.0	2.8	.0	.0	
LPE	.0	2.7	3.0	4.0	2.5	
Moore	.0	.0	.4	1.2	.0	
Rapro	.0	.0	.0	.0	.0	
Sitesa	.0	4.5	4.9	.0	.0	
Toshiba Machine	.0	.0	.0	.0	.0	
Total Europe	6.4	13.4	16.5	11.9	11.0	14.5

(Continued)

Table 4.36 (Continued)
Each Company's Revenue from Shipments of Silicon Epitaxy Equipment to Each Region
(End User Revenue in Millions of U.S. Dollars)

Company: Each
Product: Silicon Epitaxy
Region Of Consumption: Each

	1987	1988	1989	1990	1991	CAGR (%) 1987-1991
Asia/Pacific-ROW						
Applied Materials	.6	.8	.8	.9	2.0	
ASM Epitaxy	.0	.0	.0	.0	2.2	
Kokusai Electric	.0	.0	.0	.0	.0	
Lam Research	2.1	3.0	3.5	.0	.0	
LPE	.0	1.8	1.8	1.5	2.5	
Moore	.0	.0	.0	.0	.0	
Rapro	.0	.0	.0	.0	.0	
Sitesa	.0	.0	.0	.0	.0	
Toshiba Machine	.0	.0	.0	.0	.0	
Total A/P-ROW	2.7	5.6	6.1	2.4	6.7	25.5
Worldwide						
Applied Materials	18.6	47.2	22.2	25.0	32.0	
ASM Epitaxy	.0	3.1	6.2	19.2	29.9	
Kokusai Electric	1.5	4.2	5.7	2.2	5.9	
Lam Research	14.8	19.0	22.2	7.9	.0	
LPE	.0	4.5	4.8	5.5	5.0	
Moore	.0	1.0	1.6	3.0	3.3	
Rapro	.0	.0	.9	.9	.0	
Sitesa	.0	4.5	4.9	.0	.0	
Toshiba Machine	.6	2.0	6.5	4.5	12.5	
Total Worldwide	35.5	85.5	75.0	68.2	88.6	25.7

Ref: EPISHR
Source: Dataquest (April 1992)

Table 4.37
Each Company's Revenue from Shipments of Metalorganic CVD Equipment to North America (End User Revenue in Millions of U.S. Dollars)

Company: Each
Product: Metalorganic CVD
Region Of Consumption: North America

	1987	1988	1989	1990	1991	CAGR (%) 1987-1991
World MOCVD Market	34.6	42.0	44.6	44.3	51.4	10.4
North America						
Aixtron	.0	.8	3.5	4.4	6.0	
Cambridge Instruments	1.5	1.3	.0	.0	.0	
Crystal Specialties	1.7	2.3	.0	.0	.0	
CVD Equipment	1.2	1.0	1.0	.7	.7	
CVT	.0	.0	.0	.0	1.0	
Daiwa Semiconductor	.0	.0	.0	.0	.0	
EEV	.0	.0	.0	.0	.0	
Emcore	5.1	6.5	7.5	5.4	4.0	
MR Semicon	.0	.0	1.2	.0	1.2	
Nippon EMC	.0	.0	.0	.0	.0	
Nippon Sanso	.2	.0	.0	.0	.0	
Nissin Electric	.0	.0	.0	.0	.0	
Samco	.0	.0	.0	.0	.0	
Seiden	.0	.0	.0	.0	.0	
Semco Engineering	.0	.0	.0	.0	.0	
Shimada Rika	.0	.0	.0	.0	.0	
Spire	1.3	1.5	1.7	1.7	1.0	
TEL	.0	.0	.0	.0	.0	
TEL/Thermco	.0	.0	.0	.0	.0	
Thomas Schwonn	.0	.4	.0	.0	.0	
Toyoko Chemical	.0	.0	.0	.0	.0	
Ulvac	.0	.0	.0	.0	.0	
Yamoto	.0	.0	.0	.0	.0	
Total North America	11.0	13.8	14.9	12.2	13.9	6.0

Ref: MOCVDSHR
Source: Dataquest (April 1992)

Table 4.38
Each Company's Revenue from Shipments of Metalorganic CVD Equipment to Japan (End User Revenue in Millions of U.S. Dollars)

Company:	Each
Product:	Metalorganic CVD
Region Of Consumption:	Japan

	1987	1988	1989	1990	1991	CAGR (%) 1987-1991
World MOCVD Market	34.6	42.0	44.6	44.3	51.4	10.4
Japan						
Aixtron	.0	.0	.0	.0	.0	
Cambridge Instruments	.0	.0	.0	.0	.0	
Crystal Specialties	.9	.4	.0	.0	.0	
CVD Equipment	.0	.0	.0	.0	.0	
CVT	.0	.0	.0	.0	.0	
Daiwa Semiconductor	.4	.5	.0	.0	.0	
EEV	.0	.0	.0	.0	.0	
Emcore	.0	.5	2.5	5.0	6.0	
MR Semicon	.0	.0	.0	.0	.0	
Nippon EMC	1.4	1.9	2.2	1.7	2.2	
Nippon Sanso	4.7	6.3	5.7	5.6	6.9	
Nissin Electric	.0	.0	.0	.0	1.1	
Samco	.6	1.0	.6	.8	.9	
Seiden	.6	.6	.0	.0	.0	
Semco Engineering	.0	.0	.0	.0	.0	
Shimada Rika	.0	.0	.0	.0	.0	
Spire	.0	.6	.7	.0	.0	
TEL	.0	.0	2.9	.0	.0	
TEL/Thermco	2.9	1.7	.0	.0	.0	
Thomas Schwonn	.0	.0	.0	.0	.0	
Toyoko Chemical	.7	1.2	.0	.0	.0	
Ulvac	1.9	2.2	2.0	3.1	4.3	
Yamoto	.0	.0	.0	.0	1.5	
Total Japan	14.1	16.9	16.6	16.2	22.9	12.9

Ref: MOCVDSHR
Source: Dataquest (April 1992)

Table 4.39
Each Company's Revenue from Shipments of Metalorganic CVD Equipment to Europe (End User Revenue in Millions of U.S. Dollars)

Company:	Each
Product:	Metalorganic CVD
Region Of Consumption:	Europe

	1987	1988	1989	1990	1991	CAGR (%) 1987-1991
World MOCVD Market	34.6	42.0	44.6	44.3	51.4	10.4
Europe						
Aixtron	4.9	6.7	6.7	8.6	6.0	
Cambridge Instruments	1.5	1.0	.0	.0	.0	
Crystal Specialties	.0	.0	.0	.0	.0	
CVD Equipment	.0	.0	.0	.0	.0	
CVT	1.1	1.6	1.1	2.2	.0	
Daiwa Semiconductor	.0	.0	.0	.0	.0	
EEV	.7	.0	.0	.0	.0	
Emcore	.0	.0	.0	1.2	1.2	
MR Semicon	.0	.0	.8	1.5	2.2	
Nippon EMC	.0	.0	.0	.0	.0	
Nippon Sanso	.0	.0	.0	.0	.0	
Nissin Electric	.0	.0	.0	.0	.0	
Samco	.0	.0	.0	.0	.0	
Seiden	.0	.0	.0	.0	.0	
Semco Engineering	.3	.9	1.0	.0	.0	
Shimada Rika	.0	.0	.0	.0	.0	
Spire	.0	.0	.0	.0	.0	
TEL	.0	.0	.0	.0	.0	
TEL/Thermco	.0	.0	.0	.0	.0	
Thomas Schwonn	.7	.4	.0	.0	.0	
Toyoko Chemical	.0	.0	.0	.0	.0	
Ulvac	.0	.0	.0	.0	.0	
Yamoto	.0	.0	.0	.0	.0	
Total Europe	9.2	10.6	9.6	13.5	9.4	.5

Ref: MOCVDSHR
Source: Dataquest (April 1992)

Table 4.40
Each Company's Revenue from Shipments of Metalorganic CVD Equipment to Asia/Pacific-ROW
(End User Revenue in Millions of U.S. Dollars)

Company: Each
Product: Metalorganic CVD
Region Of Consumption: Asia/Pacific-ROW

	1987	1988	1989	1990	1991	CAGR (%) 1987-1991
World MOCVD Market	34.6	42.0	44.6	44.3	51.4	10.4
Asia/Pacific-ROW						
Aixtron	.0	.0	1.2	.9	3.0	
Cambridge Instruments	.3	.4	.0	.0	.0	
Crystal Specialties	.0	.0	.0	.0	.0	
CVD Equipment	.0	.3	.3	.0	.0	
CVT	.0	.0	.9	.0	.0	
Daiwa Semiconductor	.0	.0	.0	.0	.0	
EEV	.0	.0	.0	.0	.0	
Emcore	.0	.0	.0	.0	1.0	
MR Semicon	.0	.0	.0	1.5	1.2	
Nippon EMC	.0	.0	.0	.0	.0	
Nippon Sanso	.0	.0	1.1	.0	.0	
Nissin Electric	.0	.0	.0	.0	.0	
Samco	.0	.0	.0	.0	.0	
Seiden	.0	.0	.0	.0	.0	
Semco Engineering	.0	.0	.0	.0	.0	
Shimada Rika	.0	.0	.0	.0	.0	
Spire	.0	.0	.0	.0	.0	
TEL	.0	.0	.0	.0	.0	
TEL/Thermco	.0	.0	.0	.0	.0	
Thomas Schwonn	.0	.0	.0	.0	.0	
Toyoko Chemical	.0	.0	.0	.0	.0	
Ulvac	.0	.0	.0	.0	.0	
Yamoto	.0	.0	.0	.0	.0	
Total A/P-ROW	.3	.7	3.5	2.4	5.2	104.0

Ref: MOCVDSHR
Source: Dataquest (April 1992)

Table 4.41
Each Company's Revenue from Shipments of Metalorganic CVD Equipment to the World
(End User Revenue in Millions of U.S. Dollars)

Company: Each
Product: Metalorganic CVD
Region Of Consumption: World

	1987	1988	1989	1990	1991	CAGR (%) 1987-1991
World MOCVD Market	34.6	42.0	44.6	44.3	51.4	10.4
Worldwide						
Aixtron	4.9	7.5	11.4	13.9	15.0	
Cambridge Instruments	3.3	2.7	.0	.0	.0	
Crystal Specialties	2.6	2.7	.0	.0	.0	
CVD Equipment	1.2	1.3	1.3	.7	.7	
CVT	1.1	1.6	2.0	2.2	1.0	
Daiwa Semiconductor	.4	.5	.0	.0	.0	
EEV	.7	.0	.0	.0	.0	
Emcore	5.1	7.0	10.0	11.6	12.2	
MR Semicon	.0	.0	2.0	3.0	4.6	
Nippon EMC	1.4	1.9	2.2	1.7	2.2	
Nippon Sanso	4.9	6.3	6.8	5.6	6.9	
Nissin Electric	.0	.0	.0	.0	1.1	
Samco	.6	1.0	.6	.8	.9	
Seiden	.6	.6	.0	.0	.0	
Semco Engineering	.3	.9	1.0	.0	.0	
Shimada Rika	.0	.0	.0	.0	.0	
Spire	1.3	2.1	2.4	1.7	1.0	
TEL	.0	.0	2.9	.0	.0	
TEL/Thermco	2.9	1.7	.0	.0	.0	
Thomas Schwonn	.7	.8	.0	.0	.0	
Toyoko Chemical	.7	1.2	.0	.0	.0	
Ulvac	1.9	2.2	2.0	3.1	4.3	
Yamoto	.0	.0	.0	.0	1.5	
Total Worldwide	34.6	42.0	44.6	44.3	51.4	10.4

Ref: MOCVDSHR
Source: Dataquest (April 1992)

Table 4.42
Each Company's Revenue from Shipments of Molecular Beam Epitaxy Equipment to the World (End User Revenue in Millions of U.S. Dollars)

Company:	Each
Product:	Molecular Beam Epitaxy
Region Of Consumption:	Each

	1987	1988	1989	1990	1991	CAGR (%) 1987-1991
World MBE Market	68.0	80.9	74.0	58.0	58.9	-3.5
North America						
Anelva	.0	.0	.0	.0	.0	
Daido Sanso	.0	.0	.0	.0	.0	
Eiko	.0	.0	.0	.0	.0	
Emcore	.0	.0	.0	1.0	.0	
Intevac	.0	.0	.0	.0	2.5	
ISA Riber	7.0	8.0	6.5	3.6	4.0	
Nissin Electric	.0	.0	.0	.0	.0	
Perkin-Elmer	5.0	2.8	.0	.0	.0	
Seiko	.0	.0	.0	.0	.0	
Ulvac	.0	.0	.0	.0	.0	
Varian	5.2	5.4	7.8	2.1	.0	
VG Instruments	2.5	5.1	6.5	2.6	4.0	
Yamato Semico	.0	.0	.0	.0	.0	
Total North America	19.7	21.3	20.8	9.3	10.5	-14.6
Japan						
Anelva	9.7	11.5	6.8	6.2	8.7	
Daido Sanso	.0	.0	.0	.0	1.8	
Eiko	1.4	1.2	2.9	2.6	2.2	
Emcore	.0	.0	.0	.0	.0	
Intevac	.0	.0	.0	.0	.0	
ISA Riber	6.0	3.9	1.4	2.7	.8	
Nissin Electric	.0	.0	.0	.0	.6	
Perkin-Elmer	.0	.0	.0	.0	.0	
Seiko	1.2	1.4	.0	.0	.0	
Ulvac	4.3	7.5	4.0	4.9	5.9	
Varian	1.9	5.2	.5	.7	.0	
VG Instruments	8.1	5.6	4.9	6.1	4.3	
Yamoto Semico	.0	.0	1.8	1.9	5.5	
Total Japan	32.6	36.3	22.3	25.1	29.8	-2.2

(Continued)

Table 4.42 (Continued)
Each Company's Revenue from Shipments of Molecular Beam Epitaxy Equipment to the World (End User Revenue in Millions of U.S. Dollars)

Company:	Each
Product:	Molecular Beam Epitaxy
Region Of Consumption:	Each

	1987	1988	1989	1990	1991	CAGR (%) 1987-1991
Europe						
Anelva	.0	.0	.0	.0	.0	
Daido Sanso	.0	.0	.0	.0	.0	
Eiko	.0	.0	.0	.0	.0	
Emcore	.0	.0	.0	.0	.0	
Intevac	.0	.0	.0	.0	2.7	
ISA Riber	4.9	6.9	8.0	9.6	3.4	
Nissin Electric	.0	.0	.0	.0	.0	
Perkin-Elmer	.0	.0	.0	.0	.0	
Seiko	.0	.0	.0	.0	.0	
Ulvac	.0	.0	.0	.0	.0	
Varian	4.4	6.3	8.9	.0	.0	
VG Instruments	2.4	5.8	6.8	2.6	4.5	
Yamoto Semico	.0	.0	.0	.0	.0	
Total Europe	11.7	19.0	23.7	12.2	10.6	-2.4
Asia/Pacific-ROW						
Anelva	.0	.0	.0	.0	.0	
Daido Sanso	.0	.0	.0	.0	.0	
Eiko	.0	.0	.0	.0	.0	
Emcore	.0	.0	.0	.0	.0	
Intevac	.0	.0	.0	.0	.0	
ISA Riber	1.4	3.7	6.4	4.4	5.8	
Nissin Electric	.0	.0	.0	.0	.0	
Perkin-Elmer	.0	.0	.0	.0	.0	
Seiko	.0	.0	.0	.0	.0	
Ulvac	.0	.0	.0	.0	.0	
Varian	.6	.6	.0	.9	.0	
VG Instruments	2.0	.0	.8	6.1	2.2	
Yamoto Semico	.0	.0	.0	.0	.0	
Total Asia/Pacific-ROW	4.0	4.3	7.2	11.4	8.0	18.9

(Continued)

Table 4.42 (Continued)
Each Company's Revenue from Shipments of Molecular Beam Epitaxy Equipment to the World
(End User Revenue in Millions of U.S. Dollars)

Company:	Each
Product:	Molecular Beam Epitaxy
Region Of Consumption:	Each

	1987	1988	1989	1990	1991	CAGR (%) 1987-1991
Worldwide						
Anelva	9.7	11.5	6.8	6.2	8.7	
Daido Sanso	.0	.0	.0	.0	1.8	
Eiko	1.4	1.2	2.9	2.6	2.2	
Emcore	.0	.0	.0	1.0	.0	
Intevac	.0	.0	.0	.0	5.2	
ISA Riber	19.3	22.5	22.3	20.3	14.0	
Nissin Electric	.0	.0	.0	.0	.6	
Perkin-Elmer	5.0	2.8	.0	.0	.0	
Seiko	1.2	1.4	.0	.0	.0	
Ulvac	4.3	7.5	4.0	4.9	5.9	
Varian	12.1	17.5	17.2	3.7	.0	
VG Instruments	15.0	16.5	19.0	17.4	15.0	
Yamoto Semico	.0	.0	1.8	1.9	5.5	
Total Worldwide	68.0	80.9	74.0	58.0	58.9	-3.5

Ref: MBESHR
Source: Dataquest (April 1992)

Table 4.43
Each Company's Revenue from Shipments of Diffusion Furnace Equipment to North America (End User Revenue in Millions of U.S. Dollars)

Company:	Each
Product:	Diffusion Furnaces
Region:	North America

	1987	1988	1989	1990	1991	CAGR (%) 1987-1991
World Diffusion Market	145.4	295.5	330.6	324.0	335.1	23.2
Horizontal Tube						
ASM International	2.3	3.4	2.5	3.5	2.5	
BTU International	8.3	17.3	18.0	10.0	6.0	
Denko	.0	.0	.0	.0	.0	
Gasonics	7.5	9.0	8.0	6.0	7.5	
GSTC	.0	3.0	4.0	3.0	1.0	
Kokusai Electric	.0	1.2	.0	.0	.0	
Koyo Lindberg	.0	.0	.0	.0	.0	
Pacific Western	.0	.6	.6	.6	.4	
Process Technology	.0	.0	.0	.0	.0	
Silicon Valley Group	.0	.0	34.0	24.0	15.0	
Solitec	.0	.0	.0	.0	.0	
TEL/Thermco	.0	.0	.0	.0	.0	
Tempress	.5	.0	.0	.0	.0	
Thermco	15.7	42.0	.0	.0	.0	
Tokyo Electron Ltd.	.0	.0	.0	.0	.0	
Tylan	2.0	2.5	.0	.0	.0	
Tystar	.0	.0	.6	.3	.5	
Ulvac	.0	.0	.0	.0	.0	
Ulvac/BTU	.0	.0	.0	.0	.0	
Varian/TEL	.0	.0	.0	.0	3.0	
Others	.0	.0	1.3	1.9	1.2	
Total N.A. Horizontal	36.3	79.0	69.0	49.3	37.1	.5

(Continued)

Table 4.43 (Continued)
Each Company's Revenue from Shipments of Diffusion Furnace Equipment to North America (End User Revenue in Millions of U.S. Dollars)

Company: Each
Product: Diffusion Furnaces
Region: North America

	1987	1988	1989	1990	1991	CAGR (%) 1987-1991
Vertical Tube						
ASM International	.0	.0	1.0	2.0	4.0	
BTU International	.0	1.0	.0	3.0	5.0	
Denko	.0	.0	.0	.0	.0	
Disco	.0	.0	.0	.0	.0	
GSTC	.0	.0	3.0	5.0	2.0	
Helmut Seier	.0	.0	.0	.0	.0	
Koyo Lindberg	.0	.0	.0	.0	.0	
Kokusai Electric	.0	2.7	4.2	1.7	7.0	
Semitherm	.0	.5	2.0	4.0	3.0	
Shinko Electric	.0	.0	.0	.0	.0	
Silicon Valley Group	.8	2.0	3.0	10.0	17.0	
TEL/Thermco	.0	.0	.0	.0	.0	
Tokyo Electron Ltd.	.0	.0	.0	.0	.0	
Ulvac	.0	.0	.0	.0	.0	
Ulvac/BTU	.0	.0	.0	.0	.0	
Varian/TEL	.0	.0	5.6	2.1	4.8	
Total North America Vertical	.8	6.2	18.8	27.8	42.8	170.5
Total North America	37.1	85.2	87.8	77.1	79.9	21.1

Ref: DIFF
Source: Dataquest (April 1992)

Table 4.44
Each Company's Revenue from Shipments of Diffusion Furnace Equipment to Japan (End User Revenue in Millions of U.S. Dollars)

Company: Each
Product: Diffusion Furnaces
Region: Japan

	1987	1988	1989	1990	1991	CAGR (%) 1987-1991
World Diffusion Market	145.4	295.5	330.6	324.0	335.1	23.2
Horizontal Tube						
ASM International	.0	.0	2.0	2.6	2.2	
BTU International	.0	.0	.0	.0	.0	
Denko	.8	.9	.0	.0	.0	
Gasonics	.0	.0	.0	1.0	.0	
GSTC	.0	.5	.0	.0	.0	
Kokusai Electric	16.7	13.4	10.8	4.8	5.6	
Koyo Lindberg	2.6	3.3	5.0	4.5	5.9	
Pacific Western	.0	.0	.0	.0	.0	
Process Technology	.0	.0	.0	.0	.0	
Silicon Valley Group	.0	.0	.0	.0	.0	
Solitec	.0	.0	.0	.0	.0	
TEL/Thermco	22.9	.0	.0	.0	.0	
Tempress	.0	.0	.0	.0	.0	
Thermco	.0	.0	.0	.0	.0	
Tokyo Electron Ltd.	.0	44.6	52.0	38.0	22.3	
Tylan	.0	.0	.0	.0	.0	
Tystar	.0	.0	.0	.0	.0	
Ulvac	.0	.0	.0	.0	10.4	
Ulvac/BTU	1.7	9.2	10.0	13.2	.0	
Varian/TEL	.0	.0	.0	.0	.0	
Others	.0	.0	.0	.0	.0	
Total Japan Horizontal	44.7	71.9	79.8	64.1	46.4	.9

(Continued)

Table 4.44 (Continued)
Each Company's Revenue from Shipments of Diffusion Furnace Equipment to Japan
(End User Revenue in Millions of U.S. Dollars)

Company: Each
Product: Diffusion Furnaces
Region: Japan

	1987	1988	1989	1990	1991	CAGR (%) 1987-1991
Vertical Tube						
ASM International	.0	.0	2.0	2.8	1.0	
BTU International	.0	.0	.0	.0	.0	
Denko	1.2	1.8	4.0	6.9	.0	
Disco	1.5	2.9	3.6	5.8	10.0	
GSTC	.0	.0	.0	.0	.0	
Helmut Seier	.5	.7	.0	.0	.0	
Koyo Lindberg	3.1	3.5	3.1	7.6	6.7	
Kokusai Electric	7.3	13.5	16.5	34.3	31.7	
Semitherm	.0	.0	.0	.0	.0	
Shinko Electric	.0	.0	.0	.0	7.4	
Silicon Valley Group	.0	.8	.0	.0	.0	
TEL/Thermco	.7	.0	.0	.0	.0	
Tokyo Electron Ltd.	.1	8.0	16.9	48.0	48.3	
Ulvac	.0	.0	.0	.0	2.6	
Ulvac/BTU	.0	2.3	2.3	3.3	.0	
Varian/TEL	.0	.0	.0	.0	.0	
Total Japan Vertical	14.4	33.5	48.4	108.7	107.7	65.4
Total Japan	59.1	105.4	128.2	172.8	154.1	27.1

Ref: DIFF
Source: dataquest (April 1992)

Table 4.45
Each Company's Revenue from Shipments of Diffusion Furnace Equipment to Europe (End User Revenue in Millions of U.S. Dollars)

Company: Each
Product: Diffusion Furnaces
Region: Europe

	1987	1988	1989	1990	1991	CAGR (%) 1987-1991
World Diffusion Market	145.4	295.5	330.6	324.0	335.1	23.2
Horizontal Tube						
ASM International	16.2	19.3	16.0	8.0	5.0	
BTU International	7.3	8.2	9.0	5.0	3.0	
Denko	.0	.0	.0	.0	.0	
Gasonics	.0	.0	.0	.0	.0	
GSTC	.0	.8	1.0	1.0	.0	
Kokusai Electric	.0	.0	.0	.0	.0	
Koyo Lindberg	.0	.0	.0	.0	.0	
Pacific Western	.0	.0	.0	.0	.0	
Process Technology	.0	.0	.0	.0	.0	
Silicon Valley Group	.0	.0	12.0	10.0	7.0	
Solitec	.0	.0	.0	.0	.0	
TEL/Thermco	.0	.0	.0	.0	.0	
Tempress	.0	.0	.0	.0	.0	
Thermco	13.2	12.0	.0	.0	.0	
Tokyo Electron Ltd.	.0	2.3	.0	.0	.0	
Tylan	.0	.0	.0	.0	.0	
Tystar	.0	.0	.0	.0	.0	
Ulvac	.0	.0	.0	.0	.0	
Ulvac/BTU	.0	.0	.0	.0	.0	
Varian/TEL	.0	.0	.7	4.2	2.7	
Others	2.5	3.5	3.5	5.2	4.5	
Total Europe Horizontal	39.2	46.1	42.2	33.4	22.2	-13.3

(Continued)

Table 4.45 (Continued)
Each Company's Revenue from Shipments of Diffusion Furnace Equipment to Europe (End User Revenue in Millions of U.S. Dollars)

Company: Each
Product: Diffusion Furnaces
Region: Europe

	1987	1988	1989	1990	1991	CAGR (%) 1987-1991
Vertical Tube						
ASM International	.0	.0	3.0	3.0	3.0	
BTU International	.0	.0	.0	1.5	1.0	
Denko	.0	.0	.0	.0	.0	
Disco	.0	.0	.0	.0	.0	
GSTC	.0	.0	.0	.0	.0	
Helmut Seier	.0	.0	.0	.0	.0	
Koyo Lindberg	.0	.0	.0	.0	.0	
Kokusai Electric	.0	.0	.0	.0	3.8	
Semitherm	.0	.0	.0	.0	.0	
Shinko Electric	.0	.0	.0	.0	.0	
Silicon Valley Group	.0	.8	1.0	3.2	3.0	
TEL/Thermco	.0	.0	.0	.0	.0	
Tokyo Electron Ltd.	.0	.0	.0	.0	.0	
Ulvac	.0	.0	.0	.0	.0	
Ulvac/BTU	.0	.0	.0	.0	.0	
Varian/TEL	.0	.0	.0	.0	3.3	
Total Europe Vertical	.0	.8	4.0	7.7	14.1	NM
Total Europe	39.2	46.9	46.2	41.1	36.3	-1.9

NM = Not meaningful
Ref: DIFF
Source: Dataquest (April 1992)

Table 4.46
Each Company's Revenue from Shipments of Diffusion Furnace Equipment to Asia/Pacific-ROW (End User Revenue in Millions of U.S. Dollars)

Company: Each
Product: Diffusion Furnaces
Region: Asia/Pacific-ROW

	1987	1988	1989	1990	1991	CAGR (%) 1987-1991
World Diffusion Market	145.4	295.5	330.6	324.0	335.1	23.2
Horizontal Tube						
ASM International	.0	.0	1.5	1.5	2.0	
BTU International	3.7	8.5	14.0	3.0	4.0	
Denko	.0	.0	.0	.0	.0	
Gasonics	.0	.0	.0	1.0	1.2	
GSTC	.0	.0	.0	.0	.0	
Kokusai Electric	.0	4.6	.0	.0	.0	
Koyo Lindberg	.0	.0	.0	.0	.0	
Pacific Western	.0	.0	.0	.0	.0	
Process Technology	.0	.0	.0	.0	.0	
Silicon Valley Group	.0	.0	6.0	4.0	6.0	
Solitec	.0	.0	.0	.0	.0	
TEL/Thermco	.0	.0	.0	.0	.0	
Tempress	.0	.0	.0	.0	.0	
Thermco	6.0	6.0	.0	.0	.0	
Tokyo Electron Ltd.	.0	27.7	21.0	6.2	14.7	
Tylan	.0	.0	.0	.0	.0	
Tystar	.0	.0	.0	.2	.0	
Ulvac	.0	.0	.0	.0	.0	
Ulvac/BTU	.0	.0	.0	.0	.0	
Varian/TEL	.0	.0	.0	.0	.0	
Others	.0	.0	1.5	1.5	1.5	
Total A/P-ROW Horizontal	9.7	46.8	44.0	17.4	29.4	31.9

(Continued)

Table 4.46 (Continued)
Each Company's Revenue from Shipments of Diffusion Furnace Equipment to Asia/Pacific-ROW
(End User Revenue in Millions of U.S. Dollars)

Company: Each
Product: Diffusion Furnaces
Region: Asia/Pacific-ROW

	1987	1988	1989	1990	1991	CAGR (%) 1987-1991
Vertical Tube						
ASM International	.0	.0	1.0	1.0	2.0	
BTU International	.0	.0	.0	1.5	.0	
Denko	.0	.0	.0	.0	.0	
Disco	.0	.0	.0	.0	.0	
GSTC	.0	.0	.0	.0	.0	
Helmut Seier	.0	.0	.0	.0	.0	
Koyo Lindberg	.0	.0	.0	.0	.0	
Kokusai Electric	.0	10.8	22.4	10.1	20.0	
Semitherm	.0	.0	.0	.0	.0	
Shinko Electric	.0	.0	.0	.0	.0	
Silicon Valley Group	.3	.4	1.0	3.0	6.0	
TEL/Thermco	.0	.0	.0	.0	.0	
Tokyo Electron Ltd.	.0	.0	.0	.0	7.4	
Ulvac	.0	.0	.0	.0	.0	
Ulvac/BTU	.0	.0	.0	.0	.0	
Varian/TEL	.0	.0	.0	.0	.0	
Total A/P-ROW Vertical	.3	11.2	24.4	15.6	35.4	229.6
Total A/P-ROW	10.0	58.0	68.4	33.0	64.8	59.5

Ref: DIFF
Source: Dataquest (April 1992)

Table 4.47
Each Company's Revenue from Shipments of Diffusion Furnace Equipment to the World (End User Revenue in Millions of U.S. Dollars)

Company: Each
Product: Diffusion Furnaces
Region: World

	1987	1988	1989	1990	1991	CAGR (%) 1987-1991
World Diffusion Market	145.4	295.5	330.6	324.0	335.1	23.2
Horizontal Tube						
ASM International	18.5	22.7	22.0	15.6	11.7	
BTU International	19.3	34.0	41.0	18.0	13.0	
Denko	.8	.9	.0	.0	.0	
Gasonics	7.5	9.0	8.0	8.0	8.7	
GSTC	.0	4.3	5.0	4.0	1.0	
Kokusai Electric	16.7	19.2	10.8	4.8	5.6	
Koyo Lindberg	2.6	3.3	5.0	4.5	5.9	
Pacific Western	.0	.6	.6	.6	.4	
Process Technology	.0	.0	.0	.0	.0	
Silicon Valley Group	.0	.0	52.0	38.0	28.0	
Solitec	.0	.0	.0	.0	.0	
TEL/Thermco	22.9	.0	.0	.0	.0	
Tempress	.5	.0	.0	.0	.0	
Thermco	34.9	60.0	.0	.0	.0	
Tokyo Electron Ltd.	.0	74.6	73.0	44.2	37.0	
Tylan	2.0	2.5	.0	.0	.0	
Tystar	.0	.0	.6	.5	.5	
Ulvac	.0	.0	.0	.0	10.4	
Ulvac/BTU	1.7	9.2	10.0	13.2	.0	
Varian/TEL	.0	.0	.7	4.2	5.7	
Others	2.5	3.5	6.3	8.6	7.2	
Total W.W. Horizontal	129.9	243.8	235.0	164.2	135.1	1.0

(Continued)

Table 4.47 (Continued)
Each Company's Revenue from Shipments of Diffusion Furnace Equipment to the World
(End User Revenue in Millions of U.S. Dollars)

Company: Each
Product: Diffusion Furnaces
Region: World

	1987	1988	1989	1990	1991	CAGR (%) 1987-1991
Vertical Tube						
ASM International	.0	.0	7.0	8.8	10.0	
BTU International	.0	1.0	.0	6.0	6.0	
Denko	1.2	1.8	4.0	6.9	.0	
Disco	1.5	2.9	3.6	5.8	10.0	
GSTC	.0	.0	3.0	5.0	2.0	
Helmut Seier	.5	.7	.0	.0	.0	
Koyo Lindberg	3.1	3.5	3.1	7.6	6.7	
Kokusai Electric	7.3	27.0	43.1	46.1	62.5	
Semitherm	.0	.5	2.0	4.0	3.0	
Shinko Electric	.0	.0	.0	.0	7.4	
Silicon Valley Group	1.1	4.0	5.0	16.2	26.0	
TEL/Thermco	.7	.0	.0	.0	.0	
Tokyo Electron Ltd.	.1	8.0	16.9	48.0	55.7	
Ulvac	.0	.0	.0	.0	2.6	
Ulvac/BTU	.0	2.3	2.3	3.3	.0	
Varian/TEL	.0	.0	5.6	2.1	8.1	
Total Worldwide Vertical	15.5	51.7	95.6	159.8	200.0	89.5
TotalWorldwide	145.4	295.5	330.6	324.0	335.1	23.2

Ref: DIFF
Source: Dataquest (April 1992)

Table 4.48
Each Company's Revenue from Shipments of Rapid Thermal Processing Equipment to Each Region (End User Revenue in Millions of U.S. Dollars)

Company: Each
Product: Rapid Thermal Processing
Region Of Consumption: Each

	1987	1988	1989	1990	1991	CAGR (%) 1987-1991
World RTP Market	18.2	22.3	25.1	29.7	41.8	23.1
North America						
Addax Technologies	.0	.0	.0	.0	.0	
AG Associates	5.9	6.0	6.0	9.2	11.9	
Dainippon Screen	.0	.0	.0	.0	.0	
Eaton	.2	.2	.0	.0	.0	
High Temperature Eng.	.0	.0	.0	.3	.5	
Jipelec	.0	.0	.0	.7	1.0	
Kokusai	.0	.0	.0	.0	.0	
Koyo Lindberg	.0	.0	.0	.0	.0	
Nanosil	.3	.3	.4	.4	.3	
Peak Systems	2.7	4.2	3.0	3.3	4.0	
Process Products	.6	.8	1.0	.7	.7	
Sitesa Addax	.2	.0	.0	.0	.0	
Varian	.2	.2	.0	.0	.0	
Total North America	10.1	11.7	10.4	14.6	18.4	16.2
Japan						
Addax Technologies	.0	.0	.0	.0	.0	
AG Associates	1.9	2.0	2.0	4.0	9.3	
Dainippon Screen	1.0	1.2	1.8	2.3	2.0	
Eaton	.0	.2	.0	.0	.0	
High Temperature Eng.	.0	.0	.0	.0	.2	
Jipelec	.0	.0	.0	.0	.0	
Kokusai	.0	.0	.0	.0	.6	
Koyo Lindberg	.2	.6	.6	.7	.3	
Nanosil	.0	.0	.0	.1	.0	
Peak Systems	.7	2.0	2.5	2.1	2.0	
Process Products	.0	.0	.1	.0	.0	
Sitesa Addax	.0	.0	.0	.0	.0	
Varian	.7	.2	.0	.0	.0	
Total Japan	4.5	6.2	7.0	9.2	14.4	33.7

(Continued)

Table 4.48 (Continued)
Each Company's Revenue from Shipments of Rapid Thermal Processing Equipment to Each Region (End User Revenue in Millions of U.S. Dollars)

Company: Each
Product: Rapid Thermal Processing
Region Of Consumption: Each

	1987	1988	1989	1990	1991	CAGR (%) 1987-1991
Europe						
Addax Technologies	.0	.0	.0	.0	2.3	
AG Associates	2.1	1.6	1.5	.8	3.2	
Dainippon Screen	.0	.0	.0	.0	.0	
Eaton	.0	.0	.0	.0	.0	
High Temperature Eng.	.0	.0	.0	.0	.0	
Jipelec	.0	.0	.0	.0	.0	
Kokusai	.0	.0	.0	.0	.0	
Koyo Lindberg	.0	.0	.0	.0	.0	
Nanosil	.0	.0	.0	.0	.0	
Peak Systems	.0	.2	1.0	.9	1.0	
Process Products	.1	.2	.1	.4	.4	
Sitesa Addax	.5	1.2	1.5	1.0	.0	
Varian	.0	.0	.0	.0	.0	
Total Europe	2.7	3.2	4.1	3.1	6.9	26.4
Asia/Pacific-ROW						
Addax Technologies	.0	.0	.0	.0	.0	
AG Associates	.9	1.0	1.5	.6	.0	
Dainippon Screen	.0	.0	.0	.0	.0	
Eaton	.0	.0	.0	.0	.0	
High Temperature Eng.	.0	.0	.0	.0	.1	
Jipelec	.0	.0	.0	.0	.0	
Koyo Lindberg	.0	.0	.0	.0	.0	
Nanosil	.0	.0	.0	.0	.0	
Peak Systems	.0	.2	2.0	2.1	1.6	
Process Products	.0	.0	.1	.1	.4	
Sitesa Addax	.0	.0	.0	.0	.0	
Varian	.0	.0	.0	.0	.0	
Total Asia/Pacific-ROW	.9	1.2	3.6	2.8	2.1	23.6

(Continued)

Table 4.48 (Continued)
Each Company's Revenue from Shipments of Rapid Thermal Processing Equipment to Each Region (End User Revenue in Millions of U.S. Dollars)

Company:	Each
Product:	Rapid Thermal Processing
Region Of Consumption:	Each

	1987	1988	1989	1990	1991	CAGR (%) 1987-1991
Worldwide						
Addax Technologies	.0	.0	.0	.0	2.3	
AG Associates	10.8	10.6	11.0	14.6	24.4	
Dainippon Screen	1.0	1.2	1.8	2.3	2.0	
Eaton	.2	.4	.0	.0	.0	
High Temperature Eng.	.0	.0	.0	.3	.8	
Jipelec	.0	.0	.0	.7	1.0	
Kokusai	.0	.0	.0	.0	.6	
Koyo Lindberg	.2	.6	.6	.7	.3	
Nanosil	.3	.3	.4	.5	.3	
Peak Systems	3.4	6.6	8.5	8.4	8.6	
Process Products	.7	1.0	1.3	1.2	1.5	
Sitesa Addax	.7	1.2	1.5	1.0	.0	
Varian	.9	.4	.0	.0	.0	
Total Worldwide	18.2	22.3	25.1	29.7	41.8	23.1

Ref: RTPSHR
Source: Dataquest (April 1992)

Table 4.49
Each Company's Revenue from Shipments of Ion Implantation Equipment to North America (End User Revenue in Millions of U.S. Dollars)

Company:	Each
Product:	Ion Implantation
Region Of Consumption:	North America

	1987	1988	1989	1990	1991	CAGR (%) 1987-1991
World Implanter Market	185.9	377.4	456.6	369.8	343.2	16.6
Medium Current						
Balzers	.0	.0	.0	.0	.0	
Eaton	4.0	10.0	9.0	5.7	4.4	
Nissin	.0	1.2	1.3	1.9	2.8	
Sumitomo/Eaton Nova	.0	.0	.0	.0	.0	
TEL/Varian	.0	.0	.0	.0	.0	
Ulvac	.0	.0	.0	.0	.0	
Varian	5.9	6.2	13.2	9.6	9.1	
Total Medium Current	9.9	17.4	23.5	17.2	16.3	13.3
High Current						
Applied Materials	4.0	9.1	18.4	24.2	12.0	
Eaton	17.0	27.0	19.0	19.5	18.5	
Hitachi	.0	.0	.0	.0	.0	
Nissin	.0	.0	2.1	1.7	.0	
Sumitomo/Eaton Nova	.0	.0	.0	.0	.0	
TEL/Varian	.0	.0	.0	.0	.0	
Ulvac	.0	.0	.0	.0	.0	
Varian	6.6	8.4	19.8	13.0	8.1	
Total High Current	27.6	44.5	59.3	58.4	38.6	8.7
High Voltage						
Eaton	4.5	.0	.0	.0	.0	
Genus	.0	3.2	3.4	2.6	2.9	
National Electrostatics	1.8	1.2	4.0	.0	.0	
Nissin	.0	.0	.0	.0	.0	
Sumitomo Eaton Nova	.0	.0	.0	.0	.0	
Varian	1.8	1.8	.0	.0	.0	
Total High Voltage	8.1	6.2	7.4	2.6	2.9	-22.6
Total North America	45.6	68.1	90.2	78.2	57.8	6.1

Ref: IMPLSHR
Source: Dataquest (April 1992)

Table 4.50
Each Company's Revenue from Shipments of Ion Implantation Equipment to Japan (End User Revenue in Millions of U.S. Dollars)

Company: Each
Product: Ion Implantation
Region Of Consumption: Japan

	1987	1988	1989	1990	1991	CAGR (%) 1987-1991
World Implanter Market	185.9	377.4	456.6	369.8	343.2	16.6
Medium Current						
Balzers	.0	.0	.0	.0	.0	
Eaton	.0	.0	.0	.0	.0	
Nissin	11.1	26.2	34.1	30.4	18.4	
Sumitomo/Eaton Nova	2.6	2.9	.9	.0	.0	
TEL/Varian	8.4	24.1	28.0	20.4	11.7	
Ulvac	5.2	7.5	13.8	6.9	11.1	
Varian	2.3	3.4	.0	12.0	18.4	
Total Medium Current	29.6	64.1	76.8	69.7	59.6	19.1
High Current						
Applied Materials	2.0	8.6	16.5	12.1	12.7	
Eaton	.0	.0	.0	.0	.0	
Hitachi	3.8	9.6	14.4	11.2	10.2	
Nissin	1.8	4.1	14.3	7.5	11.2	
Sumitomo/Eaton Nova	18.4	42.8	47.5	51.6	45.7	
TEL/Varian	16.8	52.5	72.0	33.3	30.7	
Ulvac	2.1	3.8	.0	.0	.0	
Varian	1.4	18.0	.0	20.4	19.2	
Total High Current	46.3	139.4	164.7	136.1	129.7	29.4
High Voltage						
Eaton	.0	.0	.0	.0	.0	
Genus	.0	8.1	12.6	4.2	8.4	
National Electrostatics	.0	.0	.0	.0	.0	
Nissin	2.8	.0	2.9	.0	3.0	
Sumitomo Eaton Nova	3.1	.0	.0	.0	.0	
Varian	.0	.0	.0	.0	.0	
Total High Voltage	5.9	8.1	15.5	4.2	11.4	17.9
Total Japan	81.8	211.6	257.0	210.0	200.7	25.2

Ref: IMPLSHR
Source: Dataquest (April 1992)

Table 4.51
Each Company's Revenue from Shipments of Ion Implantation Equipment to Europe (End User Revenue in Millions of U.S. Dollars)

Company: Each
Product: Ion Implantation
Region Of Consumption: Europe

	1987	1988	1989	1990	1991	CAGR (%) 1987-1991
World Implanter Market	185.9	377.4	456.6	369.8	343.2	16.6
Medium Current						
Balzers	1.4	2.1	.8	.0	.0	
Eaton	7.0	11.0	3.5	2.6	3.7	
Nissin	.0	.9	.0	4.1	1.8	
Sumitomo/Eaton Nova	.0	.0	.0	.0	.0	
TEL/Varian	.0	.0	.0	.0	.0	
Ulvac	.0	.0	.0	.0	.0	
Varian	6.7	3.9	4.4	1.2	8.2	
Total Medium Current	15.1	17.9	8.7	7.9	13.7	-2.4
High Current						
Applied Materials	4.0	7.2	14.5	9.7	9.2	
Eaton	12.0	23.0	8.2	11.9	10.5	
Hitachi	.0	.0	.0	.0	.0	
Nissin	.0	.0	.0	.0	.0	
Sumitomo/Eaton Nova	.0	.0	.0	.0	.0	
TEL/Varian	.0	.0	.0	.0	.0	
Ulvac	.0	.0	.0	.0	.0	
Varian	5.5	2.4	3.6	5.5	6.8	
Total High Current	21.5	32.6	26.3	27.1	26.5	5.4
High Voltage						
Eaton	2.2	2.5	.0	.0	3.3	
Genus	.0	1.6	.0	.0	.0	
National Electrostatics	.0	.0	.0	.0	.0	
Nissin	.0	.0	.0	.0	.0	
Sumitomo Eaton Nova	.0	.0	.0	.0	.0	
Varian	1.8	.0	.0	.0	.0	
Total High Voltage	4.0	4.1	.0	.0	3.3	-4.7
Total Europe	40.6	54.6	35.0	35.0	43.5	1.7

Ref: IMPLSHR
Source: Dataquest (April 1992)

Table 4.52
Each Company's Revenue from Shipments of Ion Implantation Equipment to Asia/Pacific-ROW (End User Revenue in Millions of U.S. Dollars)

Company: Each
Product: Ion Implantation
Region Of Consumption: Asia/Pacific-ROW

	1987	1988	1989	1990	1991	CAGR (%) 1987-1991
World Implanter Market	185.9	377.4	456.6	369.8	343.2	16.6
Medium Current						
Balzers	1.4	2.1	.8	.0	.0	
Eaton	2.0	7.0	10.5	9.2	4.5	
Nissin	.0	.0	.0	1.1	5.0	
Sumitomo/Eaton Nova	.0	.0	.0	.0	.0	
TEL/Varian	.0	.0	.0	.0	.0	
Ulvac	.0	.0	.0	.0	.0	
Varian	3.0	9.4	11.0	8.4	8.4	
Total Medium Current	6.4	18.5	22.3	18.7	17.9	29.3
High Current						
Applied Materials	.0	.0	.0	.0	.0	
Eaton	6.0	9.0	28.8	18.7	11.6	
Hitachi	.0	.0	.0	.0	.0	
Nissin	.0	.0	.0	.0	.0	
Sumitomo/Eaton Nova	.0	.0	.0	.0	.0	
TEL/Varian	.0	.0	.0	.0	.0	
Ulvac	.0	.0	.0	.0	.0	
Varian	5.5	15.6	21.6	9.2	11.7	
Total High Current	11.5	24.6	50.4	27.9	23.3	19.3
High Voltage						
Eaton	.0	.0	.0	.0	.0	
Genus	.0	1.7	.0	.0	.0	
National Electrostatics	.0	.0	.0	.0	.0	
Nissin	.0	.0	.0	.0	.0	
Sumitomo Eaton Nova	.0	.0	.0	.0	.0	
Varian	.0	.0	.0	.0	.0	
Total High Voltage	.0	.0	1.7	.0	.0	NM
Total A/P-ROW	17.9	43.1	74.4	46.6	41.2	23.2

NM = Not meaningful
Ref: IMPLSHR
Source: Dataquest (April 1992)

Table 4.53
Each Company's Revenue from Shipments of Ion Implantation Equipment to the World (End User Revenue in Millions of U.S. Dollars)

Company:	Each
Product:	Ion Implantation
Region Of Consumption:	Worldwide

	1987	1988	1989	1990	1991	CAGR (%) 1987-1991
World Implanter Market	185.9	377.4	456.6	369.8	343.2	16.6
Medium Current						
Balzers	2.8	4.2	1.6	.0	.0	
Eaton	13.0	28.0	23.0	17.5	12.6	
Nissin	11.1	28.3	35.4	37.5	28.0	
Sumitomo/Eaton Nova	2.6	2.9	.9	.0	.0	
TEL/Varian	8.4	24.1	28.0	20.4	11.7	
Ulvac	5.2	7.5	13.8	6.9	11.1	
Varian	17.9	22.9	28.6	31.2	44.1	
Total Medium Current	61.0	117.9	131.3	113.5	107.5	15.2
High Current						
Applied Materials	10.0	24.9	49.4	46.0	33.9	
Eaton	35.0	59.0	56.0	50.1	40.6	
Hitachi	3.8	9.6	14.4	11.2	10.2	
Nissin	1.8	4.1	16.4	9.2	11.2	
Sumitomo/Eaton Nova	18.4	42.8	47.5	51.6	45.7	
TEL/Varian	16.8	52.5	72.0	33.3	30.7	
Ulvac	2.1	3.8	.0	.0	.0	
Varian	19.0	44.4	45.0	48.1	45.8	
Total High Current	106.9	241.1	300.7	249.5	218.1	19.5
High Voltage						
Eaton	6.7	2.5	.0	.0	3.3	
Genus	.0	12.9	17.7	6.8	11.3	
National Electrostatics	1.8	1.2	4.0	.0	.0	
Nissin	2.8	.0	2.9	.0	3.0	
Sumitomo Eaton Nova	3.1	.0	.0	.0	.0	
Varian	3.6	1.8	.0	.0	.0	
Total High Voltage	18.0	18.4	24.6	6.8	17.6	-.6
Total Worldwide	185.9	377.4	456.6	369.8	343.2	16.6

Ref: IMPLSHR
Source: Dataquest (April 1992)

Table 4.54
Each Company's Revenue from Shipments of Optical CD & CD SEM Equipment to North America (End User Revenue in Millions of U.S. Dollars)

Company:	Each
Product:	Optical CD & CD SEM
Region:	North America

	1987	1988	1989	1990	1991	CAGR (%) 1987-1991
World Optical CD & CD SEM Market	88.7	151.0	150.2	146.5	153.6	14.7
Optical Critical Dimension						
Biorad	.0	.0	.0	6.5	5.9	
Heidelberg Instruments	.7	1.7	.0	.0	.0	
Hitachi	.0	.0	.3	.3	.0	
IVS, Inc.	1.4	6.4	5.2	6.0	4.8	
KLA Instruments	.0	2.8	3.8	3.4	2.8	
Leica	.0	.0	.0	1.5	.6	
Leica Lasertechnik	.0	.0	.0	.3	.0	
Micro-Controle	.0	.0	.0	.0	.0	
Nano-Master	.0	.0	.0	.0	.8	
Nanometrics	1.1	1.4	.5	1.4	.9	
Nanoquest	.0	.0	5.8	.0	.0	
Nidek	.0	.0	.0	.0	.0	
Nikon	.3	.5	.0	.0	.0	
Optical Specialties	1.1	1.0	1.8	.3	1.0	
Perkin-Elmer	.0	2.3	1.4	.0	.0	
Reichert-McBain	.3	.0	.0	.0	.0	
Ryokosha	.0	.3	.0	.0	.0	
SiScan Systems	2.3	4.9	1.9	2.0	2.2	
Vickers Instruments	4.9	7.0	.0	.0	.0	
Wild Leitz	2.3	3.3	1.9	.0	.0	
Wild Leitz Instruments	.0	.0	1.4	.0	.0	
Other CD Companies	1.5	1.8	1.4	1.2	.8	
Total Optical CD	15.9	33.4	25.4	22.9	19.8	5.6

(Continued)

Table 4.54 (Continued)
Each Company's Revenue from Shipments of Optical CD & CD SEM Equipment to North America (End User Revenue in Millions of U.S. Dollars)

Company: Each
Product: Optical CD & CD SEM
Region: North America

	1987	1988	1989	1990	1991	CAGR (%) 1987-1991
CD SEM						
ABT Corporation	.0	.0	.0	.0	.0	
Amray	1.4	2.6	1.3	1.1	2.8	
Angstrom Measurements	.0	.0	.3	.0	2.2	
Biorad	.0	.0	.0	6.9	4.9	
Hitachi	7.0	10.8	15.1	13.9	8.0	
Holon	.0	.0	.0	.0	.0	
JEOL	.0	.0	.0	.0	.0	
Metrologix	.0	.0	.0	.0	.0	
Nanometrics	2.1	1.7	1.6	.5	.0	
Nanoquest	.0	.0	6.5	.0	.0	
Opal	.0	1.3	1.4	.8	.0	
Topcon	.0	.0	.0	.0	.0	
Vickers	8.5	10.1	.0	.0	.0	
Total CD SEM	19.0	26.5	26.2	23.2	17.9	-1.5
Total North America CD & CD SEM	34.9	59.9	51.6	46.1	37.7	1.9

The category of Optical CD includes dedicated overlay tools, in addition to joint linewidth/overlay measurement systems.
Ref: CDSHR
Source: Dataquest (April 1992)

Table 4.55
Each Company's Revenue from Shipments of Optical CD & CD SEM Equipment to Japan (End User Revenue in Millions of U.S. Dollars)

Company: Each
Product: Optical CD & CD SEM
Region: Japan

	1987	1988	1989	1990	1991	CAGR (%) 1987-1991
World Optical CD & CD SEM Market	88.7	151.0	150.2	146.5	153.6	14.7
Optical Critical Dimension						
Biorad	.0	.0	.0	.0	.0	
Heidelberg Instruments	.0	.4	.0	.0	.0	
Hitachi	6.0	7.1	6.3	5.1	3.6	
IVS, Inc.	.0	.0	.0	.0	.0	
KLA Instruments	.0	1.5	1.1	3.3	3.4	
Leica	.0	.0	.0	.0	.0	
Leica Lasertechnik	.0	.0	.0	.0	.0	
Micro-Controle	.0	.0	.0	.0	.0	
Nano-Master	.0	.0	.0	.0	.0	
Nanometrics	.1	.4	.0	.0	.5	
Nanoquest	.0	.0	.0	.0	.0	
Nidek	.0	.5	.3	.0	.0	
Nikon	4.5	12.9	7.0	3.8	5.9	
Optical Specialties	.0	.7	.6	.9	3.9	
Perkin-Elmer	.0	.2	.0	.0	.0	
Reichert-McBain	.0	.0	.0	.0	.0	
Ryokosha	1.4	1.7	1.4	1.0	.7	
SiScan Systems	.2	.0	2.2	.0	.0	
Vickers Instruments	.8	.0	.0	.0	.0	
Wild Leitz	.5	.2	.0	.0	.0	
Wild Leitz Instruments	.0	.0	.0	.0	.0	
Other CD Companies	1.5	2.0	1.6	1.2	1.3	
Total Optical CD	15.0	27.6	20.5	15.3	19.3	6.5

(Continued)

Table 4.55 (Continued)
Each Company's Revenue from Shipments of Optical CD & CD SEM Equipment to Japan
(End User Revenue in Millions of U.S. Dollars)

Company:	Each
Product:	Optical CD & CD SEM
Region:	Japan

	1987	1988	1989	1990	1991	CAGR (%) 1987-1991
CD SEM						
ABT Corporation	1.2	2.4	1.5	5.2	.0	
Amray	.0	.0	.0	.0	.0	
Angstrom Measurements	.0	.0	.0	.0	.0	
Biorad	.0	.0	.0	.0	.0	
Hitachi	18.6	26.9	33.5	38.8	45.6	
Holon	.8	4.8	6.1	8.9	8.0	
JEOL	2.1	2.9	.0	.0	1.7	
Metrologix	.0	.0	.0	.0	.0	
Nanometrics	.0	.0	.0	.0	.0	
Nanoquest	.0	.0	.3	.0	.0	
Opal	.0	.0	.0	1.6	1.6	
Topcon	.0	.0	.0	.0	2.1	
Vickers	.0	.7	.0	.0	.0	
Total CD SEM	22.7	37.7	41.4	54.5	59.0	27.0
Total Japan CD & CD SEM	37.7	65.3	61.9	69.8	78.3	20.0

The category of Optical CD includes dedicated overlay tools, in addition to joint linewidth/overlay measurement systems.
Ref: CDSHR
Source: Dataquest (April 1992)

Table 4.56
Each Company's Revenue from Shipments of Optical CD & CD SEM Equipment to Europe (End User Revenue in Millions of U.S. Dollars)

Company:	Each
Product:	Optical CD & CD SEM
Region:	Europe

	1987	1988	1989	1990	1991	CAGR (%) 1987-1991
World Optical CD & CD SEM Market	88.7	151.0	150.2	146.5	153.6	14.7
Optical Critical Dimension						
Biorad	.0	.0	.0	3.6	3.1	
Heidelberg Instruments	.9	1.4	.0	.0	.0	
Hitachi	.0	.0	.0	.0	.6	
IVS, Inc.	.1	.0	.0	.8	1.6	
KLA Instruments	.0	1.9	.0	.8	1.2	
Leica	.0	.0	.0	5.0	.5	
Leica Lasertechnik	.0	.0	.0	.7	.0	
Micro-Controle	.0	.0	2.2	4.4	.0	
Nano-Master	.0	.0	.0	.0	5.2	
Nanometrics	.3	.1	.2	.4	.5	
Nanoquest	.0	.0	3.2	.0	.0	
Nidek	.0	.0	.0	.0	.0	
Nikon	.2	.3	.5	.0	.0	
Optical Specialties	.1	.2	.3	.0	.0	
Perkin-Elmer	.0	.2	.0	.0	.0	
Reichert-McBain	.0	.0	.0	.0	.0	
Ryokosha	.0	.3	.0	.0	.0	
SiScan Systems	.5	.0	.7	.0	.0	
Vickers Instruments	2.6	2.0	.0	.0	.0	
Wild Leitz	2.8	5.7	4.4	.0	.0	
Wild Leitz Instruments	.0	.0	.6	.0	.0	
Other CD Companies	.5	.7	.8	.8	.5	
Total Optical CD	8.0	12.8	12.9	16.5	13.2	13.3

(Continued)

Table 4.56 (Continued)
Each Company's Revenue from Shipments of Optical CD & CD SEM Equipment to Europe
(End User Revenue in Millions of U.S. Dollars)

Company: Each
Product: Optical CD & CD SEM
Region: Europe

	1987	1988	1989	1990	1991	CAGR (%) 1987-1991
CD SEM						
ABT Corporation	.0	.0	.0	.0	.0	
Amray	.0	.0	.8	.6	.6	
Angstrom Measurements	.0	.0	.0	.0	.0	
Biorad	.0	.0	.0	.0	.0	
Hitachi	2.3	4.3	5.6	6.2	4.0	
Holon	.0	.0	.0	.0	.0	
JEOL	.0	.0	.0	.0	.0	
Metrologix	.0	.0	.0	.0	.0	
Nanometrics	.0	.0	.0	.0	.0	
Nanoquest	.0	.0	1.7	.0	.0	
Opal	.0	.0	1.4	.0	.8	
Topcon	.0	.0	.0	.0	.0	
Vickers	1.1	1.2	.0	.0	.0	
Total CD SEM	3.4	5.5	9.5	6.8	5.4	12.3
Total Europe CD & CD SEM	11.4	18.3	22.4	23.3	18.6	13.0

The category of Optical CD includes dedicated overlay tools, in addition to joint linewidth/overlay measurement systems.
Ref: CDSHR
Source: Dataquest (April 1992)

Table 4.57
Each Company's Revenue from Shipments of Optical CD & CD SEM Equipment to Asia/Pacific-ROW (End User Revenue in Millions of U.S. Dollars)

Company:	Each
Product:	Optical CD & CD SEM
Region:	Asia/Pacific-ROW

	1987	1988	1989	1990	1991	CAGR (%) 1987-1991
World Optical CD & CD SEM Market	88.7	151.0	150.2	146.5	153.6	14.7
Optical Critical Dimension						
Biorad	.0	.0	.0	.0	.9	
Heidelberg Instruments	.0	.0	.0	.0	.0	
Hitachi	.0	.0	.0	.0	.0	
IVS, Inc.	.0	.0	2.0	1.2	1.2	
KLA Instruments	.0	.0	1.6	1.1	1.9	
Leica	.0	.0	.0	.0	.7	
Leica Lasertechnik	.0	.0	.0	.0	.0	
Micro-Controle	.0	.0	.0	.0	.0	
Nano-Master	.0	.0	.0	.0	.0	
Nanometrics	.2	.4	.2	.0	.5	
Nanoquest	.0	.0	.0	.0	.0	
Nidek	.0	.0	.0	.0	.0	
Nikon	.2	.6	.5	.0	.0	
Optical Specialties	.1	.4	2.0	.7	.8	
Perkin-Elmer	.0	.2	.0	.0	.0	
Reichert-McBain	.0	.0	.0	.0	.0	
Ryokosha	.0	.2	.0	.0	.0	
SiScan Systems	.0	.0	.2	.0	.0	
Vickers Instruments	.0	.0	.0	.0	.0	
Wild Leitz	.8	.6	1.6	.0	.0	
Wild Leitz Instruments	.0	.0	.0	.0	.0	
Other CD Companies	2.1	3.2	2.7	1.2	1.0	
Total Optical CD	3.4	5.6	10.8	4.2	7.0	19.8

(Continued)

Table 4.57 (Continued)
Each Company's Revenue from Shipments of Optical CD & CD SEM Equipment to Asia/Pacific-ROW (End User Revenue in Millions of U.S. Dollars)

Company: Each
Product: Optical CD & CD SEM
Region: Asia/Pacific-ROW

	1987	1988	1989	1990	1991	CAGR (%) 1987-1991
CD SEM						
ABT Corporation	.0	.0	.0	.0	.0	
Amray	.0	.0	.0	.0	.0	
Angstrom Measurements	.0	.0	.0	.0	.0	
Biorad	.0	.0	.0	.0	.0	
Hitachi	.9	1.1	2.8	3.1	12.0	
Holon	.0	.0	.0	.0	.0	
JEOL	.0	.0	.0	.0	.0	
Metrologix	.0	.0	.0	.0	.0	
Nanometrics	.4	.8	.7	.0	.0	
Nanoquest	.0	.0	.0	.0	.0	
Opal	.0	.0	.0	.0	.0	
Topcon	.0	.0	.0	.0	.0	
Vickers	.0	.0	.0	.0	.0	
Total CD SEM	1.3	1.9	3.5	3.1	12.0	74.3
Total Asia/Pacific-ROW CD & CD SEM	4.7	7.5	14.3	7.3	19.0	41.8

The category of Optical CD includes dedicated overlay tools, in addition to joint linewidth/overlay measurement systems.
Ref: CDSHR
Source: Dataquest (April 1992)

Table 4.58
Worldwide Optical CD & CD SEM
By Equipment Category
(End User Revenue in Millions of U.S. Dollars)

Company:	All
Product:	Optical CD & CD SEM
Region:	Worldwide

	1987	1988	1989	1990	1991	CAGR (%) 1987-1991
World Optical CD & CD SEM Market	88.7	151.0	150.2	146.5	153.6	14.7
Optical Critical Dimension						
Biorad	.0	.0	.0	10.1	9.9	
Heidelberg Instruments	1.6	3.5	.0	.0	.0	
Hitachi	6.0	7.1	6.6	5.4	4.2	
IVS, Inc.	1.5	6.4	7.2	8.0	7.6	
KLA Instruments	.0	6.2	6.5	8.6	9.3	
Leica	.0	.0	.0	6.5	1.8	
Leica Lasertechnik	.0	.0	.0	1.0	.0	
Micro-Controle	.0	.0	2.2	4.4	.0	
Nano-Master	.0	.0	.0	.0	6.0	
Nanometrics	1.7	2.3	.9	1.8	2.4	
Nanoquest	.0	.0	9.0	.0	.0	
Nidek	.0	.5	.3	.0	.0	
Nikon	5.2	14.3	8.0	3.8	5.9	
Optical Specialties	1.3	2.3	4.7	1.9	5.7	
Perkin-Elmer	.0	2.9	1.4	.0	.0	
Reichert-McBain	.3	.0	.0	.0	.0	
Ryokosha	1.4	2.5	1.4	1.0	.7	
SiScan Systems	3.0	4.9	5.0	2.0	2.2	
Vickers Instruments	8.3	9.0	.0	.0	.0	
Wild Leitz	6.4	9.8	7.9	.0	.0	
Wild Leitz Instruments	.0	.0	2.0	.0	.0	
Other CD Companies	5.6	7.7	6.5	4.4	3.6	
Total Optical CD	42.3	79.4	69.6	58.9	59.3	8.8

(Continued)

Table 4.58 (Continued)
Worldwide Optical CD & CD SEM
By Equipment Category
(End User Revenue in Millions of U.S. Dollars)

Company: All
Product: Optical CD & CD SEM
Region: Worldwide

	1987	1988	1989	1990	1991	CAGR (%) 1987-1991
CD SEM						
ABT Corporation	1.2	2.4	1.5	5.2	.0	
Amray	1.4	2.6	2.1	1.7	3.4	
Angstrom Measurements	.0	.0	.3	.0	2.2	
Biorad	.0	.0	.0	6.9	4.9	
Hitachi	28.8	43.1	57.0	62.0	69.6	
Holon	.8	4.8	6.1	8.9	8.0	
JEOL	2.1	2.9	.0	.0	1.7	
Metrologix	.0	.0	.0	.0	.0	
Nanometrics	2.5	2.5	2.3	.5	.0	
Nanoquest	.0	.0	8.5	.0	.0	
Opal	.0	1.3	2.8	2.4	2.4	
Topcon	.0	.0	.0	.0	2.1	
Vickers	9.6	12.0	.0	.0	.0	
Total CD SEM	46.4	71.6	80.6	87.6	94.3	19.4
Total Worldwide CD & CD SEM	88.7	151.0	150.2	146.5	153.6	14.7

The category of Optical CD includes dedicated overlay tools, in addition to joint linewidth/overlay measurement systems.
Ref: CDSHR
Source: Dataquest (April 1992)

Table 4.59
Each Company's Revenue from Shipments of Wafer Inspection Equipment to North America (End User Revenue in Millions of U.S. Dollars)

Company: Each
Product: Wafer Inspection
Region: North America

	1987	1988	1989	1990	1991	CAGR (%) 1987-1991
World Wafer Inspection Market	57.7	100.5	117.2	90.8	89.7	11.7
Wafer Inspection						
Canon	.0	.0	.0	.0	.0	
Estek	.1	.2	.0	.0	.0	
Hitachi	.0	.0	.0	.0	.9	
Insystems	1.1	6.4	7.1	7.4	6.5	
KLA Instruments	11.6	16.8	23.4	14.9	11.0	
Leica	.0	.0	.0	.8	1.4	
Micro-Controle	.0	.0	.0	.0	.0	
Nidek	.0	.0	.2	.8	1.7	
Nikon	2.9	3.4	4.4	2.1	3.3	
Optical Specialties	3.6	1.8	1.3	.1	.1	
Wild Leitz	2.2	5.0	1.8	.0	.0	
Carl Zeiss	.6	.9	.9	.7	.7	
Other Companies	1.1	1.2	1.0	.9	.8	
Total N.A. Wafer Inspection	23.2	35.7	40.1	27.7	26.4	3.3

Ref: INSPSHR
Source: Dataquest (April 1992)

Table 4.60
Each Company's Revenue from Shipments of Wafer Inspection Equipment to Japan (End User Revenue in Millions of U.S. Dollars)

Company: Each
Product: Wafer Inspection
Region: Japan

	1987	1988	1989	1990	1991	CAGR (%) 1987-1991
World Wafer Inspection Market	57.7	100.5	117.2	90.8	89.7	11.7
Wafer Inspection						
Canon	2.0	3.0	3.5	3.8	4.0	
Estek	.0	.0	.0	.0	.0	
Hitachi	.0	.0	.0	.0	9.8	
Insystems	1.1	3.4	4.2	7.0	3.9	
KLA Instruments	11.5	18.4	20.0	16.1	9.9	
Leica	.0	.0	.0	.0	.0	
Micro-Controle	.0	.0	.0	.0	.0	
Nidek	2.3	5.0	4.5	5.7	5.2	
Nikon	4.4	8.8	10.0	7.1	7.4	
Optical Specialties	.0	.0	.0	.0	.0	
Wild Leitz	.0	.0	.0	.0	.0	
Carl Zeiss	.0	.0	.0	.0	.0	
Other Companies	.5	.7	.7	.5	.9	
Total Japan Wafer Inspection	21.8	39.3	42.9	40.2	41.1	17.2

Ref: INSPSHR
Source: Dataquest (April 1992)

Table 4.61
Each Company's Revenue from Shipments of Wafer Inspection Equipment to Europe (End User Revenue in Millions of U.S. Dollars)

Company: Each
Product: Wafer Inspection
Region: Europe

	1987	1988	1989	1990	1991	CAGR (%) 1987-1991
World Wafer Inspection Market	57.7	100.5	117.2	90.8	89.7	11.7
Wafer Inspection						
Canon	.0	.0	.0	.0	.0	
Estek	.0	.0	.0	.0	.0	
Hitachi	.0	.0	.0	.0	.0	
Insystems	.0	.0	3.0	1.2	2.6	
KLA Instruments	3.6	4.8	7.0	4.7	3.3	
Leica	.0	.0	.0	5.2	2.5	
Micro-Controle	.0	.0	3.1	5.0	5.4	
Nidek	.0	.4	.3	.2	.2	
Nikon	1.1	2.0	2.5	1.2	.8	
Optical Specialties	.2	.2	.0	.0	.0	
Wild Leitz	2.1	4.5	6.5	.0	.0	
Carl Zeiss	1.2	.9	.9	.7	.7	
Other Companies	.3	.1	.1	.1	.1	
Total Europe Wafer Inspection	8.5	12.9	23.4	18.3	15.6	16.4

Ref: INSPSHR
Source: Dataquest (April 1992)

Table 4.62
Each Company's Revenue from Shipments for Wafer Inspection Equipment to Asia/Pacific-ROW (End User Revenue in Millions of U.S. Dollars)

Company:	Each
Product:	Wafer Inspection
Region:	Asia/Pacific-ROW

	1987	1988	1989	1990	1991	CAGR (%) 1987-1991
World Wafer Inspection Market	57.7	100.5	117.2	90.8	89.7	11.7
Wafer Inspection						
Canon	.0	.0	.0	.4	.4	
Estek	.0	.0	.0	.0	.0	
Hitachi	.0	.0	.0	.0	.9	
Insystems	.0	.0	.0	1.2	.0	
KLA Instruments	.9	8.0	6.7	1.3	2.2	
Leica	.0	.0	.0	.8	1.0	
Micro-Controle	.0	.0	.0	.0	.0	
Nidek	.8	.8	.3	.0	.0	
Nikon	1.1	1.6	2.2	.3	1.6	
Optical Specialties	.2	.5	.7	.2	.0	
Wild Leitz	.4	.9	.5	.0	.0	
Carl Zeiss	.0	.0	.0	.0	.0	
Other Companies	.8	.8	.4	.4	.5	
Total A/P-ROW Wafer Inspection	4.2	12.6	10.8	4.6	6.6	12.0

Ref: INSPSHR
Source: Dataquest (April 1992)

Table 4.63
Each Company's Revenue from Shipments of Wafer Inspection Equipment to the World (End User Revenue in Millions of U.S. Dollars)

Company:	Each
Product:	Wafer Inspection
Region:	World

	1987	1988	1989	1990	1991	CAGR (%) 1987-1991
World Wafer Inspection Market	57.7	100.5	117.2	90.8	89.7	11.7
Wafer Inspection						
Canon	2.0	3.0	3.5	4.2	4.4	
Estek	.1	.2	.0	.0	.0	
Hitachi	.0	.0	.0	.0	11.6	
Insystems	2.2	9.8	14.3	16.8	13.0	
KLA Instruments	27.6	48.0	57.1	37.0	26.4	
Leica	.0	.0	.0	6.8	4.9	
Micro-Controle	.0	.0	3.1	5.0	5.4	
Nidek	3.1	6.2	5.3	6.7	7.1	
Nikon	9.5	15.8	19.1	10.7	13.1	
Optical Specialties	4.0	2.5	2.0	.3	.1	
Wild Leitz	4.7	10.4	8.8	.0	.0	
Carl Zeiss	1.8	1.8	1.8	1.4	1.4	
Other Companies	2.7	2.8	2.2	1.9	2.3	
Total W.W. Wafer Inspection	57.7	100.5	117.2	90.8	89.7	11.7

Ref: INSPSHR
Source: Dataquest (April 1992)

Chapter 5

Wafer Fab Equipment—Company Rankings

This section of the wafer fab equipment database presents the ranking of wafer fab equipment manufacturers by 1991 revenue, as shown in Table 5.1. Line 1 in the table shows the total worldwide wafer fab equipment market. Individual company data shown in the table represent 86 percent of the 1991 total wafer fab equipment market of approximately $6,039 million. The companies listed here represent virtually all worldwide industry sales in the key front-end equipment categories of lithography, automatic photoresist processing, etch and clean, deposition, diffusion, ion implantation, and CD/wafer inspection. The remaining 14 percent of the total worldwide wafer fab equipment includes other process control, factory automation, and other front-end equipment. Company sales for these categories are not included in the table.

Table 5.1 includes only company sales of front-end equipment; it does not include company sales of assembly and test equipment. For instance, back-end equipment sales by General Signal or ASM International are not included. Likewise, KLA's CD/wafer inspection equipment sales only are included; KLA's sales of mask inspection equipment (part of the Other Process Control Equipment category) are not.

The revenue reported in Table 5.1 is for the calendar year and includes system sales, upgrades, and retrofits, but it does not include service and spare parts. Thus, the revenue reported here will differ from each company's sales as reported in its financial statements.

Some companies, such as Silicon Valley Group, have experienced significant growth as a result of mergers and acquisitions. Please refer to Table 1.3 in Chapter 1 for a summary of merger and acquisition activities in the wafer fab equipment industry.

Several companies are denoted as being involved in wafer fab equipment joint venture activities. The entries for these companies do not include the revenue of the joint ventures. Instead, the reader should refer to the individual entry for the joint venture equipment company. For example, the estimated revenue of the TEL/Varian or Varian/TEL joint ventures is listed separately from Tokyo Electron Ltd. and Varian Associates.

Table 5.1
Each Company's Revenue from Shipments of Semiconductor Wafer Fab Equipment to the World (End User Revenue in Millions of U.S. Dollars)

Company: Each
Product: Each
Region Of Consumption: World

	1987	1988	1989	1990	1991	1991 Rank
World Fab Equipment Market	3,140.6	4,987.8	6,017.4	5,871.3	6,039.5	
Nikon						1
Steppers	218.8	490.2	653.7	518.4	538.2	
Critical Dimension	5.2	14.3	8.0	3.8	5.9	
Wafer Inspection	9.5	15.8	19.1	10.7	13.1	
Total	233.5	520.3	680.8	532.9	557.2	
Applied Materials						2
Dry Etch	102.0	196.7	208.0	175.0	154.0	
APCVD	14.5	15.7	9.0	5.0	.0	
LPCVD	.0	.0	.0	26.0	32.0	
PECVD	31.0	75.4	143.0	170.0	186.4	
Sputtering	.0	.0	.0	15.0	55.0	
Silicon Epitaxy	18.6	47.2	22.2	25.0	32.0	
Ion Implantation	10.0	24.9	49.4	46.0	33.9	
Total	176.1	359.9	431.6	462.0	493.3	
Tokyo Electron Ltd.[1]						3
Resist Processing Equip.	36.2	90.5	99.3	105.9	126.2	
Dry Etch	.0	44.6	80.6	99.2	110.0	
Wet Process	.0	.0	.0	.0	5.6	
LPCVD	.0	18.4	30.6	45.8	62.8	
MOCVD	.0	.0	2.9	.0	.0	
Diffusion	.1	82.6	89.9	92.2	92.7	
Total	36.3	236.1	303.3	343.1	397.3	
Hitachi						4
Direct Write	8.7	9.6	9.4	19.5	17.8	
Maskmaking	13.4	3.8	6.6	6.2	6.7	
Steppers	33.3	49.2	75.5	103.8	86.7	
Dry Strip	.0	4.6	5.0	2.7	5.6	
Dry Etch	2.1	2.3	2.3	4.5	1.5	
ECR Etch	16.7	32.3	45.3	87.0	113.7	
APCVD	.0	.5	1.1	.0	.0	
Ion Implantation	3.8	9.6	14.4	11.2	10.2	
Wafer Inspection	.0	.0	.0	.0	11.6	
Critical Dimension	34.8	50.2	63.6	67.4	73.8	
Total	112.8	162.1	223.2	302.3	327.6	

(Continued)

Table 5.1 (Continued)
Each Company's Revenue from Shipments of Semiconductor Wafer Fab Equipment to the World (End User Revenue in Millions of U.S. Dollars)

Company: Each
Product: Each
Region Of Consumption: World

	1987	1988	1989	1990	1991	1991 Rank
Canon[2]						5
Contact Proximity	11.0	8.6	6.3	10.5	7.9	
Projection Aligners	40.6	69.1	49.4	56.4	47.2	
Steppers	89.8	125.0	182.9	202.2	219.7	
Resist Processing Equip.	1.0	3.8	10.1	8.4	12.3	
Wafer Inspection	2.0	3.0	3.5	4.2	4.4	
Total	144.4	209.5	252.2	281.7	291.5	
Varian Associates[3]						6
LPCVD	7.9	6.4	5.0	.0	.0	
Sputtering	48.3	61.3	73.0	84.0	90.9	
Molecular Beam Epitaxy	12.1	17.5	17.2	3.7	.0	
Rapid Thermal Processing	.9	.4	.0	.0	.0	
Ion Implantation	40.5	69.1	73.6	79.3	89.9	
Total	109.7	154.7	168.8	167.0	180.8	
Silicon Valley Group						7
Projection Aligners	.0	.0	.0	37.0	21.2	
Steppers	.0	.0	.0	30.6	30.4	
Resist Processing Equip.	33.0	37.4	54.0	44.0	48.9	
LPCVD	5.3	7.6	16.0	22.5	25.8	
Diffusion	1.1	4.0	57.0	54.2	54.0	
Total	39.4	49.0	127.0	188.3	180.3	
Anelva						8
Dry Etch	18.1	38.5	45.6	23.8	16.3	
ECR Etch	4.2	3.1	2.9	5.6	6.0	
ECR CVD	1.0	.8	1.0	.4	2.2	
LPCVD	.7	2.3	1.1	1.4	2.8	
PECVD	.0	1.4	.4	.0	.0	
Sputtering	44.7	53.8	80.9	90.8	114.5	
Evaporation	4.9	6.2	4.3	4.1	4.1	
Molecular Beam Epitaxy	9.7	11.5	6.8	6.2	8.7	
Total	83.3	117.6	143.0	132.3	154.6	
Kokusai Electric						9
LPCVD	10.4	30.8	47.1	62.7	63.6	
Diffusion	24.0	46.2	53.9	50.9	68.1	
Dry Etch	1.4	1.5	1.0	1.1	.0	
Silicon Epitaxy	1.5	4.2	5.7	2.2	5.9	
Rapid Thermal Processing	.0	.0	.0	.0	.6	
APCVD	.0	.7	.0	.0	.0	
Total	37.3	83.4	107.7	116.9	138.2	

(Continued)

Table 5.1 (Continued)
Each Company's Revenue from Shipments of Semiconductor Wafer Fab Equipment to the World (End User Revenue in Millions of U.S. Dollars)

Company: Each
Product: Each
Region Of Consumption: World

	1987	1988	1989	1990	1991	1991 Rank
Dainippon Screen						10
Resist Processing Equip.	31.2	40.2	67.7	59.2	69.5	
Wet Process	21.7	49.5	68.5	65.7	66.5	
Rapid Thermal Processing	1.0	1.2	1.8	2.3	2.0	
Total	53.9	90.9	138.0	127.2	138.0	
LAM Research						11
Dry Etch	32.0	65.0	83.2	109.2	127.1	
LPCVD	.0	.0	.0	2.7	1.9	
Silicon Epitaxy	14.8	19.0	22.2	7.9	.0	
Total	46.8	84.0	105.4	119.8	129.0	
Ulvac[4]						12
Dry Strip	3.6	4.9	5.5	2.3	2.3	
Dry Etch	3.6	6.0	8.7	6.6	6.2	
ECR Etch	2.1	2.3	.0	.0	.0	
LPCVD	1.4	3.8	4.2	4.5	18.3	
Diffusion	.0	.0	.0	.0	13.0	
Sputtering	34.0	48.7	55.7	58.6	54.5	
Evaporation	8.0	14.0	14.6	13.5	8.5	
Molecular Beam Epitaxy	4.3	7.5	4.0	4.9	5.9	
MOCVD	1.9	2.2	2.0	3.1	4.3	
Ion Implantation	7.3	11.3	13.8	6.9	11.1	
Total	66.2	100.7	108.5	100.4	124.1	
ASM International						13
Diffusion	18.5	22.7	29.0	24.4	21.7	
PECVD	44.5	51.6	51.0	49.6	40.0	
LPCVD	19.9	25.8	18.0	27.5	30.5	
Silicon Epitaxy	.0	3.1	6.2	19.2	29.9	
Total	82.9	103.2	104.2	120.7	122.1	
General Signal Companies						14
Ultratech						
Steppers	40.6	73.0	62.3	28.0	36.0	
Drytek						
Dry Strip	1.0	1.2	1.4	.0	.0	
Dry Etch	17.0	25.0	30.0	22.0	25.0	
Total	18.0	26.2	31.4	22.0	25.0	

(Continued)

Table 5.1 (Continued)
Each Company's Revenue from Shipments of Semiconductor Wafer Fab Equipment to the World (End User Revenue in Millions of U.S. Dollars)

Company: Each
Product: Each
Region Of Consumption: World

	1987	1988	1989	1990	1991	1991 Rank
Semiconductor Systems, Inc.						
Resist Processing Equip.	10.8	22.0	22.0	23.0	.0	
General Signal Thinfilm						
Diffusion	.0	4.3	8.0	9.0	3.0	
LPCVD	.0	3.8	6.0	7.0	3.0	
APCVD	.0	1.3	.8	.8	.5	
Sputtering	.0	2.6	2.0	.0	.0	
Total	.0	12.0	16.8	16.8	6.5	
Circuits Proc. Apparatus						
Sputtering	3.0	.0	.0	.0	.0	
Tempress						
Diffusion	.5	.0	.0	.0	.0	
GCA						
Steppers	.0	.0	68.9	78.2	46.8	
Total General Signal Companies	72.4	133.2	201.4	168.0	114.3	
Materials Research Corp. (Sony)						15
Dry Etch	.0	.0	.0	4.7	9.6	
Sputtering	.0	.0	.0	62.6	84.5	
Total	.0	.0	.0	67.3	94.1	
Novellus Systems, Inc.						16
PECVD	3.6	23.7	49.0	63.0	64.0	
Sputtering				.0	1.8	
LPCVD				1.0	5.7	
Total	3.6	23.7	49.0	64.0	71.5	
ASM Lithography						17
Steppers	36.7	58.6	123.2	91.0	71.3	
Direct Write	8.0	7.2	7.2	.0	.0	
Maskmaking	4.0	2.4	2.4	.0	.0	
Total	48.7	68.2	132.8	91.0	71.3	
Eaton[5]						18
Ion Implantation	54.7	89.5	79.0	67.6	56.5	
Resist Processing Equip.	10.5	11.0	10.5	4.7	4.3	
Rapid Thermal Processing	.2	.4	.0	.0	.0	
Total	65.4	100.9	89.5	72.3	60.8	
Alcan Technology						19
Dry Strip	5.0	10.2	13.1	11.7	19.2	
Dry Etch	.0	.0	.0	2.5	5.6	
APCVD	.0	.0	.0	15.0	26.8	
Total	5.0	10.2	13.1	29.2	51.6	

(Continued)

Table 5.1 (Continued)
Each Company's Revenue from Shipments of Semiconductor Wafer Fab Equipment to the World (End User Revenue in Millions of U.S. Dollars)

Company: Each
Product: Each
Region Of Consumption: World

	1987	1988	1989	1990	1991	1991 Rank
Varian/TEL						20
Resist Processing Equip.	.0	.0	19.4	13.8	17.1	
Dry Etch	.0	.0	6.2	11.6	10.9	
LPCVD	.0	.0	.0	4.8	9.6	
Diffusion	.0	.0	6.3	6.3	13.8	
Total	.0	.0	31.9	36.5	51.4	
Watkins-Johnson						21
APCVD	16.0	36.0	42.0	41.0	48.5	
Genus						22
LPCVD	13.2	33.4	62.0	44.0	34.8	
Ion Implantation	.0	12.9	17.7	6.8	11.3	
Total	13.2	46.3	79.7	50.8	46.1	
Sumitomo/Eaton Nova						23
Ion Implantation	24.1	45.7	48.4	51.6	45.7	
E.T. Electrotech						24
PECVD	13.3	20.3	15.5	17.5	20.0	
Dry Etch	7.2	14.1	15.0	17.5	12.0	
Sputtering	6.0	9.0	14.1	13.5	12.0	
Total	26.5	43.4	44.6	48.5	44.0	
Nissin Electric						25
Ion Implantation	15.7	32.4	54.7	46.7	42.2	
Molecular Beam Epitaxy	.0	.0	.0	.0	.6	
MOCVD	.0	.0	.0	.0	1.1	
Total	15.7	32.4	54.7	46.7	43.9	
TEL/Varian						26
Ion Implantation	25.2	76.6	100.0	53.7	42.4	
JEOL						27
Direct Write	30.8	31.1	31.6	35.4	26.8	
Maskmaking	18.1	5.0	15.8	10.4	11.1	
Critical Dimension	2.1	2.9	.0	.0	1.7	
Total	51.0	39.0	47.4	45.8	39.6	
Gasonics						28
Dry Etch	.0	.0	.0	.0	5.0	
Dry Strip	2.0	3.0	6.2	8.2	22.9	
Diffusion	7.5	9.0	8.0	8.0	8.7	
Total	9.5	12.0	14.2	16.2	36.6	

(Continued)

Table 5.1 (Continued)
Each Company's Revenue from Shipments of Semiconductor Wafer Fab Equipment to the World (End User Revenue in Millions of U.S. Dollars)

Company: Each
Product: Each
Region Of Consumption: World

	1987	1988	1989	1990	1991	1991 Rank
KLA Instruments						29
Critical Dimension	.0	6.2	6.5	8.6	9.3	
Wafer Inspection	27.6	48.0	57.1	37.0	26.4	
Total	27.6	54.2	63.6	45.6	35.7	
Kaijo Denki						30
Wet Process	10.1	14.6	25.2	37.1	33.1	
Sanyko Engineering						31
Wet Process	8.1	23.8	35.1	39.1	32.7	
Sugai						32
Wet Process	4.5	20.7	30.9	35.7	32.6	
Tegal						33
Dry Strip	5.2	5.2	3.5	3.0	3.5	
Dry Etch	35.6	46.4	41.0	31.0	29.0	
Total	40.8	51.6	44.5	34.0	32.5	
Tokyo Ohka Kogyo						34
Dry Strip	9.2	19.9	26.0	18.7	15.7	
Dry Etch	7.1	10.0	21.7	16.6	15.3	
Total	16.3	29.9	47.7	35.3	31.0	
BTU International[6]						35
LPCVD	7.9	14.5	17.5	12.2	10.5	
Diffusion	19.3	35.0	41.0	24.0	19.0	
Total	27.2	49.5	58.5	36.2	29.5	
FSI International[7]						36
Resist Processing Equip.	.0	.0	.0	.0	4.8	
Wet Process	18.3	21.3	25.2	17.9	21.8	
Total	18.3	21.3	25.2	17.9	26.6	
Machine Technology, Inc.						37
Resist Processing Equip.	12.7	10.0	11.3	21.0	26.6	
Dry Strip	2.7	4.5	1.5	.2	.0	
Sputtering	3.0	5.0	1.0	.0	.0	
Total	18.4	19.5	13.8	21.2	26.6	
AG Associates						38
Rapid Thermal Processing	10.8	10.6	11.0	14.6	24.4	
Plasma Systems						39
Dry Strip	5.4	10.4	17.0	24.9	21.2	
Dry Etch	1.9	3.2	3.3	1.7	1.5	
Total	7.3	13.6	20.3	26.6	22.7	

(Continued)

Table 5.1 (Continued)
Each Company's Revenue from Shipments of Semiconductor Wafer Fab Equipment to the World (End User Revenue in Millions of U.S. Dollars)

Company: Each
Product: Each
Region Of Consumption: World

	1987	1988	1989	1990	1991	1991 Rank
Santa Clara Plastics						40
Wet Process	16.0	14.6	16.6	10.1	20.2	
Sumitomo Metals						41
Dry Strip	.0	.0	.0	.0	2.1	
ECR Etch	5.6	6.2	12.0	15.7	15.4	
ECR CVD	.0	.0	6.0	5.4	2.7	
Total	5.6	6.2	18.0	21.1	20.2	
Leica and Leica Lasertechnik						42
Direct Write	.0	.0	.0	10.8	10.7	
Maskmaking	.0	.0	.0	2.5	2.5	
Critical Dimension	.0	.0	.0	7.5	1.8	
Wafer Inspection	.0	.0	.0	6.8	4.9	
Total	.0	.0	.0	27.6	19.9	
Dan Science Co., Ltd.						43
Wet Process	.0	2.9	12.7	18.2	19.8	
Convac						44
Resist Processing Equip.	10.9	13.8	12.2	15.4	18.9	
Shimada						45
Wet Process	3.9	5.5	8.6	22.1	18.6	
MOCVD	.0	.0	.0	.0	.0	
Silicon Epitaxy	.0	.0	.0	.0	.0	
Total	3.9	5.5	8.6	22.1	18.6	
Shibaura Engineering Works (Formerly Tokuda)						46
Dry Etch	9.4	3.2	32.4	24.1	14.1	
Sputtering	11.1	7.0	5.6	5.8	4.0	
Total	20.5	10.2	38	29.9	18.1	
Semitool and Semitherm						47
Wet Process	18.8	15.4	10.9	11.5	12.1	
Diffusion	.0	.5	2.0	4.0	3.0	
LPCVD	.0	.5	1.0	1.5	1.5	
Total	18.8	16.4	13.9	17.0	16.6	
Toshiba						48
Maskmaking	3.5	7.7	7.2	.0	.0	
APCVD	5.0	6.0	4.2	3.2	3.2	
Silicon Epitaxy	.6	2.0	6.5	4.5	12.5	
Total	9.1	15.7	17.9	7.7	15.7	

(Continued)

Table 5.1 (Continued)
Each Company's Revenue from Shipments of Semiconductor Wafer Fab Equipment to the World (End User Revenue in Millions of U.S. Dollars)

Company: Each
Product: Each
Region Of Consumption: World

	1987	1988	1989	1990	1991	1991 Rank
Koyo Lindberg						49
APCVD	.2	1.3	.6	.8	.6	
LPCVD	2.0	4.5	4.1	3.1	1.9	
Diffusion	5.7	6.8	8.1	12.1	12.6	
Rapid Thermal Processing	.2	.6	.6	.7	.3	
Total	8.1	13.2	13.4	16.7	15.4	
Tazmo						50
Resist Processing Equip.	4.6	5.7	9.3	17.5	15.2	
Axitron						51
MOCVD	4.9	7.5	11.4	13.9	15.0	
Ateq						52
Direct Write	.0	.0	.0	.0	.0	
Maskmaking	1.6	11.2	13.7	14.0	15.0	
Total	1.6	11.2	13.7	14.0	15.0	
Maruwa						53
Wet Process	.0	3.6	5.4	12.3	15.0	
Plasma-Therm						54
Dry Etch	13.7	12.9	15.2	18.0	13.8	
PECVD	4.6	6.0	3.0	3.0	1.2	
Total	18.3	18.9	18.2	21.0	15.0	
VG Instruments						55
Molecular Beam Epitaxy	15.0	16.5	19.0	17.4	15.0	
Verteq						56
Wet Process	6.5	11.8	12.7	13.5	14.9	
Karl Suss						57
Contact Proximity	13.6	13.7	16.3	13.5	12.9	
X-Ray Aligners	.0	4.6	2.8	1.6	1.8	
Total	13.6	18.3	19.1	15.1	14.7	
Biorad						58
Critical Dimension	.0	.0	.0	17.0	14.8	
ISA Riber						59
Molecular Beam Epitaxy	19.3	22.5	22.3	20.3	14.0	
Semiconductor Systems, Inc.						60
Resist Processing Equip.	.0	.0	.0	.0	14.0	
Shinko Electric (Formerly Denko)						61
LPCVD	2.1	2.3	3.5	3.8	6.2	
Diffusion	2.0	2.7	4.0	6.9	7.4	
Total	4.1	5.0	7.5	10.7	13.6	

(Continued)

Table 5.1 (Continued)
Each Company's Revenue from Shipments of Semiconductor Wafer Fab Equipment to the World (End User Revenue in Millions of U.S. Dollars)

Company: Each
Product: Each
Region Of Consumption: World

	1987	1988	1989	1990	1991	1991 Rank
Enya						62
Wet Process	6.2	7.6	11.6	11.7	11.6	
LPCVD	.6	3.6	3.4	3.5	.0	
PECVD	1.9	4.2	3.5	3.8	1.6	
Total	8.7	15.4	18.5	19.0	13.2	
Insystems						63
Wafer Inspection	2.2	9.8	14.3	16.8	13.0	
Disco						64
Diffusion	1.5	2.9	3.6	5.8	10.0	
LPCVD	.0	.0	.0	.0	2.7	
Total	1.5	2.9	3.6	5.8	12.7	
Amaya						65
APCVD	5.5	17.5	19.0	16.0	12.3	
Emcore						66
Molecular Beam Epitaxy	.0	.0	.0	1.0	.0	
MOCVD	5.1	7.0	10.0	11.6	12.2	
Total	5.1	7.0	10.0	12.6	12.2	
SubMicron Systems, Inc.						67
Wet Process	.0	.0	2.0	10.0	12.0	
Nano-Master (Formerly Micro-Controle)						68
Critical Dimension	.0	.0	2.2	4.4	6.0	
Wafer Inspection	.0	.0	3.1	5.0	5.4	
Total	.0	.0	5.3	9.4	11.4	
ETE Company, Inc.						69
Wet Process	.0	2.0	4.0	9.7	10.9	
Temescal						70
Sputtering	.0	.0	.1	.1	.0	
Evaporation	9.9	8.7	11.2	13.0	10.8	
Total	9.9	8.7	11.3	13.1	10.8	
Etec						71
Direct Write	.0	.0	.0	10.5	.0	
Maskmaking	.0	.0	.0	14.0	10.5	
Total	.0	.0	.0	24.5	10.5	

(Continued)

Table 5.1 (Continued)
Each Company's Revenue from Shipments of Semiconductor Wafer Fab Equipment to the World (End User Revenue in Millions of U.S. Dollars)

Company: Each
Product: Each
Region Of Consumption: World

	1987	1988	1989	1990	1991	1991 Rank
Ramco						72
Dry Strip	8.7	9.6	11.0	16.0	10.3	
Centrotherm						73
Diffusion	.5	1.0	5.8	8.4	6.7	
LPCVD	.0	.0	4.5	4.8	3.1	
Total	.5	1.0	10.3	13.2	9.8	
Matrix						74
Dry Strip	5.2	7.2	7.0	9.0	7.5	
Dry Etch	.0	.0	.0	.0	2.3	
Total	5.2	7.2	7.0	9.0	9.8	
CVC Products						75
Sputtering	9.7	12.3	12.0	7.5	7.0	
Evaporation	.0	1.6	2.0	2.7	2.7	
Total	9.7	13.9	14.0	10.2	9.7	
Universal Plastics						76
Wet Process	3.7	8.5	9.4	8.0	9.1	
Peak Systems						77
Rapid Thermal Processing	3.4	6.6	8.5	8.4	8.6	
Samco						78
Dry Strip	.0	.8	1.0	.9	1.1	
Dry Etch	.0	.0	2.2	2.8	3.4	
PECVD	.0	.0	1.0	2.3	3.0	
MOCVD	.6	1.0	.6	.8	.9	
Total	.6	1.8	4.8	6.8	8.4	
S&K Products International						79
Wet Process	8.5	9.4	11.6	8.0	8.2	
Holon						80
Critical Dimension	.8	4.8	6.1	8.9	8.0	
Oxford Plasma Technology						81
ECR Etch	.0	1.6	2.0	2.4	2.2	
ECR CVD	.0	1.6	2.0	2.5	1.5	
Dry Etch	.0	.0	.0	3.1	4.1	
Total	.0	3.2	4.0	8.0	7.8	

(Continued)

Table 5.1 (Continued)
Each Company's Revenue from Shipments of Semiconductor Wafer Fab Equipment to the World (End User Revenue in Millions of U.S. Dollars)

Company: Each
Product: Each
Region Of Consumption: World

	1987	1988	1989	1990	1991	1991 Rank
Pokorny						82
Wet Process	4.3	4.7	8.2	7.4	7.8	
IVS, Inc.						83
Critical Dimension	1.5	6.4	7.2	8.0	7.6	
Kuwano Electric						84
Wet Process	6.3	13.6	9.4	9.6	7.1	
Nidek						85
Critical Dimension	.0	.5	.3	.0	.0	
Wafer Inspection	3.1	6.2	5.3	6.7	7.1	
Total	3.1	6.7	5.6	6.7	7.1	
Tohokasei						86
Wet Process	.0	3.3	3.5	10.9	7.1	
Yamoto Co., Ltd.						87
MOCVD	.0	.0	.0	.0	1.5	
Molecular Beam Epitaxy	.0	.0	1.8	1.9	5.5	
Total	.0	.0	1.8	1.9	7.0	
Nippon Sanso						88
MOCVD	4.9	6.3	6.8	5.6	6.9	
Semifab						89
Wet Process	7.7	7.0	7.6	6.5	6.5	
Leybold-Heraeus						90
Sputtering	12.0	7.8	8.8	7.8	4.4	
Evaporation	1.5	.5	1.8	1.5	2.0	
Total	13.5	8.3	10.6	9.3	6.4	
Toyoko Chemical						91
Wet Process	.0	2.4	2.8	5.1	.9	
LPCVD	.0	.0	5.8	5.9	5.0	
MOCVD	.7	1.2	.0	.0	.0	
Diffusion	.0	.0	.0	.0	.0	
Total	.7	3.6	8.6	11.0	5.9	
Yuasa						92
Resist Processing Equip.	3.6	6.0	8.8	7.3	5.9	
Optical Specialties, Inc.						93
Critical Dimension	1.3	2.3	4.7	1.9	5.7	
Wafer Inspection	4.0	2.5	2.0	.3	.1	
Total	5.3	4.8	6.7	2.2	5.8	

(Continued)

Table 5.1 (Continued)
Each Company's Revenue from Shipments of Semiconductor Wafer Fab Equipment to the World (End User Revenue in Millions of U.S. Dollars)

Company: Each
Product: Each
Region Of Consumption: World

	1987	1988	1989	1990	1991	1991 Rank
Japan Production Engineering						94
PECVD	4.5	6.5	7.0	8.0	5.6	
Musashi						95
Wet Process	.0	.5	1.9	6.7	5.5	
CFM Technology						96
Wet Process	.0	1.0	.3	2.1	5.3	
Intevac						97
Molecular Beam Epitaxy	.0	.0	.0	.0	5.2	
Denton Vacuum						98
Sputtering	.1	.1	.9	1.5	1.8	
Evaporation	.2	.2	1.2	3.0	3.2	
Total	.3	.3	2.1	4.5	5.0	
LPE						99
Silicon Epitaxy	.0	4.5	4.8	5.5	5.0	
Solitec						100
Resist Processing Equip.	6.2	7.5	9.0	5.8	4.9	
LPCVD	3.6	6.0	5.0	5.0	.0	
Total	9.8	13.5	14.0	10.8	4.9	
SCI Manufacturing						101
Wet Process	4.5	1.9	2.4	.4	4.8	
MR Semicon						102
MOCVD	.0	.0	2.0	3.0	4.6	
CHA Industries						103
Sputtering	.3	.7	.1	.4	.7	
Evaporation	6.0	6.3	7.1	4.0	3.7	
Total	6.3	7.0	7.2	4.4	4.4	
Sapi Equipements						104
Wet Process	.0	.0	5.5	4.8	3.5	
Advantage Production Technology						105
Wet Process	.0	.0	.0	.0	3.4	
Amray						106
Critical Dimension	1.4	2.6	2.1	1.7	3.4	
Moore						107
Silicon Epitaxy	.0	1.0	1.6	3.0	3.3	

(Continued)

Table 5.1 (Continued)
Each Company's Revenue from Shipments of Semiconductor Wafer Fab Equipment to the World (End User Revenue in Millions of U.S. Dollars)

Company: Each
Product: Each
Region Of Consumption: World

	1987	1988	1989	1990	1991	1991 Rank
Fuji Electric						108
Wet Process	.0	2.6	10.7	2.0	2.1	
ECR CVD	.0	.0	.0	.0	.9	
Total	0	2.6	10.7	2.0	3.0	
Hampshire Instruments						109
X-Ray	.0	1.8	.0	.0	2.4	
Nanometrics						110
Critical Dimension	4.2	4.8	3.2	2.3	2.4	
Opal						111
Critical Dimension	.0	1.3	2.8	2.4	2.4	
AET Addax						112
RTP	.0	.0	.0	.0	2.3	
Angstrom Measurements						113
Critical Dimension	.0	.0	.3	.0	2.2	
Eiko						114
Molecular Beam Epitaxy	1.4	1.2	2.9	2.6	2.2	
Nippon EMC						115
MOCVD	1.4	1.9	2.2	1.7	2.2	
SiScan Systems						116
Critical Dimension	3.0	4.9	5.0	2.0	2.2	
Topcon						117
Critical Dimension	.0	.0	.0	.0	2.1	
BCT Spectrum						118
LPCVD	.0	.0	.0	.0	2.0	
CPA						119
Sputter	.0	.0	.0	1.0	2.0	
Dalton Corporation						120
Wet Process	.0	.0	2.6	2.6	1.9	
Fusion Semiconductor Systems						121
Dry Strip	.5	1.0	1.5	1.5	1.9	
Daido Sanso						122
Molecular Beam Epitaxy	.0	.0	.0	.0	1.8	
Kurt J. Lesker						123
Sputtering	.8	.8	.8	1.0	1.0	
Evaporation	.3	.3	.6	.6	.8	
Total	1.1	1.1	1.4	1.6	1.8	

(Continued)

Table 5.1 (Continued)
Each Company's Revenue from Shipments of Semiconductor Wafer Fab Equipment to the World (End User Revenue in Millions of U.S. Dollars)

Company: Each
Product: Each
Region Of Consumption: World

	1987	1988	1989	1990	1991	1991 Rank
m.FSI						124
Dry Strip	.0	.0	.0	.0	1.7	
Alameda Instruments						125
Wet Process	.0	.0	.0	1.2	1.6	
LFE						126
Dry Strip	1.0	1.5	1.7	1.4	1.5	
Mattson Technologies						127
Dry Strip	.0	.0	.0	.0	1.5	
Process Products						128
RTP	.7	1.0	1.3	1.2	1.5	
Shinko Seiki						129
Dry Strip	.0	.0	.0	.0	1.1	
Sputtering	.0	.0	.0	.0	.4	
Total	0	0	0	0	1.5	
Sputtered Films						130
Sputtering	1.0	.6	1.2	1.0	1.5	
Carl Zeiss						131
Wafer Inspection	1.8	1.8	1.8	1.4	1.4	
Pacific Western						132
LPCVD	.0	.0	.0	.0	.0	
PECVD	7.9	6.2	2.8	2.5	1.0	
APCVD	.2	.0	.0	.0	.0	
Diffusion	.0	.6	.6	.6	.4	
Total	8.1	6.8	3.4	3.1	1.4	
Process Technology, Ltd.						133
LPCVD	4.3	4.0	2.5	3.0	1.4	
Pure Aire Corporation						134
Wet Process	2.4	2.8	3.0	1.3	1.4	
Athens						135
Wet Process	1.0	4.0	2.0	4.2	1.2	
Innotec						136
Sputtering	2.4	4.2	.5	.8	.7	
Evaporation	.0	1.0	.2	.4	.5	
Total	2.4	5.2	.7	1.2	1.2	

(Continued)

Table 5.1 (Continued)
Each Company's Revenue from Shipments of Semiconductor Wafer Fab Equipment to the World (End User Revenue in Millions of U.S. Dollars)

Company: Each
Product: Each
Region Of Consumption: World

	1987	1988	1989	1990	1991	1991 Rank
CVT						137
MOCVD	1.1	1.6	2.0	2.2	1.0	
Jipelec						138
RTP	.0	.0	.0	.7	1.0	
Spire						139
MOCVD	1.3	2.1	2.4	1.7	1.0	
Adv. Film Technology, Inc.						140
Sputter	.0	.0	.0	.7	.8	
High Temperature Engineering						141
RTP	.0	.0	.0	.3	.8	
Tystar						142
LPCVD	.0	.0	.8	.4	.3	
Diffusion	.0	.0	.6	.5	.5	
Total	.0	.0	1.4	.9	.8	
CVD Equipment						143
MOCVD	1.2	1.3	1.3	.7	.7	
Elionix						144
ECR Etch	.3	.3	.3	1.2	.7	
Ryokosha						145
Critical Dimension	1.4	2.5	1.4	1.0	.7	
Wellman Furnaces						146
LPCVD	.0	.5	.3	.0	.0	
Diffusion	2.0	2.5	.5	.2	.5	
Total	2.0	3.0	.8	.2	.5	
Nanosil						147
RTP	.3	.5	.4	.5	.3	
Ion Tech						148
Sputtering	.7	.5	.1	.1	.2	
Poly-Flow Engineering						149
Wet Process	.5	.2	4.4	.5	.2	
ABT Corporation						
Critical Dimension	1.2	2.4	1.5	5.2	.0	
American Semiconductor Equipment Technology						
Steppers	11.3	16.0	4.0	.0	.0	

(Continued)

Table 5.1 (Continued)
Each Company's Revenue from Shipments of Semiconductor Wafer Fab Equipment to the World (End User Revenue in Millions of U.S. Dollars)

Company: Each
Product: Each
Region Of Consumption: World

	1987	1988	1989	1990	1991	1991 Rank
Anicon						
LPCVD	3.7	.0	.0	.0	.0	
Balzers						
Sputtering	13.9	11.0	8.2	7.0	.0	
Evaporation	2.9	2.9	5.4	6.5	.0	
Total	16.8	13.9	13.6	13.5	.0	
Branson/IPC						
Dry Strip	7.8	15.0	16.0	14.5	.0	
Dry Etch	1.6	.0	3.2	3.5	.0	
Total	9.4	15.0	19.2	18.0	.0	
BTU/Ulvac						
LPCVD	.0	.0	.0	1.6	.0	
Cambridge Instruments						
Direct Write	10.0	8.0	12.0	.0	.0	
Maskmaking	.0	5.0	2.5	.0	.0	
MOCVD	3.3	2.7	.0	.0	.0	
Total	13.3	15.7	14.5	.0	.0	
Chemitronics						
Dry Strip	.0	1.4	.0	.0	.0	
Chlorine Engineering						
Dry Strip	.6	.0	2.8	2.7	.0	
Crystal Specialties						
MOCVD	2.6	2.7	.0	.0	.0	
Daiwa Semiconductor						
MOCVD	.4	.5	.0	.0	.0	
Dexon						
Wet Process	3.1	5.5	6.4	1.0	.0	
EEV						
MOCVD	.7	.0	.0	.0	.0	
Estek						
Wet Process	1.2	1.1	.0	.0	.0	
Wafer Inspection	.1	.2	.0	.0	.0	
Total	1.3	1.3	.0	.0	.0	
Focus Semiconductor						
LPCVD	1.0	2.5	.0	.0	.0	

(Continued)

Table 5.1 (Continued)
Each Company's Revenue from Shipments of Semiconductor Wafer Fab Equipment to the World
(End User Revenue in Millions of U.S. Dollars)

Company: Each
Product: Each
Region Of Consumption: World

	1987	1988	1989	1990	1991	1991 Rank
GCA						
Resist Processing Eqp.	7.0	5.5	.0	.0	.0	
Steppers	47.4	104.0	.0	.0	.0	
Dry Etch	4.0	5.0	.0	.0	.0	
Total	58.4	114.5	.0	.0	.0	
Heidelberg Instruments						
Critical Dimension	1.6	3.5	.0	.0	.0	
Helmut Seier						
LPCVD	.3	.3	.0	.0	.0	
Diffusion	.5	.7	.0	.0	.0	
Total	.8	1.0	.0	.0	.0	
Integrated Air Systems						
Wet Process	3.0	2.0	.0	.0	.0	
Kyoritsu						
Wet Process	.0	2.7	2.5	3.1	.0	
Materials Research Corp.						
Dry Etch	4.4	13.0	7.4	.0	.0	
Sputter	23.1	34.0	54.0	.0	.0	
Total	27.5	47.0	61.4	.0	.0	
Nanoquest						
Critical Dimension	.0	.0	17.5	.0	.0	
National Electrostatics						
Ion Implantation	1.8	1.2	4.0	.0	.0	
Perkin-Elmer						
Projection	88.0	78.6	44.9	.0	.0	
Steppers	25.2	5.0	10.2	.0	.0	
Direct Write	9.6	12.8	9.9	.0	.0	
Maskmaking	27.0	27.0	21.0	.0	.0	
X-Ray	.0	.0	2.0	.0	.0	
Dry Etch	.0	.0	.0	.0	.0	
MBE	5.0	2.8	.0	.0	.0	
Sputter	3.1	.9	1.0	.0	.0	
Critical Dimension	.0	2.9	1.4	.0	.0	
Total	157.9	130.0	90.4	.0	.0	

(Continued)

Table 5.1 (Continued)
Each Company's Revenue from Shipments of Semiconductor Wafer Fab Equipment to the World
(End User Revenue in Millions of U.S. Dollars)

Company: Each
Product: Each
Region Of Consumption: World

	1987	1988	1989	1990	1991	1991 Rank
Rapro						
Silicon Epitaxy	.0	.0	.9	.9	.0	
Reichert-McBain						
Critical Dimension	.3	.0	.0	.0	.0	
Seiden Sha						
MOCVD	.6	.6	.0	.0	.0	
Seiko						
MBE	1.2	1.4	.0	.0	.0	
Semco Engineering						
MOCVD	.3	.9	1.0	.0	.0	
Sitesa						
RTP	.7	1.2	1.5	1.0	.0	
Spectrum CVD						
LPCVD	2.3	1.4	3.6	3.2	.0	
TEL/Lam						
Dry Etch	17.4	.0	.0	.0	.0	
TEL/Thermco						
LPCVD	8.3	.0	.0	.0	.0	
MOCVD	2.9	1.7	.0	.0	.0	
Diffusion	23.6	.0	.0	.0	.0	
RTP	.0	.0	.0	.0	.0	
Total	34.8	1.7	.0	.0	.0	
Thermco						
LPCVD	7.0	6.5	.0	.0	.0	
Diffusion	34.9	60.0	.0	.0	.0	
Total	41.9	66.5	.0	.0	.0	
Thomas Schwonn						
MOCVD	.7	.8	.0	.0	.0	
Tylan						
LPCVD	4.0	1.5	.0	.0	.0	
Diffusion	2.0	2.5	.0	.0	.0	
Total	6.0	4.0	.0	.0	.0	
Ulvac/BTU						
LPCVD	.5	3.5	4.0	6.2	.0	
Diffusion	1.7	11.5	12.3	16.5	.0	
Total	2.2	15.0	16.3	22.7	.0	

(Continued)

Table 5.1 (Continued)
Each Company's Revenue from Shipments of Semiconductor Wafer Fab Equipment to the World (End User Revenue in Millions of U.S. Dollars)

Company: Each
Product: Each
Region Of Consumption: World

	1987	1988	1989	1990	1991	1991 Rank
Wild Leitz and Wild Leitz Instruments						
Critical Dimension	6.4	9.8	9.9	.0	.0	
Wafer Inspection	4.7	10.4	8.8	.0	.0	
Total	11.1	20.2	18.7	.0	.0	
Vickers Instruments						
Critical Dimension	17.9	21.0	.0	.0	.0	

[1]Wafer fab equipment joint venture activity: TEL/Varian, Varian/Tel (not included here; please refer to individual entry)
[2]Wafer fab equipment joint venture activity: Alcan (not included here; please refer to individual entry)
[3]Wafer fab equipment joint venture activity: TEL/Varian, Varian/TEL (not included here; please refer to individual entry)
[4]Former Wafer fab joint venture activity: BTU/Ulvac, Ulvac/BTU (not included here; please refer to individual entry)
[5]Wafer fab equipment joint venture activity: Sumitomo/Eaton Nova (not included here; please refer to individual entry)
[6]Former wafer fab joint venture activity: BTU/Ulvac, Ulvac/BTU (not included here; please refer to individual entry)
[7]Wafer fab equipment joint venture activity: m*FSI (not included here; please refer to individual entry)
Source: Dataquest (April 1992)

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Semiconductor Equipment, Manufacturing, and Materials Forecast

MarketTrends

Semiannual Edition

Semiconductor Equipment, Manufacturing, and Materials
SEMM-SVC-MT-9202
December 28, 1992

Dataquest®

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Chapter 1
Executive Summary: Adjustment to Excess Capacity Nearing Completion, Recovery in Capital Spending One Year Off

The end game to the global semiconductor investment downturn that began in 1990 is under way. Ironically, the final corrective adjustments are taking place in Japan, the very country that led the investment boom.

As a result, we expect worldwide semiconductor capital spending and semiconductor wafer fab equipment sales to bottom in 1993 and then begin a sustained period of growth through the middle of the decade. Our forecast has global spending declining 0.1 percent in 1993, and equipment sales up 1.2 percent.

The adjustments to capital spending that have been under way over the last three years are finally bringing semiconductor capacity into line with demand. The bottom line is that IC manufacturers have cut the rate at which capacity will grow in the future. Not only are plans to add new capacity being delayed or canceled, but also device manufacturers are closing down older fabs.

On a square-inch basis, 1992 actual capacity will be 10 percent less than originally planned for one year ago, and 11 percent less in 1993. The decreases occurred in all regions of the world, but the steepest cuts occurred in capacity that Japanese companies had planned to bring online.

The sharp retrenchment in Japanese capital spending is at the center of the decline in capacity. We estimate that spending in Japan will be slashed by 29 percent in 1992, and will further decline by 13 percent in 1993. The United States and Europe are also experiencing slower growth of installed capacity, though the decline is not nearly as pronounced as it is in Japan. Plans to add capacity in the Asia/Pacific region continue to push ahead.

What the Recovery Will Look Like

Dataquest believes that the adjustment to capacity now taking place will lead to an improvement in the profitability of device makers over the next several years. Better profitability for device makers is the cornerstone assumption in our forecast of an accelerating capital spending cycle beginning in 1994.

Several other themes are fundamental building blocks of our forecast. The following paragraphs detail these themes.

The ascension of the Asia/Pacific countries, though not a new idea, still remains at the top of our list of important drivers for capital spending, equipment purchases, and future silicon demand. However, we do believe that a rotation away from the current countries dominating device production in Asia is under way. This long-term trend will benefit China, India, Malaysia, and Thailand.

Device production in the United States will show considerable strength, considering the maturation of the U.S. industry. Two forces are at work here. First, the dominance of U.S. system makers in the workstation and PC markets will sustain a healthy growth rate for data processing chips including MPUs, digital signal processing (DSP), and memory devices. Second, the economic gains being made by South American countries will accelerate the demand for high-tech equipment. U.S.-based device makers will be one of the major beneficiaries of this growing demand.

Japanese device makers are expected to de-emphasize market share and to adopt a more market-driven strategy. Consequently, we do not expect capital spending, equipment purchases, or silicon demand to grow at levels seen in the late 1980s. The semiconductor industry in Japan will be more balanced with domestic demand. Increased emphasis will be placed on value-added applications such as RISC-based MPUs, microcontrollers, and ASIC devices. Though Japan's ownership of the MOS memory market is over, we expect Japanese companies to remain key players in this market through alliances.

The path of recovery for the European semiconductor industry is unclear. It is likely that future growth will continue to hinge on non-European companies, but this dependence is risky considering the opportunities available to device makers in other regions of the world. Our forecast assumes that the economies of the region will improve in 1994. Domestic European device makers should be a major beneficiary of an improving economic climate. Even so, the long-term growth of these companies will be tied to their global competitiveness, which still lags other world-class device makers.

Dataquest Perspective

The recovery we are forecasting for global semiconductor capital spending and equipment markets is unlikely to achieve the overheated levels of the last upturn. But strong growth for semiconductors, driven by an economic recovery in the industrialized nations and a growing emphasis on semiconductor production in the industrializing nations of the Far East, is forecast to produce a period of sustained growth for global semiconductor capital spending through 1996.

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Chapter 2
Semiconductor Capital Spending Forecast

This chapter presents data on worldwide semiconductor capital spending, by region. Capital spending in a region includes spending by all semiconductor producers with plants in that region. Components of capital spending are property, plant, and equipment expenditure for both front- and back-end semiconductor operations.

Chapter Highlights

- Dataquest forecasts modest decline in global semiconductor capital spending in 1993.
- Japan spending will decline another 13 percent following a slide of 29 percent in 1992. Structural change is under way in Japan, which is moving to a more value-added strategy.
- U.S. spending is expected to show strong growth in 1993. U.S. spending will be dominated by the $1.6 billion that Intel plans to invest. The PC boom continues as the driver. We believe that spending will be strong in later years as recovery occurs in other segments of U.S. industry.
- European spending is forecast to decline for the third year in a row in 1993. Weak European economies will be the biggest problem in 1993. Europe will be heavily dependent on foreign investment.
- Asia/Pacific spending is expected to make modest gains in 1993. Long-term prospects for high growth rates in Asia/Pacific are still on track.

Capital Spending Tables

Two tables in this chapter emphasize capital spending. Table 2-1 shows historical capital spending by region for the years 1985 through 1991. Table 2-2 shows forecast capital spending by region for the years 1991 through 1996.

Yearly exchange rate variations can have a significant effect on the 1985 through 1992 data in the tables. Appendix B provides a more complete explanation of the exchange rates used in this document.

Table 2-1
Worldwide Capital Spending by Region - Historical
Includes Merchant and Captive Semiconductor Companies
(Millions of U.S. Dollars)

	1985	1986	1987	1988	1989	1990	1991	CAGR (%) 1986-1991
North America	2,629	2,082	2,594	3,434	3,875	4,088	3,851	13.1
Percent Growth	-16.2	-20.8	24.6	32.4	12.8	5.5	-5.8	
Japan	3,336	1,845	2,432	4,610	5,473	5,425	5,636	25.0
Percent Growth	-11.5	-44.7	31.8	89.6	18.7	-0.9	3.9	
Europe	800	765	875	984	1,211	1,512	1,234	10.0
Percent Growth	4.8	-4.4	14.4	12.5	23.1	24.9	-18.4	
Asia/Pacific-ROW	534	437	534	1,060	1,905	1,495	2,274	39.1
Percent Growth	23.0	-18.2	22.2	98.5	79.7	-21.5	52.1	
Worldwide	7,299	5,129	6,435	10,088	12,464	12,520	12,995	20.4
Percent Growth	-10.0	-29.7	25.5	56.8	23.6	0.4	3.8	

Source: Dataquest (December 1992)

Table 2-2
Worldwide Semiconductor Capital Spending, by Region - Forecast, 1991-1996
(Millions of Dollars)

	1991	1992	1993	1994	1995	1996	CAGR (%) 1991-1996
North America	3,851	3,559	4,004	4,328	4,787	5,347	6.8
Percent Growth	-3.8	-7.6	12.5	8.1	10.6	11.7	
Japan	5,636	4,019	3,508	3,894	4,233	5,059	-2.1
Percent Growth	1.0	-28.7	-12.7	11.0	8.7	19.5	
Europe	1,234	1,087	1,041	1,143	1,400	1,863	8.6
Percent Growth	-17.5	-11.9	-4.2	9.8	22.5	33.0	
Asia/Pacific-ROW	2,274	2,319	2,417	2,632	3,118	3,976	11.8
Percent Growth	63.9	2.0	4.2	8.9	18.5	27.5	
Worldwide	12,995	10,983	10,970	11,997	13,538	16,244	4.6
Percent Growth	2.9	-15.5	-0.1	9.4	12.9	20.0	

Source: Dataquest (December 1992)

Capital Spending Bumps Along Bottom

Worldwide semiconductor capital spending is forecast to decline 0.1 percent in 1993, following a steep decline of 15.5 percent in 1992. Our previous forecast, issued in August 1992, anticipated a small increase in capital spending in 1993. However, further deterioration of the fundamentals in the Japanese and European markets and delays of projects in the Asia/Pacific region have prompted us to lower our spending forecast for 1993.

Our longer-term forecast for 1994 through 1996 remains intact. We believe that spending will bottom in the first half of 1993 and begin a more sustained expansion through 1996. Even so, we continue to emphasize that the recovery in spending over our forecast horizon will not mirror the heady growth that followed the last global spending downturn in 1985.

Spurts in capital spending such as the semiconductor industry experienced from 1987 to 1991 are unlikely to occur without a new product driver or the opening of new markets such as China or India. We are cautious about either of these trends driving the demand for new semiconductor production capacity in the next several years.

In the new product arena, personal communicators, HDTV, and multimedia will not have much of an impact on device production until the second half of the decade. As far as new regional market opportunities go, the upsides for new fab facilities are considerable, given pent-up demand in the underdeveloped regions of the world. But a difficult business climate, frail legal systems, and wanting infrastructures all suggest that the growth of a domestic semiconductor industry in these underdeveloped countries will take time.

United States Leads Recovery

We are forecasting semiconductor capital spending in the United States to show a respectable recovery in 1993, up 12.5 percent. Furthermore, we anticipate that the rate of growth will accelerate as the U.S. economy shows further improvement toward the middle of the decade.

Device demand in the United States has been strong throughout 1992, encouraging many device companies to increase their spending plans for 1993. Companies with devices going into PC applications, disk-drive systems, networking gear, and personal communications systems have had their sales turn up sharply. Major beneficiaries of this trend are AMD, Intel, and Motorola.

The PC boom in the United States has played an especially important role in fueling IC demand. AMD, Intel, and Motorola have all reported better than 20 percent device revenue growth in the last quarter, largely because of an increase in MPU sales. It is no coincidence that these companies are also increasing capital spending. AMD has just announced a new fab line in Austin, Texas and an expansion of its facility in Santa Clara, California; Intel has announced a $1.6 billion capital investment plan for 1993 targeting expansions at seven of its fab lines worldwide, and Motorola is moving ahead to expand its MOS 11 line and will spend $700 million on its semiconductor operations in 1993.

Not All Segments Participate

On the other hand, merchant and captive device makers selling into the mainframe/midrange systems market, auto industry, or military segment continue to struggle. For example, IBM, Digital Equipment Corporation, and VLSI Technology are all reporting poor years for their semiconductor operations. We do not expect these lagging segments to improve much before 1994, and it is anticipated that spending by companies targeting these markets will continue to trail the overall U.S. industry.

Digital may be the notable exception. The company plans a new fab for building the Alpha RISC microprocessor. However, the level of spending on this facility will ultimately be determined by the success of the Alpha AXP line of computers. The jury is still out on that count.

There are also trends on a micro level preventing more robust growth in capital spending in the United States, when compared with previous periods. First, the United States has the oldest semiconductor fab infrastructure, and we believe that the rate of fab closures will continue at a steady pace because of obsolescence (see Table 2-3). National Semiconductor is an excellent example of this trend. It has shut down or sold facilities in Salt Lake City, Utah, Puyallup, Washington, and Tucson, Arizona. Second, we expect the rate of investment by foreign companies in U.S. fab capacity to decrease. The decline in Japanese investment in U.S. fabs will be especially notable. Finally, we believe that U.S. device companies will continue to pursue high-value-added niche applications concentrating on design and using overseas foundries to manufacture the devices.

Japan Still Struggling

One only has to look at the flurry of poor quarterly reports coming out of Japan to understand why semiconductor capital spending in Japan will continue to decline in 1993. By our estimates, spending will fall 12.7 percent in 1993, following a precipitous drop of 28.7 percent in 1992.

Across the board, Japanese device makers are reporting miserable earnings and are scrambling to shore up their balance sheets by cutting spending. A downturn in all the major semiconductor end-use markets in Japan is causing companies to be more cautious. Data processing, consumer electronic, auto, and communications applications are all suffering.

Mainframe demand, which is the largest data processing segment using ICs, has gone negative in 1992, and it is unclear when financial and manufacturing companies will begin buying these systems again. In PCs, a fierce price war in overseas markets is exposing the vulnerability of Japanese PC makers. Already, U.S. and Taiwanese companies

Table 2-3
1992 Fab Closings

Company	City	State	Technology	Geometry (Microns)	Wafer Size (Inches)
Unisys Components Group	Rancho Bernardo	CA	BIP MOS	1.5	4
Micrel Semiconductor	San Jose	CA	DMOS BIP	1.0	4
Motorola	Mesa	AZ	BIP BICMOS	0.5	4
AMD	Santa Clara	CA	BIP	1.5	4
Signetics (to Close)	Orem	UT	BIP	2.0	4
Xicor	Milpitas	CA	CMOS MOS	2.0	4
Hewlett-Packard	Palo Alto	CA	CMOS	0.5	4
LSI Logic (to Close)	Edmonton, Alberta		CMOS	1.5	6

Source: Dataquest (December 1992)

are targeting Japan with their lower-priced machines. This practice is widely expected to enable them to gain market share at the expense of the established domestic vendors.

Japanese consumer electronics sales are weak, causing companies to cut production of semiconductors going into this application. Pressure on household incomes continues to erode consumer confidence, which is being translated into reduced consumption expenditure.

Vehicle sales have fallen on a year-to-year basis for the last 18 months in a row, with the exception of June 1992. Reflecting difficulties in the auto sector, Nissan Motor, Japan's second largest automaker, reported its first pretax loss since World War II and suspended its dividend for the first time ever.

The communications sector is also weak as NTT, Japan's domestic phone company, has dramatically cut its own capital spending budgets. As a result, telecom systems are also recording weak sales.

Structural Change for Japanese Industry

The current downturn in Japan is driven by domestic asset deflation and the reversal of the credit cycle of the late 1980s. Stock prices are more than 50 percent below their peak, and urban land prices have fallen about 20 percent. Negative money supply growth demonstrates the severity of the financial system's capital shortage.

We believe that 1993 is likely to be marked by a softening in the labor market through further reductions in compensation growth and cutbacks in regular employment growth. It is likely that the slower growth in wages is the endgame of an adjustment process that began in the fall of 1990 with a tightening of monetary policy by the Bank of Japan.

Consequently, we expect an improved environment for semiconductor capital spending in 1994 and beyond. But the unbridled spending spree by Japanese companies is not likely to be repeated. Slower domestic gross national product (GNP) growth, mounting competitive pressure, and lopsided trade imbalances all suggest that the scramble for semiconductor market share will no longer be the driving strategy for Japanese device makers.

European Spending Doubtful

Dataquest is forecasting that semiconductor capital spending in Europe will continue to slide in 1993. We expect spending to decline another 4.2 percent in 1993, following declines in 1991 and 1992. Our forecast calls for stronger growth in spending toward the middle of the decade. Frankly, however, uncertainty surrounding this back-end-loaded forecast is high.

We are assuming that at some point toward the middle of the decade the European market will become a more enticing region for setting up manufacturing operations. Eastern Europe, which is directly responsible for the current economic downturn, may be the key to growth of the European semiconductor industry over the long term. If market forces are allowed to take hold in Eastern Europe, then it is conceivable that a determined and educated engineering work force with its back against the wall could possibly repeat the industrial revolution recently achieved in Taiwan and Korea.

The problem in the short term is simply the lack of projects. U.S. and Japanese companies are finishing a round of investment in new facilities. Hitachi and Mitsubishi are planning facilities for 1994, but these investments may well rest on an improved business climate in Europe (see Table 2-4). Intel will finish equipping its Ireland fab in 1993. Other than these plans, there is little on the horizon.

Spending by the three largest European device makers also looks sketchy. Siemens now appears more concerned with having access to leading-edge device technology through its partnering than actually setting up manufacturing operations. Philips has dramatically cut its spending, reflecting the company's tough financial position. An improvement in spending will most likely be tied to the consumer electronics business cycle, which remains stalled worldwide.

On a more positive note, France and Italy are ploughing $1 billion in new capital into semiconductor maker SGS-Thomson. The two governments also are supporting the company's five-year research and development program, which will cost 5 billion francs ($926 million). The first payment in the capital increase—$500 million—will be paid before December 15, 1992.

The commitment by France and Italy will certainly benefit European capital spending in the near term. The challenge for SGS-Thomson is to effectively put this capital to work to shape a globally competitive company.

Certainly, the patience and funds of these two governments is not inexhaustible. Mounting deficits in both countries raise questions concerning how long their largess will continue. Consequently, we are cautious in assuming future support at this level.

Prospects Remain Bright in Asia/Pacific

Semiconductor capital spending in Asia/Pacific is expected to increase by 2.0 percent in 1992 and show a modest improvement of 4.2 percent in 1993. The growth in spending in 1992 is much lower than our original estimate of 22 percent one year ago.

Device makers including Hyundai, Goldstar, Charter, and Tech Singapore have pushed out or canceled plans for new fabs. Hyundai is just beginning to order equipment for a 4Mb/16Mb line that we expected to be finished in 1993. Goldstar delayed plans for its 16Mb line in Chongju-city. Charter canceled plans for expanding in Singapore. Finally, Tech Singapore has delayed equipment purchases into 1993.

Table 2-4
Planned European Investments

Company	Country	Device	Technology	Geometry (Microns)	Wafer Size (Inches)
Production Begins 1993					
Intel	Ireland	MPU	BiCMOS	0	8
Mietec Alcatel	Belgium	ASIC	CMOS	0.5	6
National Semiconductor	Scotland	Lin	BIP	NA	6
SGS-Thomson	France	ASIC	CMOS BiCMOS	0.5	8
Production Begins 1994					
Fujitsu	United Kingdom	DRAM	CMOS	0.5	6
Mitsubishi	Germany	DRAM	CMOS	0.8	6

NA = Not available
Source: Dataquest (December 1992)

Our spending increase estimate of 4.2 percent in 1993 is based on company spending plans in which we have high confidence. Our estimates assume that Samsung will proceed with a 3,000-wafer-start expansion at its new 200mm facility and that Goldstar will begin investing in its Chongju fab to produce 16Mb DRAMs.

However, the final decision to proceed for both companies may swing on the U.S. government's final policy on DRAM tariffs. The U.S. Department of Commerce will make that final decision by March 1993. We are assuming that the current tariffs will be reduced to the 10 percent range. We anticipate that a favorable outcome will prompt the Korean companies to open the spending spigot.

High Growth Prospects Maintained

The lumpy capital spending levels over the last several years in Asia/Pacific have not dissuaded us about the strong prospects for growth in this region. The investment in large MOS memory lines by the Koreans has caused spending to jump and then fall off as the spending on these projects ramped and then declined.

As we move further into the 1990s, we believe that the growth in capital spending in Asia/Pacific will outpace growth in the more established semiconductor producing regions. Taking Japan's lead, many Asian governments are targeting the semiconductor industry as a cornerstone of their industrial policy. China, India, Malaysia, and Thailand are all expected to win a larger share of the spending in this region.

The sheer size of the semiconductor end-use markets in China and India suggest that some time out in the future device production in these countries will dwarf the size of the production capacity of current production-leading Asian nations.

Dataquest Perspective

Dataquest believes that 1993 will be the bottom of the current semiconductor spending cycle. The worldwide decline in spending that began in the United States and Europe in 1991 and struck with a vengeance in Japan in 1992 is slowly winding down. We expect device makers to begin accelerating their rate of spending, following a small decline in global spending in 1993, as capacity utilization rates and profitability improve. We believe that this accelerating growth trend is sustainable through 1996.

The bottom of the current spending cycle marks a fundamental change in the global semiconductor industry. The spending boom that began in 1987 and was led by Japan-based companies is over. We do not believe that spending in Japan will return to the peak level achieved in 1991 at any time over the next five years.

If one could characterize the last spending cycle in a phrase, it would most certainly be the domination of Japanese companies. For the next leg of the capital spending cycle, the scramble for the Asian market is the theme likely to dominate.

Chapter 3
Wafer Fab Equipment Forecast

Chapter Highlights

- Worldwide equipment market is down 15.5 percent in 1992.
- The worldwide market will be flat in 1993; there will be a moderate upturn in 1994.
- Solid growth in North America in 1993 will be led by microprocessor manufacturers.
- 1993 spending in Japan will continue to slide because of further weakening of domestic economy.
- Demand in Europe will remain weak.
- Asia/Pacific spending will increase slightly in 1993 as the region prepares for the next round of expansion.
- Equipment spending growth will be led by multilevel metallization process equipment.

This chapter presents historical and forecast data on the worldwide wafer fabrication equipment market, by region and by equipment segment. Equipment spending in a region refers to spending by all companies—both domestic and foreign—within the region.

Yearly exchange rate variations can have a significant effect on 1985 through 1991 data appearing in the tables in this chapter. Appendix B details the exchange rates used in this document.

Tables in this chapter provide details on the following:

- Table 3-1: Historical market data, by geographic region, for the years 1986 through 1991
- Table 3-2: Forecast market data, by geographic region, for the years 1991 through 1996
- Table 3-3: Historical data, by equipment segment, for the years 1986 through 1991
- Table 3-4: Forecast data, by equipment segment, for the years 1991 through 1996

Wafer Fabrication Equipment Forecast

Overcapacity Weighs Down the Equipment Market

The massive capital expenditure from 1988 through 1991 weighed heavy on the backs of many semiconductor companies in 1992, dragging equipment sales down 15.5 percent. This drop is significantly larger than the 10 percent drop predicted in Dataquest's midyear forecast, and was exacerbated by major additional capital spending cuts announced by most major Japanese semiconductor companies at the midpoint of their fiscal year at the end of September, in response to weak semiconductor sales and a lingering overcapacity problem, particularly 4Mb DRAM fab capacity.

Dataquest's midyear forecast predicted 11 percent growth in 1993, accelerating to 18 percent in 1994. However, a worsening of the Japanese economy in 1992, with no obvious signs of recovery in 1993, combined with continued weakness in Europe and a pause in the Asia/Pacific growth, will be only partially offset by modest improvement in the U.S. economy. This has caused us to downgrade our 1993 forecast to a 1.2 percent increase in worldwide wafer fab equipment revenue.

Dataquest believes that 1994 will mark the removal of the recessionary cloaks from both Japan and Europe. We also believe that the U.S. economy will continue to strengthen, and a resumption of semiconductor fab capacity growth will occur in the Asia/Pacific region, triggering a moderate 11.0 percent growth in the worldwide wafer fab equipment market. The recovery should continue through 1996, driven by expansion of 0.5-micron technology fab capacity and establishment of 0.35-micron production capacity. It should be emphasized, however, that Dataquest does not expect a repeat of the enormous wafer fab equipment revenue growth rates of the late 1980s. The increasing cost of constructing and equipping new wafer fabrication facilities, coupled with intensifying competition in the semiconductor product markets, will slow the growth of overall wafer fab capacity. More semiconductor companies will enter partnerships and strategic alliances to defray the cost of technology development and investment in manufacturing facilities. Consequently, the compound annual growth rate (CAGR) in wafer fab equipment revenue from 1991 through 1996 is forecast to be a restrained 6.1 percent.

Regional Analysis

Table 3-1 shows the historical wafer fab equipment market data, by geographic region, for the years 1986 through 1991. Table 3-2 contains the forecast market data, by geographic region, for the years 1991 through 1996.

North America

The North American region represents the one bright spot in a relatively lackluster 1993 wafer fab equipment market; Dataquest forecasts a solid 12.8 percent growth for the North American wafer

Table 3-1
Worldwide Wafer Fab Equipment Market, by Region - Historical, 1986-1991
(Millions of U.S. Dollars)

	1986	1987	1988	1989	1990	1991	CAGR (%) 1986-1991
North America	1,078	1,106	1,536	1,666	1,597	1,536	7.4
Percent Growth	-14.4	2.6	38.9	8.5	-4.1	-3.8	
Japan	1,018	1,278	2,270	2,806	2,987	3,017	24.3
Percent Growth	-28.4	25.5	77.7	23.6	6.4	1.0	
Europe	454	528	663	725	768	634	6.9
Percent Growth	-2.7	16.2	25.6	9.5	5.8	-17.5	
Asia/Pacific-ROW	164	230	519	820	520	852	39.1
Percent Growth	-21.7	40.6	125.9	58.0	-36.6	63.9	
Worldwide	2,713	3,141	4,988	6,017	5,871	6,039	17.4
Percent Growth	-19.2	15.7	58.8	20.6	-2.4	2.9	

Source: Dataquest (December 1992)

Table 3-2
Worldwide Wafer Fab Equipment Market, by Region - Forecast, 1991-1996
(Millions of U.S. Dollars)

	1991	1992	1993	1994	1995	1996	CAGR (%) 1991-1996
North America	1,536	1,517	1,711	1,948	2,250	2,620	11.3
Percent Growth	-3.8	-1.3	12.8	13.8	15.5	16.5	
Japan	3,017	2,108	1,961	2,103	2,328	2,782	-1.6
Percent Growth	1.0	-30.1	-7.0	7.3	10.7	19.5	
Europe	634	596	566	629	770	1,024	10.1
Percent Growth	-17.5	-5.9	-5.0	11.0	22.5	33.0	
Asia/Pacific-ROW	852	883	928	1,054	1,295	1,711	15.0
Percent Growth	63.9	3.6	5.1	13.5	23.0	32.1	
Worldwide	6,039	5,104	5,166	5,733	6,643	8,138	6.1
Percent Growth	2.9	-15.5	1.2	11.0	15.9	22.5	

Source: Dataquest (December 1992)

fab equipment market in 1993. Semiconductor production in the United States has grown relatively strongly in 1992, and we expect this growth to continue. U.S. chip companies are dominant participants in high-value-added IC markets, such as microprocessors, LAN chip sets, graphics accelerators, fax/modem chip sets, hard disk controllers, and telecommunications products. Demand is high for these products because of heated growth in the personal computer, local area network, wireless communications, and mobile communications markets, resulting in expanding sales and profits for semiconductor suppliers that share in those business segments.

Consequently, most of the new fab construction and fab capacity expansion is occurring at companies such as Intel, AMD, and Motorola. Intel is equipping a new fab line in Oregon and is undertaking a $400 million conversion of its six-inch R&D facility in Santa Clara, California to an eight-inch production facility. It is expected to announce a new $800 million U.S. production facility to begin construction in 1993. AMD has announced plans to build a new $700 million production fab in Austin, Texas to manufacture 486 microprocessors, which is scheduled for completion in 1994. Motorola is installing equipment in its MOS 11 facility in Austin.

Unfortunately, not every company has experienced fertile growth in 1992. IBM, Digital Equipment Corporation, LSI Logic, VLSI Technology, Cypress Semiconductor, and others struggled. National Semiconductor and Texas Instruments began to emerge from lengthy and painful restructuring periods, and are in good shape for growth in the long term. But they are likely to employ restrained spending policies in the near term.

The projected growth in 1993 for the wafer fab equipment market thus is primarily driven by pockets of profitability, and is attenuated by the lingering effects of the last downturn. Dataquest believes that the U.S. semiconductor community's health will continue to improve as we move toward the middle of the decade, nurtured by the demand for highly integrated advanced logic products for the data processing, telecom, and consumer electronics markets. These markets play to the strengths of the U.S. electronics industry: high-performance microprocessors and embedded processors; computer-aided design methodology for ASIC and cell-based ICs; and mixed-signal technology and digital signal processing for telecom, automotive, and future consumer electronics applications. Dataquest therefore forecasts the North American region to exhibit a CAGR from 1991 through 1996 of 11.3 percent.

The year 1992 was pivotal for the North America-based wafer fab equipment companies—it was the year in which they reversed a seven-year period of market share erosion. This was partly because of the precipitous loss of market share experienced by Japanese equipment companies in 1992—caused by the collapse of their home market—which translated to a direct gain in market share by U.S. equipment companies. However, the U.S. wafer fab equipment industry is responsible for a large part of the turnaround, owing to improvements in technological capability, equipment productivity, and reliability. Sematech has also played a major role in helping U.S. equipment companies develop a strategy for improvement and to execute that plan. The severe revenue hit taken by the Japanese equipment companies served to accelerate the turnaround in 1992. U.S. wafer fab equipment organizations should avoid lapsing into a complacent attitude, however. Their Japanese counterparts will certainly redouble their efforts to penetrate the North American, Asia/Pacific, and European regions to offset sales declines in Japan. Also, it would be shortsighted to discount the Japanese market. Japan will still lead all regions in wafer fab equipment spending in spite of the large cutbacks experienced in 1992, and the Japanese equipment companies will guard their home market aggressively.

Japan

An already poor year for Japanese electronics companies took a catastrophic turn at the midpoint of the Japanese fiscal year. With industry stalwarts such as Fujitsu, Hitachi, Mitsubishi, NEC, and Toshiba reporting depressed earnings and even losses, and the unthinkable concept of layoffs being openly discussed, the capital spending slide in Japan abruptly broke into a free-fall. As discussed in Chapter 2, Dataquest revised its 1992 capital spending drop in Japan downward from 23.5 percent originally predicted in our midyear forecast to our current projection of a 29 percent downturn. The delayed or canceled fab expansions created a powerful undertow for the wafer fab equipment suppliers to the Japanese market. Only the most powerful players managed to keep their losses to a minimum in Japan, with lesser companies experiencing an agonizing drop in revenue. Dataquest estimates that wafer fab equipment revenue plummeted by 30.1 percent in 1992. The future is almost imperceptibly brighter: we foresee an additional slippage of 7 percent in 1993, before the market finally turns around in 1994. All told, the CAGR for 1991 through 1996 is negative 1.6 percent.

Dataquest does not believe that the turnaround in the Japanese economy will occur in 1993. As pointed out in Chapter 2, the current economic trough is being fueled by domestic asset deflation, not by a cyclical downturn. Cheap capital ignited the explosive investment of the late 1980s, but Japan is currently experiencing a capital shortage. The full extent of the bad debt held by Japan's banks has not been released, but is estimated to be as high as ¥22 trillion. The stock market and real estate bubbles have burst, and have probably not completed their downward correction. The real estate and stock market assets were the source of the massive capital formation of the late 1980s; with the deflation of both of these asset bases, the financial system simply does not have the cash to fund new investment. Private sector demand is predicted to contract by 1.5 percent in 1993, resulting in net gross national product (GNP) growth of only 1 percent. Dataquest believes that the Japanese bubble economy has not completed its correction; the earliest that a recovery will occur is late 1993, and more likely in 1994.

The effect of the deflationary adjustment process on the electronics companies has been profound. Much of the wafer fab capacity expansion from 1988 through 1991 was for 4Mb DRAM manufacturing capacity. These fabs ran at extremely low utilization rates until recently; 4Mb DRAM demand has strengthened in the last few months mainly because of the sharp rise in PC sales. However, the 4Mb DRAM market was late in developing, and Dataquest believes that there is plenty of spare 4Mb DRAM capacity in Japan; it will not be necessary to expand the existing capacity base unless the DRAM market sustains its present growth well into 1993. The question is, how long can the current feeding frenzy in the PC market be sustained?

Even more recently, 4Mb DRAM demand spurted and prices rose on the basis of the U.S. Department of Commerce's preliminary antidumping ruling against the Korean DRAM manufacturers and the concomitant tariffs levied on them. Some observers have even predicted that a DRAM shortage will arise similar to the 1Mb DRAM shortage in the late 1980s. We do not believe that this will occur. The Korean DRAM suppliers only represent about a 15 percent market share in DRAMs, not a large enough fraction to create a shortage, especially in light of the overcapacity situation in Japan. Dataquest believes that any supply perturbations on the part of the Koreans could easily be absorbed by the Japanese DRAM suppliers. Dataquest therefore concludes that, although 4Mb DRAM prices have stabilized, they are unlikely to rise further. And although Japanese DRAM suppliers should enjoy increased sales levels in 1993, they will neither stretch their present manufacturing capacity nor see their profit margins increase to the point where they can justify further investment.

Dataquest believes that the major Japanese chip producers will change their product strategies to ease their dependence on commodity MOS memory. This will entail conversion of DRAM fabs to advanced logic and ASIC fabs, and future fabs will tend to accommodate more diverse product mixes. This implies that the equipment purchases will incorporate more multilevel metal process equipment. Equipment buys will be made selectively, and in areas of strategic importance, such as processes that support new product development, and the addition of some 0.5-micron manufacturing capacity to prevent massive market share loss in 16Mb DRAMs. The migration from DRAMs to higher-value-added products will require reduced fab capacity levels, hence a reduced rate of investment in fabs and equipment in the long term. We therefore forecast that wafer fab equipment spending in Japan will not climb to its historic high mark, set in 1991, until beyond 1996.

As previously mentioned, 1992 was the year in which U.S.-based wafer fab equipment companies reversed a lengthy period of worldwide market share erosion. The converse side of that observation is that Japan-based wafer fab equipment suppliers recorded a loss of market share after seven consecutive years of market share gain. This is partially because of the 30.1 percent drop in equipment revenue in Japan, of which Japanese equipment companies commanded a 64.7 percent market share. However, certain wafer fab equipment segments performed significantly better than the overall equipment market, and these segments were associated with multilevel metal process technology, a process area where the Japanese equipment companies are not strong. Selected pockets of revenue opportunity were associated with advanced sputtering systems, metal CVD systems, dielectric and metal etch systems, and intermetal dielectric CVD systems. The Japanese companies were unable to take advantage of revenue opportunities in these specific areas, which exacerbated the market share shift in 1992.

Europe

The European wafer fab equipment market had a 17.5 percent drop in 1991. It is projected to drop 5.9 percent in 1992, and another 5.0 percent in 1993. We do not foresee any growth until 1994, and the forecast CAGR from 1991 through 1996 is projected at 10.1 percent. This growth is predicated on a strong resurgence in 1994 through 1996. A fair amount of uncertainty underlies this projected growth; we are assuming that the European region will attract new investment when the English, German, and French economies rebound. An indigenous semiconductor industry at the very least is required to support the regional telecommunications infrastructure. If the European economic community nations can establish a common set of goals and establish a set of policies that truly enables them to function as a united body, then the motivation to establish manufacturing operations within the region would be more compelling. Potential opportunities may also exist in the Eastern European countries. However, these should be viewed as long-term developments, because these countries must stabilize politically and socially as well as economically before consistent growth can be sustained.

The major semiconductor suppliers in Europe are in a prolonged spending freeze. Philips is operating at low capacity utilization, and has no plans to invest beyond baseline maintenance levels. Siemens also is not planning any major fab capacity expansion. It will invest some money in the 16Mb DRAM facility in Corbeil-Essonnes, France, jointly built with IBM. Siemens will also invest in the joint 256Mb DRAM development project with IBM and Toshiba, although that investment will be made in the North American region. SGS-Thomson has pumped moderate levels of cash into its 0.5-micron fab in France, and the French and Italian governments recently announced a new $1 billion infusion into SGS-Thomson. This will certainly contribute to wafer fab equipment spending growth in the region, but SGS-Thomson's long-term strategy, and therefore its long-term prospects, remain unclear.

Japanese companies have largely curtailed fab investment plans in Europe because of their own financial problems. Intel will be taking equipment deliveries in its Ireland fab in 1993, and will represent a major portion of the equipment spending in the region.

Most of the equipment sales in Europe are from North America- and Japan-based equipment companies. European wafer fab equipment companies have experienced a steady erosion of market share in the last few years. From 1987 to 1991, European wafer fab equipment companies watched their domestic market share slip from 34 percent to 24.3 percent. Dataquest believes that this loss of market share will continue unless the European wafer fab equipment companies pursue a strategy of partnering with their key customers or benefit from government assistance through organizations such as JESSI to aid them in new product definition and development.

Asia/Pacific-Rest of World

The Asia/Pacific wafer fab equipment market grew at a tepid 3.6 percent in 1992, following torrid growth of 63.9 percent in 1991. This erratic growth behavior is in part because of the relatively small number of companies and fabs in the region; buying cycles occur and drive the equipment market growth at high rates, then a period of stagnation ensues while semiconductor production catches up with the new capacity. Dataquest believes that some companies in the Asia/Pacific region have adopted a mildly cautious stance in regard to continued wafer fab capacity expansion, in light of the serious problems currently experienced by Japanese companies partly because of their aggressive capacity expansion a few years ago. Goldstar has delayed its 16Mb DRAM manufacturing capacity expansion into 1993. Hyundai is placing equipment orders now for delivery in 1993, but this production capacity increase is undertaken to remain even with Goldstar and Samsung, rather than to trigger a new round of expansion. Tech Semiconductor in Singapore has pushed out most of its initial equipment deliveries until early 1993, and Charter Semiconductor canceled plans to build a second fab.

The slowdown in the frenetic capacity expansion cooled the wafer fab equipment market in 1992. Dataquest expects 1993 to be a relatively quiet year as the companies within the Asia/Pacific region grow into their manufacturing capacity. We are therefore forecasting the Asia/Pacific wafer fab equipment market to increase only 5.1 percent in 1993. We do, however, expect a more aggressive growth pattern to resume in 1994 as the demand for 16Mb DRAMs takes off. Our forecast CAGR from 1991 through 1996 is a robust 15.0 percent for the Asia/Pacific region.

Long-term growth opportunities abound in the Asia/Pacific region in several countries. China recently avowed its intent to develop a strong semiconductor industry as part of its industrialization plan. India represents a potentially huge market, as it develops an indigenous semiconductor manufacturing capability. In addition to these countries, Thailand, Malaysia, the Philippines, and Vietnam represent opportunities for chip suppliers to set up offshore manufacturing facilities. As the less industrialized countries in the region pursue aggressive development of an electronics infrastructure as a centerpiece of their industrial policy, growth prospects for wafer fab equipment suppliers are potentially enormous.

Wafer Fab Equipment Market Trends

Table 3-3 shows wafer fab equipment market historical data by equipment segment for the years 1986 through 1991. Table 3-4 shows wafer fab equipment market forecast data by equipment segment for the years 1991 through 1996.

The semiconductor industry, and by extension the wafer fab equipment industry, is entering a period of modest growth. Dataquest is forecasting CAGR of only 6.1 percent for 1991 through 1996, after the furious 17.4 percent CAGR from 1986 through 1991. Dataquest believes that this is indicative of the maturation of the semiconductor industry and its wafer fab equipment business. At least for commodity semiconductors, the competitive forces of the marketplace have caused the manufacturing community to shift its strategy from one of aggressive technology development with the requisite massive levels of investment and short technology life cycle, to one based on low-cost, high-productivity manufacturing operations, extending the useful life of fabs and equipment as far as possible. Of course, leading-edge technology is important, but it has changed from a competitive advantage that once differentiated a company to a basic requirement needed just to participate in the market. Now everyone has the technology. To be successful, a company must be able to utilize the technology in a low-cost, high-yield manufacturing process.

Equipment Segments

As Table 3-4 shows, Dataquest forecasts stepper revenue growing at a CAGR of only 5.1 percent from 1991 to 1996, below the overall market CAGR of 6.1 percent. The overexpansion of 1988 to 1991 was primarily for submicron fab capacity, and most of that fab capacity utilized i-line stepper technology. Dataquest believes that an abundance of i-line stepper capacity exists, a surplus that has been amplified by the improving productivity of the steppers. The next major growth cycle in stepper shipments will be driven by the transition to 0.35-micron production processes, and Dataquest does not expect that to happen until the 1995 to 1996 time frame.

Major wafer fab equipment segments forecast to outperform the overall wafer fab equipment markets are dry strip, dry etch, CVD, PVD, high-voltage ion implant, wafer inspection, and factory automation.

Dry photoresist stripping equipment is forecast to grow at a CAGR of 7.5 percent from 1991 through 1996. Feeding this growth will be the increasing number of masking steps in advanced semiconductor manufacturing processes. The market will also grow as new dry strip technologies displace older processes to address radiation damage concerns for reduced gate oxide thickness and reduced defect densities, particularly for stripping resist after high dose implants.

Dry etch equipment sales will grow at a CAGR of 7.6 percent for the years 1991 through 1996. Factors responsible for the dry etch equipment market growth are the need for additional etch systems as single-wafer etch platforms displace batch etch systems, displacement

Table 3-3
Worldwide Wafer Fab Equipment Market, by Equipment Type - Historical, 1986-1991 (Millions of U.S. Dollars)

	1986	1987	1988	1989	1990	1991	CAGR (%) 1986-1991
World Fab Equipment Market	2,713	3,141	4,988	6,017	5,871	6,040	17.4
Lithography							
Contact/Proximity	31	25	22	23	24	21	-7.9
Projection	171	129	148	94	93	68	-16.7
Steppers	363	503	921	1,181	1,052	1,029	23.2
Maskmaking Lithography	51	68	62	69	47	46	-2.0
Direct-Write Lithography	68	67	69	70	76	55	-4.1
X-Ray	1	0	6	5	2	4	39.3
Total	685	791	1,228	1,442	1,295	1,224	12.3
Automatic Photoresist							
Processing Equipment	149	168	253	334	326	369	19.9
Etch and Clean							
Wet Process	161	167	277	377	400	405	20.3
Dry Strip	35	58	100	121	118	119	27.5
Dry Etch	237	307	533	670	690	705	24.3
Ion Milling	8	8	10	13	13	17	16.4
Total	441	540	920	1,180	1,221	1,246	23.1
Deposition							
Chemical Vapor Deposition	218	260	466	611	717	747	27.9
Physical Vapor Deposition	237	251	302	368	409	474	14.9
Silicon Epitaxy	46	36	86	75	68	89	13.9
Metalorganic CVD	31	35	42	45	44	51	10.4
Molecular Beam Epitaxy	66	68	81	74	58	59	-2.2
Total	599	649	977	1,173	1,296	1,420	18.9

(Continued)

Table 3-3 (Continued)
Worldwide Wafer Fab Equipment Market, by Equipment Type - Historical, 1986-1991 (Millions of U.S. Dollars)

	1986	1987	1988	1989	1990	1991	CAGR (%) 1986-1991
Diffusion	156	145	296	331	324	335	16.6
Rapid Thermal Processing	16	18	22	25	30	42	21.9
Ion Implantation							
Medium Current	55	61	118	131	114	108	14.6
High Current	55	107	241	301	250	218	32.0
High Voltage	10	18	18	25	7	18	12.4
Total	119	186	377	457	370	343	23.6
Process Control							
CD (Optical & SEM)	44	89	151	150	147	154	28.3
Wafer Inspection	42	58	101	117	91	90	16.3
Other Process Control	287	286	355	404	368	398	6.7
Total	374	432	607	672	605	641	11.4
Factory Automation	81	99	130	195	216	227	22.9
Other Equipment	96	112	177	210	190	193	15.1
Total World Fab Equipment	2,713	3,141	4,988	6,017	5,871	6,040	17.4
Percent Change	-19	16	59	21	-2	3	

Note: Some columns do not add to totals shown because of rounding.
Source: Dataquest (December 1992)

Table 3-4
Worldwide Wafer Fab Equipment Market, by Equipment Type - Forecast, 1991-1996 (Millions of U.S. Dollars)

	1991	1992	1993	1994	1995	1996	CAGR (%) 1991-1996
World Fab Equipment Market	6,040	5,104	5,166	5,733	6,643	8,138	6.1
Lithography							
Contact/Proximity	21	15	15	11	13	8	-17.1
Projection	68	51	41	40	40	49	-6.5
Steppers	1,029	827	837	923	1,076	1,318	5.1
Maskmaking Lithography	46	41	46	57	73	90	14.3
Direct-Write Lithography	55	51	52	57	73	90	10.1
X-Ray	4	10	10	17	27	41	57.5
Total	1,224	995	1,002	1,106	1,302	1,595	5.4
Automatic Photoresist							
Processing Equipment	369	296	300	338	392	480	5.4
Etch and Clean							
Wet Process	405	332	331	367	419	513	4.8
Dry Strip	119	102	103	120	140	171	7.5
Dry Etch	705	623	641	711	830	1017	7.6
Ion Milling	17	10	10	11	13	16	-0.5
Total	1,246	1,067	1,085	1,210	1,402	1,717	6.6
Deposition							
Chemical Vapor Deposition	747	664	677	751	877	1,074	7.5
Physical Vapor Deposition	474	429	455	516	605	732	9.1
Silicon Epitaxy	89	56	46	46	47	57	-8.5
Metalorganic CVD	51	41	41	46	47	57	2.1
Molecular Beam Epitaxy	59	51	46	46	47	57	-0.7
Total	1,420	1,240	1,266	1,405	1,621	1,977	6.8

(Continued)

Table 3-4 (Continued)
Worldwide Wafer Fab Equipment Market, by Equipment Type - Forecast, 1991-1996 (Millions of U.S. Dollars)

	1991	1992	1993	1994	1995	1996	CAGR (%) 1991-1996
Diffusion	335	276	274	304	352	431	5.2
Rapid Thermal Processing	42	36	36	46	53	73	11.9
Ion Implantation							
Medium Current	108	92	93	109	120	146	6.4
High Current	218	184	181	201	226	277	4.9
High Voltage	18	20	31	46	53	65	29.9
Total	343	296	305	355	399	488	7.3
Process Control							
CD (Optical & SEM)	154	128	124	126	140	171	2.2
Wafer Inspection	90	77	77	86	106	130	7.7
Other Process Control	398	342	341	361	412	505	4.9
Total	641	546	542	573	658	806	4.7
Factory Automation	227	194	196	224	272	342	8.5
Other Equipment	193	158	160	172	193	228	3.4
Total World Fab Equipment	6,040	5,104	5,166	5,733	6,643	8,138	6.1
Percentage Change	2.9	-15.5	1.2	11.0	15.9	22.5	

Note: Some columns may not add to totals shown because of rounding.
Source: Dataquest (December 1992)

of older RF diode plasma sources by advanced, low-pressure plasma sources for 0.5-micron technology and below, and the integration of dry strip and wet rinse modules with the dry etch chamber, particularly for metal etch systems. The number of dry etch units shipped will also grow because of the need for additional oxide etch and metal etch capacity as more multilevel metal process capacity is added to fabs.

The expansion of multilevel metal processing capacity is being driven by the continuing growth of the advanced logic and ASIC segments of the worldwide semiconductor industry, and the migration of commodity DRAMs to two-level metal technology for the 16Mb and 4Mb shrink products. This shift in the pattern of wafer fab equipment shipments is the primary reason behind the relatively high forecast growth rates for the CVD and PVD equipment segments. Additional process capacity for intermetal dielectric (IMD) deposition, metal sputter deposition, and CVD metal deposition for contact and via plugs is required as the average number of metal interconnect levels grows. The tightening design rules enhance the growth of these equipment segments: The equipment platforms migrate toward single-wafer processes; the need for contact and via plugs drives the CVD metal market; and the use of stacked metal structures with barrier metal layers places stringent demands on sputter deposition systems. The resultant demand for sophisticated CVD and PVD process tools will cause these equipment segments to grow at a CAGR from 1991 through 1996 of 7.5 percent and 9.1 percent, respectively.

Dataquest forecasts very high growth in the high-energy ion implant equipment segment; a CAGR of 29.9 percent is predicted for the years 1991 through 1996. High-energy ion implant processes can eliminate the need for the use of epitaxial wafers, which can trim about $100 per wafer from the wafer cost. Judicious use of high-energy implant steps can also result in the elimination of the well mask and the field implant masking steps, simplifying the process flow, which will pay dividends in terms of shorter cycle time, reduced processing cost per wafer, and reduced defect densities. Dataquest believes that semiconductor manufacturers will embrace process simplification opportunities such as those offered by high energy ion implants as they become increasingly cost-sensitive.

The sales of wafer inspection equipment will also be driven by the need for reduced manufacturing costs. In-line wafer inspection and defect identification systems can help reduce costs for a company in two ways: They can identify defects and thereby help to raise yields, and they can help identify and eliminate defects quickly, before major yield problems propagate through the manufacturing line. Such systems can pay for themselves in a short time; the identification and elimination of a single defect type can represent millions of dollars in sales to a chip vendor. Dataquest forecasts a 7.7 percent CAGR for wafer inspection equipment for the years 1991 through 1996.

Factory automation equipment is a segment that market demand may finally have caught up with. The use of both interbay and intrabay factory automation equipment is expected to increase in new fab construction and existing fab conversions. Minimization of operator handling can reduce the number of defects added to a wafer, and can result in a reduction in the number of clean room personnel. Again, the demand for factory automation equipment will be driven by the opportunity to improve yields and reduce operating costs. State-of-the-art wafer fabs will increase the degree of automation for those reasons. Consequently, Dataquest projects the CAGR for factory automation equipment at 8.5 percent for 1991 through 1996.

Dataquest Perspective

The year 1992 was one of transition for the wafer fab equipment industry. It marked a period of adjustment between the heady growth of the 1980s in the semiconductor industry and the more conservative investment strategies that we believe will become pervasive in the 1990s and beyond. This change will result in more restrained market growth. The burgeoning costs of process technology development and new fab construction have forced the semiconductor community to become far more selective in its choice of equipment suppliers. The cost of equipment is rising as the process tools become increasingly sophisticated, and the penalty is greater if the semiconductor manufacturer selects the wrong tool. Consequently, evaluation of new wafer fab equipment entails more than running a simple set of trials to assess the process capability. Whereas once equipment vendors had only to satisfy the technical requirements of the R&D engineer, they must now satisfy the needs of the manufacturing engineer as well. Equipment attributes such as wafer throughput, machine reliability, cost of consumables, scheduled maintenance requirements, and required internal engineering support are specified and evaluated. Cost of ownership is now the figure of merit looked to for differentiating wafer fab equipment.

The result of this shift in the attitude of the wafer fab equipment user is that the relationship between the equipment vendor and the customer is now more important than ever. In the future, the wafer fab equipment vendors will need to involve their key customers from the product definition stage through field testing of the machine. Partnering between supplier and user is a trend already under way, and will become a necessity for any successful equipment company.

The wafer fab equipment industry underwent a polarization of sorts in 1992. Although the worldwide equipment market was down 15.5 percent, a few equipment companies enjoyed solid revenue growth and market share gains. Although there has been a consistent concentration of power among the top several equipment companies in the industry, 1992 represented an acceleration of this shifting balance of power. Dataquest believes that this phenomenon can be attributed to two primary factors. The first factor is that the companies experiencing the greatest success in the last year participated in the equipment segments that showed the strongest performance—multilevel metallization process equipment, particularly for submicron process technology. The other characteristic shared by the most successful organizations in 1992 was that they had a well-established set of relationships with their customer base. They were global companies, employing global applications support and service organizations. They had established positive track records for delivering the complete suite of equipment, process, and service. In short, they were able to win the confidence of customers through a combination of enabling technology, low cost of ownership, and first-class support of the tool and process from order receipt through final acceptance of the machine. This is the level of interaction with the customer that is an absolute necessity for success in the wafer fab equipment market of the 1990s. The rest of the industry will have to engender the same level of cooperation and trust with its customer base if it expects to be able to participate in the future.

Chapter 4
Silicon Wafer Forecast

Chapter Highlights

- Silicon consumption in the United States shows modest growth in 1992, despite a strong upturn in device revenue. The divergence between silicon demand and device revenue is because of the surge in sales of high-value-added microprocessor parts. A similar trend is expected in 1993 because PC unit sales are forecast to remain robust. Silicon wafer unit demand over the longer term will be modest, when compared with earlier periods.
- Silicon consumption in Japan declined steeply in 1992. It is likely that the decline in demand hit bottom in the fourth quarter. But serious problems that face the Japanese semiconductor industry over the next five years cause us to be more conservative in our forecast for silicon growth.
- Silicon consumption in Europe is expected to decline further in 1993. If we are correct in our forecast, then unit consumption will have decreased three years in a row. The only promise for improvement on the horizon lies with investment being made by foreign companies.
- Silicon consumption in Asia/Pacific jumped in 1992. For the first time, this region's usage of silicon wafers surpassed that of Europe. Korean device manufacturers' production of DRAMs was the main driver. The continuation of a healthy investment cycle in front-end lines bodes well for future silicon demand.

Silicon Forecast Tables

Tables in this chapter include Dataquest's most recent forecasts of regional unit silicon wafer consumption. Three tables detail unit consumption in the four major regions of the world, the United States, Japan, Europe, and Asia/Pacific. Individual forecasts of the major product segments such as prime, epitaxial, and test and monitor wafers are included.

Tables in this chapter provide details on the following:

- Table 4-1: Forecast of captive and merchant silicon and merchant epitaxial wafer consumption
- Table 4-2: Forecast of merchant epitaxial wafer consumption

- Table 4-3: Forecast of merchant and captive silicon wafer consumption
- Table 4-4: Forecast of merchant silicon wafer consumption

Mixed Reviews for the United States

Many semiconductor companies are weathering the stagnant economic climate hanging over the U.S. economy. Device companies with products targeting the PC market are benefiting from the 20 to 25 percent unit growth in PCs in 1992. However, not all IC vendors are participating in this upturn. Device makers with products going into the mainframe/midrange computer markets, consumer applications, and military applications have reported a range of results for 1992 from marginally up to significantly down.

We now anticipate that silicon wafer unit demand (millions of square inches) in the United States will grow 5.0 percent in 1992 (see Table 4-1). The growth rate for silicon wafers is considerably lower than the growth rate of U.S. semiconductor revenue as reported by WSTS, about 15 percent revenue growth in 1992. The difference in growth rates is because of the increase in high-priced MPU sales in the overall U.S. revenue mix. Consequently, a higher average selling price had more of an impact on the 15 percent revenue growth rate than the increase in units.

Winners and Losers

The primary beneficiaries of this trend are microprocessor makers AMD, Intel, and Motorola. These three companies' sales of devices shot ahead this year. In the last quarter alone, all three companies' revenue jumped in the range of 20 to 25 percent year-to-year. Epi wafer demand in 1992 has also surged, up 22 percent (see Table 4-2), since both Intel and AMD built their microprocessors using epi wafers.

The prime, test, and monitor wafer market in the United States saw much more sedate growth in 1992, up only 2.3 percent (see Tables 4-3 and 4-4). The growth of this segment reflects the more modest sales gains made in many of the non-PC-related device applications. An application particularly hard hit was the mainframe/midrange systems market. Amdahl, Digital Equipment, and IBM all recorded dismal sales in a year widely heralded to be the beginning of a cyclic upturn for large system manufacturers. The weak system market translated into dismal sales for captive device operations and external chip suppliers selling product into this computer segment.

Consequently, silicon wafer vendors' 1992 performance in the United States will depend heavily on which accounts they supplied. For example, the surge in epi demand left OTC, SEH, and Wacker scrambling to bring up additional ASM epi reactor capacity. These vendors supply Intel, which has only qualified ASM epi systems to date. On the other hand, the weak demand for wafers at IBM is expected to impact vendors such as MEMC, which are primary suppliers.

Table 4-1
Forecast of Captive and Merchant Silicon* and Merchant Epitaxial Wafer Consumption (Units—Millions of Square Inches)

	1991	1992	1993	1994	1995	1996	CAGR (%) 1992-1996
United States	611	642	678	728	761	806	5.8
Percent Growth	-4.5	5.0	5.7	7.3	4.6	5.8	
Japan	1,046	957	995	1,086	1,140	1,209	6.0
Percent Growth	5.4	-8.5	4.0	9.1	5.0	6.0	
Europe	208	200	197	217	241	261	6.9
Percent Growth	-11.7	-4.0	-1.5	10.5	11.0	8.0	
Asia/Pacific-ROW	194	241	274	310	366	410	14.2
Percent Growth	7.5	24.0	14.0	13.0	18.0	12.0	
Total	2,059	2,039	2,145	2,341	2,509	2,684	7.1
Percent Growth	0.5	-1.0	5.2	9.2	7.2	7.0	

*Includes prime, test, and monitor wafers
Note: Columns may not add to totals shown because of rounding.
Source: Dataquest (December 1992)

Table 4-2
Forecast of Merchant Epitaxial Wafer Consumption
(Units—Millions of Square Inches)

	1991	1992	1993	1994	1995	1996	CAGR (%) 1992-1996
United States	92	112	126	137	147	157	8.9
Percent Growth	4.0	22.0	12.5	9.0	7.0	7.0	
Japan	104	100	103	107	111	116	3.7
Percent Growth	11.6	-3.5	2.5	4.3	4.0	4.0	
Europe	20	21	24	33	38	42	19.6
Percent Growth	7.4	2.3	16.7	35.0	17.0	11.0	
Asia/Pacific-ROW	7	8	9	10	13	17	21.3
Percent Growth	43.5	17.9	16.7	11.7	27.9	30.0	
Total	222	240	262	287	309	332	8.4
Percent Growth	9	8.2	8.8	9.7	7.8	7.4	

Note: Columns may not add to totals shown because of rounding.
Source: Dataquest (December 1992)

Table 4-3
Forecast of Merchant and Captive Silicon* Wafer Consumption
(Units—Millions of Square Inches)

	1991	1992	1993	1994	1995	1996	CAGR (%) 1992-1996
United States	520	530	553	591	615	649	5.2
Percent Growth	-5.9	2.0	4.3	6.9	4.0	5.5	
Japan	942	857	893	979	1,029	1,093	6.3
Percent Growth	4.8	-9.0	4.2	9.7	5.1	6.2	
Europe	188	179	172	185	203	218	5.1
Percent Growth	-13.3	-4.6	-3.6	7.1	9.9	7.4	
Asia/Pacific-ROW	188	233	265	300	353	393	14.0
Percent Growth	6.6	24.0	13.9	13.0	17.7	11.3	
Total	1,837	1,799	1,883	2,054	2,199	2,352	6.9
Percent Growth	-0.4	-2.1	4.7	9.1	7.1	7.0	

*Includes prime, test, and monitor wafers
Note: Columns may not add to totals shown because of rounding.
Source: Dataquest (December 1992)

Table 4-4
Forecast of Merchant Silicon* Wafer Consumption (Units—Millions of Square Inches)

	1991	1992	1993	1994	1995	1996	CAGR (%) 1992-1996
United States	450	460	483	521	545	579	5.9
Percent Growth	-4.7	2.3	4.9	7.9	4.6	6.2	
Japan	902	817	853	939	989	1,053	6.5
Percent Growth	5.7	-9.4	4.4	10.1	5.3	6.5	
Europe	183	174	167	180	198	213	5.2
Percent Growth	-12.4	-4.8	-3.7	7.3	10.2	7.6	
Asia/Pacific-ROW	188	233	265	300	353	393	14.0
Percent Growth	6.6	24.0	13.9	13.0	17.7	11.3	
Total	1,722	1,684	1,768	1,939	2,084	2,237	7.4
Percent Growth	0.7	-2.2	5.0	9.7	7.5	7.3	

*Includes prime, test, and monitor wafers
Note: Columns may not add to totals shown because of rounding.
Source: Dataquest (December 1992)

Forward to 1993 and Beyond

Dataquest believes that the U.S. silicon wafer market will continue to be driven by system applications, especially PCs and workstations, and by network applications. Lower prices will continue to fuel unit sales of PCs and workstations. In addition, the growth of graphics-based applications utilizing the power of a new generation of MPUs will increase the demand for silicon wafers. Finally, in the communications segment, the trend to a distributed computing architecture by many U.S. businesses will remain as a major driver in device growth.

But in 1993, the PC and workstation business will remain the primary driver, and silicon wafer demand will again be tied closely to unit shipments of these systems. We expect the steady improvement in the U.S. economy over the next several years to gradually increase the demand for devices in other applications such as auto and consumer electronics. We anticipate a more broad-base recovery in the electronic food chain by 1994. Consequently, we expect silicon usage to grow 7.3 percent in 1994 and to have a 5.8 percent compound annual growth rate (CAGR) from 1992 to 1996.

Our view on the mainframe/midrange market is that the current downturn is a secular shift rather than a cyclic shift. Our current silicon forecast assumes that demand for semiconductors in this segment will decline over the five-year forecast horizon.

Dataquest Perspective

Dataquest's five-year forecast for silicon is modest when compared with historical levels. Our silicon forecast mirrors the slower macroeconomic environment that we believe the U.S. economy will experience through 1996.

There are also trends on a micro level contributing to the slower growth of silicon wafer demand. First, the United States has the oldest semiconductor fab infrastructure, and we believe that the rate of fab closures will continue at a steady pace because of obsolescence. Second, we expect the rate of investment by foreign companies in U.S. fab capacity to decrease. The decline in Japanese investment in U.S. fabs will be especially notable. Finally, we believe that U.S. device companies will continue to pursue high-value-added niche applications concentrating on design and using overseas foundries to manufacture the devices.

Japan's Recovery Problematic

The current economic slide in Japan has hit the Japanese electronic industry hard. Asset deflation in the financial sector of the economy, both in equities and real estate, has spilled over into the industrial sector. Weak end markets in the computer and consumer segments have caused device demand to decline sharply, about 10 percent according to current WSTS data. We expect silicon usage in 1992 to drop 8.5 percent (see Table 4-1).

End-Use Markets Deteriorate

Miserable business confidence and constrained capital spending budgets have eroded the demand for computer systems, the largest end-use application for semiconductors, especially in the mainframe market. MITI's August production data, the latest as of press time, show mainframe sales off 23 percent in August year-to-year and down 22 percent from July. With banks, financial institutions, and manufacturers all cutting capital budgets, it is unlikely that this segment will recover in 1993. PC production was down 1 percent year-to-year and off 23 percent from July.

In addition, consumer electronic sales have hit the skids as export market and domestic demand still remain weak. MITI's August data show most product segments off sharply, including camcorders, VCRs, TVs, and home appliances. Videodisk players and digital audio disk players bucked the trend, showing solid growth in production year-to-year, though not strong enough to offset declines in the other product segments. Inventories of consumer goods continue to increase, though seasonal factors may be at work here.

Forward to 1993

We have decreased our projections for the growth of silicon wafer demand in Japan since our forecast one year ago. We now estimate that silicon demand will grow 6.0 percent CAGR through 1996, down from the year-ago forecast of 7.8 percent. As the Japanese economic problems unfold, the impact on the Japanese semiconductor industry is proving more severe than our earlier assumptions expected.

Our estimate is that silicon demand will edge up slightly in 1993. Our forecast growth rate is 4.0 percent in 1993, versus a decrease of 8.5 percent in 1992. Though we believe that the silicon cycle has bottomed, we cannot identify any major driving factors that will cause demand to bounce back in 1993.

The five major Japanese device companies—Fujitsu, Hitachi, Mitsubishi, NEC, and Toshiba—are all facing steep declines in revenue and profits in their information/communications equipment, consumer electronic goods, and semiconductor groups.

We believe that weak semiconductor demand is because of further production control by Japanese consumer electronic manufacturers and sluggish domestic demand for data processing equipment, including mainframes and PCs. Furthermore, we expect little improvement in the domestic demand for these goods in 1993.

Since the lion's share of these five companies' semiconductor sales are in Japan and a significant portion of these domestic sales are to their own captive end-use operations, we believe that the major Japanese semiconductor makers will only see a moderate upturn in 1993. Overseas markets will remain a bright spot for these companies because demand for MOS memory products, 4Mb and 1Mb, will continue to improve. But, because of the relatively small size of the export market, we do not believe that this opportunity will completely offset the weak domestic market.

We believe that the structural problems built up in the Japanese economy will take time to work themselves out. Especially hard hit by the deflation of assets will be capital spending by Japanese businesses. As a result, demand for data processing equipment, including computers and office automation equipment, is expected to lag over our five-year forecast period. Because this is the largest end-use application for semiconductors in Japan, accounting for 42 percent of semiconductor usage, we are not optimistic about semiconductor production snapping back.

Consumer applications, which account for 29 percent of semiconductor usage in Japan, also face future challenges. The most immediate problem is the lack of any major new product driving demand for semiconductors as the VCR did in the 1980s. Furthermore, shifts in technology used in consumer products threaten to disrupt the vertical integration structure of the large Japanese consumer electronic companies such as Matsushita and Sony. The key technologies required for future consumer products such as personal communicators, multimedia equipment, and HDTV will be software, microprocessors, and memory devices. Because Japanese companies lead in only one of these technologies, it is not clear how the domestic semiconductor industry will benefit as these products move to market.

External forces that threaten to weaken the demand for silicon wafers in Japan also are building. Mounting trade surpluses with the United States and a more protectionist stance by the Clinton administration may result in the United States being more aggressive in pushing for access to the Japanese semiconductor market.

The downturn in the demand for silicon wafers could not have come at a more awkward time for Japanese wafer vendors. Many companies have just completed a round of investment in 200mm wafer production lines. As one might well expect, this new capacity is not being used extensively because many semiconductor companies have put on hold their 200mm fab plans. Prices for the large-diameter wafers are under pressure and threaten to prevent companies from earning a return on their investment.

Dataquest Perspective

The uncertainty in the Japanese electronic market has caused us to be more cautious about the growth of silicon usage. Even so, one should not underestimate the influence that the Japanese electronics market has on the global electronics food chain and the semiconductor industry in particular. It is difficult to ignore a market that will process 46 percent of the world's silicon in 1993, by our estimates. The sheer size of the electronic market will guarantee that the Japanese semiconductor will remain a dominant force in the global industry.

European Slump

Business activity in Europe remains difficult. Economic activity in Germany is falling off, the United Kingdom continues to be in recession, Spain's growth rate is slowing, and Northern Europe is quite depressed. As we have noted elsewhere, the European economy is unarguably the biggest drag on silicon demand.

The fact that growth of silicon usage is almost entirely dependent on investment being made by non-European companies is perhaps the most alarming trend. With the completion of the Mietec Alcatel facility in 1993, there will be no new green-field investment in front-end production fabs undertaken by domestic European companies. If the semiconductor investment climate in the United States and Japan remains stagnant, then U.S. and Japanese companies may well rethink their planned investment in Europe, further cutting into our forecast growth for European silicon consumption.

A deterioration in European device manufacturers' competitiveness is also causing us to be more cautious in forecasting silicon wafer usage. The three largest Europe-based companies—Philips, SGS-Thomson, and Siemens—continue to lag Asian, Japanese, and U.S. companies in the design of devices and the development of semiconductor process technology. The current downturn in capital spending at these companies suggest that the competition issue will not turn around any time soon.

European Company Performance

Philips has been particularly hard hit by the slowdown in consumer electronic demand. The company delayed until the end of the year the introduction of its digital compact cassette player. Even so, we do not expect this product to generate much demand for semiconductors. Other systems under development are HDTV and new compact disc systems. Introduction of these products is too far off to have much of an effect on device production for our forecast period. Philips' early device investment in China over the long term may be the key to the rejuvenation of this company's semiconductor operations.

Siemens has cut back sharply on the production of semiconductors in Europe. The company closed three fabs in Germany during 1991 and continued to cut employees in 1992 at its semiconductor operations. The partnership strategy Siemens is now pursuing suggests that access to leading-edge device technology is more critical than adding manufacturing capacity. A de-emphasis on manufacturing will most certainly result in a decline in silicon wafer demand.

The third major European company, SGS-Thomson, continues to struggle with profitability problems. The company is moving ahead with plans to invest in a submicron, 200mm process technology. A research/pilot line is scheduled for completion in 1993. However, the French and Italian governments, the primary source of capital for SGS-Thomson, are struggling to lower their national budget deficits. If fiscal conservatism continues to be part of these governments' political agenda, then the governments' continued support of SGS-Thomson could be threatened.

On a more positive note, telecommunications devices will remain a strong area for several European companies such as Siemens and Mietec Alcatel. The underdeveloped communications infrastructure of the eastern European countries means that telecommunications gear will remain strong for the remainder of the decade.

Foreign Companies Lead the Way

Our forecast growth for the European silicon market, 6.9 percent CAGR through 1996, is tied closely to spending on new fabs and expansions of existing facilities by non-European companies such as Fujitsu, Intel, Mitsubishi, Motorola, NEC, and National Semiconductor. Especially noteworthy is Intel's investment in a new line in Ireland. We expect epi wafer demand to grow 16 percent in 1993 and surge another 35 percent in 1994, based largely on Intel's requirements.

Previously, we were more optimistic about Japanese companies spurring the demand for silicon wafers in Europe. But as domestic problems in Japan have mounted over the last year, we have turned more cautious. Only Fujitsu and Mitsubishi are planning facilities in 1994, and there is even a possibility that these may be delayed. NEC is spending additional money to expand its facilities in England, but Dataquest believes that this is tied more closely with its agreement to make parts for Toshiba, which has decided not to put a fab in Europe.

Texas Instruments is now ramping its Avezzano, Italy facility, helped by the upturn in the U.S. memory market. Consequently, TI's silicon usage should also increase in 1993. National is closing several bipolar lines in Santa Clara, California and moving production to a new line in Scotland.

Dataquest Perspective

Though the formation of a unified Europe is certainly not the compelling reason for investing in new fabs that many foreign device makers thought it would be several years ago, we believe that it may yet prove to be a boon to Europe-based semiconductor production and to the demand for silicon consumption. Certainly, the end-use market demand is there. The main problem is that such an upturn is not on our five-year forecast horizon, which extends through 1996.

Asia/Pacific Rolls On

The 1992 growth of silicon consumption is surpassing our expectations. Our current estimate is that unit consumption will be up 24 percent in 1992, and we are forecasting a further increase of 14 percent in 1993. The five-year growth rate through 1996 is estimated to be 14.2 percent CAGR, which is twice the growth rate of any other region in the world.

Koreans Lead

The phenomenal growth in silicon consumption in Asia/Pacific in 1992 is tied directly to the Korean DRAM producers. Revenue for the semiconductor divisions at the three major Korean device makers shot ahead in 1992 (see Table 4-5). We believe that the global demand for DRAMs will remain strong through 1993, pushing up silicon unit demand in Asia/Pacific another 14 percent. A major uncertainty surrounding our forecast are the recent dumping tariffs placed on the Korean DRAM vendors.

In spite of the tariffs, major Korean suppliers continue to add production capacity, but are asking at the same time whether they can maintain their market share growth by selling at higher prices forced on them by the U.S. government. Major users, which have a substantial interest in the eventual outcome in the resolution of this issue, so far are silent. They all recognize that it was only the Koreans that limited the Japanese DRAM hegemony that developed in the late 1980s, but are likewise sympathetic to the interest of U.S. suppliers.

Our forecast assumes that the Koreans will hold the market share gains they have won and further penetrate western markets. However, it is unlikely that the size of the market share gains achieved in 1992 will be repeated in 1993.

Perhaps the biggest obstacle to the long-term growth of the silicon wafer market is the strong hand of the Korean economic planners. The government has favored the high-technology sector to the exclusion of other sectors of the economy. This policy has resulted in a capital spending boom on new semiconductor capacity. But such a strategy is risky, considering the heavy dependence on device exports to pay for this investment. In our opinion, a more balanced semiconductor industry in Korea, where end-use applications such as PCs thrived, would be a more solid foundation on which to build a domestic semiconductor industry.

Other Countries Also Prosper

The new fab lines being built in this region (see Table 4-6) suggest that the dominance of Korea in this region will wane. Fabs constructed in China, Malaysia, Singapore, and Taiwan suggest that

Table 4-5
Korean Sales of Semiconductors (Millions of U.S. Dollars)

	1992 Revenue	1992 Growth Rate (%)
Samsung	1,173	32.0
Goldstar	525	130.0
Hyundai	422	127.0

Source: Dataquest (December 1992)

Table 4-6
New Fabs Planned for Asia/Pacific

Company	Country	Year Planned	Products	Geometry (Microns)	Wafer Size (Inches)
Goldstar	South Korea	1993	16Mb DRAM 4Mb SRAM	0.5	8
MOSel/Vitelic Corporation	Taiwan	1993	4Mb DRAM	0.6	6
NEC China	China	1993	Telecom Consumer ICs	2.0	6
Semiconductor Complex	India	1993	LSI	3.0	6
Tech Semiconductor Singapore Ltd.	Singapore	1993	16Mb DRAM	0.6	8
Wuxi Microelectronics Corporation	China	1993	Telecom ICs	3.0	5
Hitachi	Malaysia	1994	1Mb DRAM 4Mb DRAM	0	6
Hua Yue Microelectronics Company	China	1994	NA	1.0	6
Mimos	Malaysia	1994	NA	1.5	6
MOSel/Vitelic Corporation	Taiwan	1994	16Mb DRAM	0.5	8
Samsung	South Korea	1994	4Mb 16Mb DRAM	0.6	8
Syntek	Taiwan	1994	NA	0	6
United Microelectronics	Taiwan	1994	SRAM	0	8

NA = Not available
Source: Dataquest (December 1992)

these countries increasingly will play a more important role in the growth of the Asia/Pacific semiconductor industry.

Taiwan's market-driven economy is in many respects much healthier than Korea's. Though its silicon consumption is much smaller than Korea's, its semiconductor industry is better balanced. Taiwan has a thriving computer market, which provides device makers a domestic market for their product. As a result, we forecast silicon demand to grow at 8.3 percent CAGR through 1996.

However, the real star performer in terms of growth in silicon consumption will be the group of countries that fall under the rubric Rest of World (ROW). We estimate that silicon consumption for this group will push ahead at a 22.3 percent CAGR. Countries that will benefit from this growth will be Singapore, Malaysia, India, and China. Much of the growth in the ROW category will be fueled by investment and technology transfers from Japanese, U.S., and to a lesser extent European companies.

Dataquest Perspective

The Asia/Pacific region remains the most vibrant in terms of growth rates in silicon consumption. However, we do expect some rotation in the growth of silicon consumption away from the current leader, Korea, to those countries just beginning to build their industrial infrastructures. The ultimate growth opportunities will be China and India because of the sheer size of the market. But political turmoil, fragile legal systems, and underdeveloped infrastructures make the timing of these opportunities difficult to gauge.

Chapter 5
Semiconductor Consumption Forecast

This chapter presents data on the worldwide semiconductor market by region. The regional semiconductor market, or regional semiconductor consumption, deals with where chips are consumed; this contrasts with regional semiconductor production, which deals with where chips are made. The data presented here are for the merchant market and do not include the value of chips made by captive semiconductor manufacturers for internal use.

Yearly exchange rate variations can have a significant effect on the 1985 through 1991 data in the following tables. For more information about the exchange rates used and their effects, refer to Appendix B.

Semiconductor Consumption

Table 5-1 shows the historical regional semiconductor consumption for the years 1985 through 1991; it also breaks down the merchant market by nationality of the merchant semiconductor companies. Table 5-2 shows forecast semiconductor consumption by region for the period from 1991 through 1996.

Table 5-1
Worldwide Semiconductor Consumption by Region—Historical
Includes Merchant and Captive Semiconductor Companies
(Millions of U.S. Dollars)

	1985	1986	1987	1988	1989	1990	1991	CAGR (%) 1986-1991
North America	9,418	10,844	12,858	15,844	17,070	16,540	16,990	9.4
Percent Growth	NA	15.1	18.6	23.2	7.7	-3.1	2.7	
Japan	8,149	11,855	14,927	20,772	21,491	20,257	22,496	13.7
Percent Growth	NA	45.5	25.9	39.2	3.5	-5.7	11.1	
Europe	4,795	5,587	6,498	8,491	9,498	10,415	11,014	14.5
Percent Growth	NA	16.5	16.3	30.7	11.9	9.7	5.8	
Asia/Pacific-ROW	1,979	2,548	3,968	5,752	6,280	7,333	9,194	29.3
Percent Growth	NA	28.8	55.7	45.0	9.2	16.8	25.4	
Worldwide	24,341	30,834	38,251	50,859	54,339	54,545	59,694	14.1
Percent Growth	NA	26.7	24.1	33.0	6.8	0.4	9.4	

NA = Not applicable
Source: Dataquest (December 1992)

Table 5-2
Worldwide Consumption by Region
Merchant Semiconductor Sales Only—Forecast
(Millions of U.S. Dollars)

	1991	1992	1993	1994	1995	1996	CAGR (%) 1991-1996
North America	16,990	19,564	22,613	25,456	26,127	27,579	
Annual Growth (%)	2.7	15.1	15.6	12.6	2.6	5.6	10.2
Japan	22,496	20,371	22,975	25,870	27,810	29,645	
Annual Growth (%)	11.1	-9.4	12.8	12.6	7.5	6.6	5.7
Europe	11,014	11,809	13,663	15,603	16,493	17,828	
Annual Growth (%)	5.8	7.2	15.7	14.2	5.7	8.1	10.1
Asia/Pacific-ROW	9,194	11,181	13,417	15,698	17,692	19,939	
Annual Growth (%)	25.4	21.6	20.0	17.0	12.7	12.7	16.7
Worldwide	59,694	62,925	72,668	82,627	88,122	94,991	
Annual Growth (%)	9.4	5.4	15.5	13.7	6.7	7.8	9.7

Source: Dataquest (December 1992)

Chapter 6
Semiconductor Production Forecast

This chapter presents data on worldwide semiconductor production by region. Semiconductor production is defined by the place where the wafers are fabricated, and regional semiconductor production includes all production in the region, including merchant and captive producers and all foreign producers. For instance, North American semiconductor production includes IBM and Delco fabs as well as Japanese and European fabs in the United States.

Yearly exchange rate variations can have a significant effect on the 1985 through 1991 data in the following tables. For more information about the exchange rates used and their effects, refer to Appendix B.

Semiconductor Production

Table 6-1 shows historical semiconductor production for the years 1985 through 1991, and Table 6-2 shows forecast production for the period from 1991 through 1996.

Table 6-1
Worldwide Semiconductor Production by Region—Historical Merchant and Captive Semiconductor Company Sales
(Millions of U.S. Dollars)

	1985	1986	1987	1988	1989	1990	1991	CAGR (%) 1986-1991
Total North America	12,654	14,456	16,712	20,171	21,324	22,789	25,103	11.7
Percent Growth	NA	14.2	15.6	20.7	5.7	6.9	10.2	
Percent Worldwide	46.7	42.9	40.3	37.0	36.8	39.2	39.8	
Merchant	10,411	12,129	14,116	17,326	18,464	19,959	22,460	
Captive	2,243	2,327	2,596	2,845	2,860	2,830	2,643	
Total Japan	10,651	14,686	19,004	26,693	28,429	26,376	29,411	14.9
Percent Growth	NA	37.9	29.4	40.5	6.5	-7.2	11.5	
Percent Worldwide	39.3	43.5	45.8	49.0	49.0	45.4	46.7	
Merchant	10,500	14,524	18,824	26,388	28,119	26,069	29,121	
Captive	151	162	180	305	310	307	290	
Total Europe	3,403	3,831	4,674	5,789	6,290	6,780	6,086	9.7
Percent Growth	NA	12.6	22.0	23.9	8.7	7.8	-10.2	
Percent Worldwide	12.6	11.4	11.3	10.6	10.8	11.7	9.7	
Merchant	3,024	3,426	4,223	5,277	5,782	6,307	5,677	
Captive	379	405	451	512	508	473	409	
Total Asia/Pacific-ROW	406	756	1,087	1,868	1,974	2,210	2,435	26.4
Percent Growth	NA	86.2	43.8	71.8	5.7	12.0	10.2	
Percent Worldwide	1.5	2.2	2.6	3.4	3.4	3.8	3.9	
Merchant	406	756	1,087	1,868	1,974	2,210	2,435	
Captive	NA	NA	NA	NA	NA	NA	NA	
Worldwide	27,114	33,729	41,477	54,521	58,017	58,155	63,036	13.3
Merchant	24,341	30,835	38,250	50,859	54,339	54,545	59,694	
Percent Growth	NA	26.7	24.0	33.0	6.8	0.4	9.4	
Captive	2,773	2,894	3,227	3,662	3,678	3,610	3,342	
Percent Growth	NA	4.4	11.5	13.5	0.4	-1.8	-7.4	

NA = Not applicable
Source: Dataquest (December 1992)

Table 6-2
Worldwide Semiconductor Production by Region—Forecast
Merchant and Captive Semiconductor Company Sales
(Millions of U.S. Dollars)

	1991	1992	1993	1994	1995	1996	CAGR (%) 1991-1996
Total North America	25,103	27,695	31,136	34,542	36,063	38,592	9.0
Percent Growth	10.2	10.3	12.4	10.9	4.4	7.0	
Percent Worldwide	39.8	41.9	41.1	40.3	39.5	39.3	
Merchant	22,460	25,170	28,704	32,142	33,663	36,192	10.0
Captive	2,643	2,525	2,432	2,400	2,400	2,400	-1.9
Total Japan	29,411	29,161	33,734	36,193	38,319	40,621	6.7
Percent Growth	11.5	-0.9	15.7	7.3	5.9	6.0	
Percent Total	46.7	44.2	44.5	42.2	42.0	41.4	
Merchant	29,121	28,946	33,500	35,943	38,069	40,371	6.8
Captive	290	215	234	250	250	250	-2.9
Total Europe	6,086	6,294	7,018	8,631	9,324	10,292	11.1
Percent Growth	-10.2	3.4	11.5	23.0	8.0	10.4	
Percent Worldwide	9.7	9.5	9.3	10.1	10.2	10.5	
Merchant	5,677	5,915	6,613	8,180	8,812	9,784	11.5
Captive	409	379	405	451	512	508	4.4
Total Asia/Pacific-ROW	2,435	2,895	3,851	6,362	7,578	8,644	28.8
Percent Growth	10.2	18.9	33.1	65.2	19.1	14.1	
Percent Worldwide	3.9	4.4	5.1	7.4	8.3	8.8	
Merchant	2,435	2,895	3,851	6,362	7,578	8,644	28.8
Captive	NA	NA	NA	NA	NA	NA	
Worldwide	63,036	66,044	75,739	85,728	91,284	98,149	9.3
Merchant	59,694	62,925	72,668	82,627	88,122	94,991	9.7
Percent Growth	9.4	5.4	15.5	13.7	6.7	7.8	
Captive	3,342	3,119	3,071	3,101	3,162	3,158	-1.1
Percent Growth	-7.4	-6.7	-1.5	1.0	2.0	-0.1	

NA = Not applicable
Source: Dataquest (December 1992)

Appendix A
Regional Economic Outlook for Our Forecast

This appendix provides a discussion of the macroeconomic factors and trends affecting the major semiconductor producing regions. The focus is on the current and future general business environment in these regions and the assumptions used in our forecast.

The Regional Economic Outlook for Our Forecast (November 1992)

Unarguably, the industrialized countries are in a tough spot collectively. As Table A-1 shows, the United States is now moving out of a stagnant period of economic weakness, though the recovery is spotty. The Japanese and European economies continue to slide. The Asian region remains the bright spot, though demand is not large enough to pull the rest of the global economy along.

United States Shaking Off the Recession

The seemingly chronic stagnation that has gripped the U.S. economy for the last three years appears to be breaking. We believe that the economy will experience modest growth in gross domestic product (GDP) for the rest of 1992 and into 1993, accompanied by low inflation. GDP growth rates should pick up in 1994 and beyond as foreign demand for U.S. goods accelerates. Latin America will be an especially important engine for U.S. growth toward the middle of the decade.

Government data on the U.S. economy continue to be mixed, supporting our thesis that the recovery will be slower in gaining speed when compared with previous recoveries. Signs of recovery are evident in the third-quarter GDP, which climbed 2.7 percent after rising only 1.7 percent in the second period. But at the same time, durable goods orders such as cars and computers declined in September for the third straight month.

Business profits are up, jumping $50 billion in the third quarter. But job creation remains problematic because businesses are still cautious about adding employees. Consequently, the unemployment rate remains stuck in the 7 percent range.

We continue to emphasize that the main factor preventing more robust growth for the next several years is the forecast weak rebound in real income. The problems with income are attributable to lingering consumer and business debt overhang, weak productivity growth, high levels of business failures, and weak demographic demand for housing. With unit consumer spending having a less than normal recovery, the rebound in industrial productivity is also certain to fall short of normal historic cyclical proportions.

Unarguably, the signs of recovery are attributable to headway being made on several of these problems. The loosening of monetary policy and the resultant decline in interest rates have enabled households and corporations to refinance their high fixed-rate debt. That reliquidification process is improving the cash flow and boosting domestic demand to a degree.

Unfortunately, part of the gain in the domestic economy is being offset by weak demand in overseas economies. This trend—a modestly improving domestic economy and a deteriorating trade balance—is an economic theme that will extend well into 1993.

Dataquest also expects fiscal policy (government spending) to begin to displace monetary policy (lower interest rates) as the government's main tool for stimulating the economy. President-elect Bill Clinton emphasized throughout the campaign the need for increased investment in the public sector, in addition to incentives (tax credits and tax cuts) to spur the private sector.

The Sun Also Sets

The notion that the Japanese real economy is experiencing no more than a mild adjustment to asset deflation is increasingly undermined by the flow of statistics out of Japan. GDP in the third calendar quarter sunk 1.5 percent.

Business confidence is falling and the corporate sector is set to keep retrenching on capital spending, inventory, and employment fronts. Consumer confidence is also declining as disposable income falls and jobs become less secure. Overall, we believe that the industrial recession will intensify into calendar 1993 and that there will be an increasing degree of spillover into the sheltered parts of the economy.

The unemployment rate, now at 2.2 percent, is expected to rise as corporations reduce labor costs. We also believe that the growth in wages will slow, especially wages paid as bonuses. These trends will lower household income and cause a continued weakness in consumer expenditure.

External demand is cushioning the impact of the downturn on many segments of the Japanese economy. The trade surplus with the rest of the world continues to widen. It is running about U.S.$100 billion in calendar 1992. It is unlikely that any headway will be made to lower this imbalance in 1993.

The run-up in the trade surplus is because of a collapse of imports rather than a push by Japanese companies to export. Needless to say, the lopsided surplus will continue to aggravate relations with foreign countries and is expected to draw a response, especially from the United States and the European Economic Community, in the form of increased trade tariffs.

As Dataquest has emphasized for two years, asset deflation is at the center of Japan's economic problems. A sharp drop in stock prices and lower real estate values have depressed the reserves available to Japanese financial institutions. This trend is barring banks from providing the liquidity to reinvigorate the economy.

On October 14, Federal Reserve Board Chairman Alan Greenspan pointed out to a group of Japanese bankers that economic recovery from a steep decline in the price of financial assets historically has taken much longer and been more modest than a recovery from a cyclical downturn. We could not agree more and continue to expect the Japanese economy to underperform over the next two years.

Europe Unravels

The European economy is expected to be weak through 1993. The three anchor economies in Western Europe—England, France, and Germany—are all experiencing economic difficulties.

England Slides Further

It is now quite evident that the spurt in the U.K. economy last spring was a fleeting phenomenon. It is likely that GDP will be negative in the fourth quarter, and the prospects into 1993 provide little hope for much improvement.

The collapse of sterling and Europe's exit from the European exchange rate mechanism (ERM) on September 16 (Black Wednesday) are the most recent and dramatic symptoms of the malaise infecting England's economy. Business and consumer confidence was declining prior to this policy shock. Confidence levels declined even further following September 16.

We have thrown out our previous assumption that English interest rates would not move lower until 1993 because of the shift in the policy on ERM. Fallout from the government's decision on ERM and political reaction to coal mine closures have persuaded the government to cut base rates to 8 percent.

In one respect, decoupling from ERM will permit England to duck the bitter medicine the Bundesbank is now administering to the German economy. But, lower interest rates in England only make the current situation a bit more palatable. Even so, the key problem facing the English economy—the downturn in business on the continent—will persist. Therefore, it is unlikely that any improvement in England's economy is sustainable, even with the lower rates, until the upturn in the rest of Europe is under way.

When Will the Bundesbank Move?

Our previous estimate that German rates would not move lower until the middle of 1993 now appears conservative. Because of the political pressure surrounding the unraveling of ERM and a weaker economic outlook, the Bundesbank will most likely make significant cuts in rates by the first quarter of 1993.

Even so, the lower rates are likely only to have a muted impact on the German economy. The burdens of unification still weigh heavy on the German economy. The Dun & Bradstreet Corporation has lowered its expectation for German economic growth in 1993 since our last forecast.

The weaker economic growth is likely to exacerbate the deteriorating finances of the German government because of substantial tax revenue loss in 1993. The sizable government deficit is likely to remain stuck at DM120 billion, or move higher, causing the government to cast about for additional tax revenue to lighten the burden. Raising additional taxes will crowd out private investment and slow the recovery.

The deterioration of the economic picture in the United Kingdom and Germany is slowing economic activity in France. Over the longer term, France's strengthening competitive position vis-a-vis its European trading partners will be the main driver for a recovery. An upturn in domestic demand will most likely be slower coming because the pace of job creation is weak.

Asia/Pacific Pushes Ahead

Most economists continue to forecast the fastest growth in the world for the Asia/Pacific region. We believe that annual gross national product (GNP) growth rates over the next five years will range from 5 percent to 8 percent for Hong Kong, Indonesia, Malaysia, Singapore, South Korea, Taiwan, and Thailand. Moreover, underdeveloped countries such as China P.R.C., India, and Vietnam increasingly will boost the economic activity of the Pacific Basin as the decade wears on.

In 1991, many of the Pacific Basin countries suffered from slow worldwide growth because the health of their economies is tied so closely to exports. Countries such as Korea and Singapore, which are heavily dependent on sales to the West, experienced a deceleration in GNP growth because of the slow U.S. and European economies.

But Taiwan's economy was more resilient because it benefited from strong exports to trading partners in Southeast Asia and China, which were not impacted by the recession in the West. We believe that the intraregional trade theme is a trend that will increasingly impact not only Taiwan's economy but also the other industrializing countries in the region.

The only dark cloud on the horizon is the threat of a slower rate of investment by Japanese companies because of the financial problems at home. If the Japanese banking system were to stumble, then the flow of investment to the Pacific Basin would certainly suffer. But, this downside has a low probability.

Table A-1
International Economic Forecasts, GDP/GNP Growth Rates (Percentage)

Country	Currently In or Near Recession?	Last 1992/1993 GDP/GNP Change	1988	1989	1990	1991	1992	1993	1994	1995	1996
North America											
Canada			4.6	2.3	0.5	-1.7	1.9	4.0	3.4	3.0	3.0
United States			3.9	2.5	1.0	-0.7	1.7	2.6	2.3	2.4	2.4
Western Europe											
Austria			4.0	3.7	4.6	3.0	2.3	3.0	3.9	3.6	3.6
Belgium	Yes	Down	4.9	3.7	3.8	1.4	1.5	2.5	2.7	2.9	2.9
Denmark	Yes		1.2	0.8	1.7	1.0	1.7	2.6	3.0	3.3	3.3
Finland	Yes		5.4	5.4	0.4	-6.6	-1.2	2.0	3.5	3.8	3.8
France			4.6	4.7	2.3	0.9	2.1	2.7	3.3	3.3	3.3
Germany*	Yes		3.5	3.9	4.7	3.2	1.1	2.8	4.2	3.8	3.8
Ireland			4.4	6.4	7.1	1.2	2.3	3.0	3.4	3.3	3.3
Italy	Yes	Down	4.2	2.9	2.2	1.4	1.2	1.5	2.0	2.4	2.4
Netherlands	Yes		2.8	4.2	3.9	2.1	1.5	2.5	3.1	2.9	2.9
Norway		Down	-0.5	0.4	1.8	1.9	1.9	2.5	3.0	3.0	3.0
Portugal		Down	3.9	5.1	4.4	2.9	2.5	3.1	4.0	4.0	4.0
Spain		Down	5.2	4.8	3.6	2.5	2.1	2.5	3.0	4.0	4.0
Sweden	Yes	Down	2.3	2.4	0.4	-1.4	-0.5	1.0	2.0	2.9	2.9
Switzerland	Yes	Down	2.8	3.7	2.2	-0.5	0.8	2.1	2.4	2.0	2.0
United Kingdom	Yes	Down	4.1	2.2	1.0	-2.4	-1.0	1.3	2.0	3.0	3.0
Central Europe											
Hungary	Yes		2.7	3.8	-4.0	-6.7	-1.0	2.0	4.0	5.0	5.0
Poland	Yes		2.5	-0.1	-11.6	-9.0	-2.0	1.5	3.0	4.0	4.0

(Continued)

Table A-1 (Continued)
International Economic Forecasts, GDP/GNP Growth Rates (Percentage)

Country	Currently In or Near Recession?	Last 1992/1993 GDP/GNP Change	1988	1989	1990	1991	1992	1993	1994	1995	1996
Asia/Pacific											
Australia			3.8	4.4	1.3	-1.2	2.0	3.9	3.7	3.3	3.3
Hong Kong			8.3	2.8	3.2	4.2	5.5	5.6	5.0	5.0	5.0
Indonesia			6.5	7.5	7.4	5.8	6.0	6.5	6.5	6.5	6.5
Japan			6.3	4.8	5.3	4.4	2.0	3.3	3.5	4.0	4.0
Malaysia			9.1	8.6	9.8	8.8	7.9	7.5	7.5	7.6	7.6
New Zealand	Yes		2.9	-0.7	0.5	-2.1	2.0	2.6	2.5	2.5	2.5
Singapore			11.1	9.4	8.2	6.7	6.0	6.5	6.5	6.5	6.5
South Korea			11.5	6.2	9.0	8.4	7.0	7.5	7.5	7.5	7.5
Taiwan			7.3	7.6	5.3	7.3	7.0	7.0	7.0	7.0	7.0
Thailand		Down	13.2	12.0	10.0	7.9	7.0	6.0	7.5	7.5	7.5
Central/Latin America											
Argentina			-2.6	-4.5	0.4	5.0	4.9	4.1	4.0	2.5	2.5
Brazil	Yes		-0.1	3.3	-4.0	1.2	1.3	2.0	2.5	4.0	4.0
Mexico			1.2	3.3	4.4	3.6	4.0	5.0	5.0	5.0	5.0
Venezuela			5.8	-8.9	6.7	9.2	4.0	7.0	5.5	4.0	4.0

*West Germany prior to 1993, unified Germany data thereafter.
Source: Economic Analysis Department, The Dun & Bradstreet Corporation

Appendix B
Exchange Rate Definitions

When converting a company's local currency sales into U.S. dollars, or vice versa, it is important to use the preliminary 1992 exchange rates in Table B-1. This will prevent inconsistencies in the conversion of offshore sales between each company. The preliminary 1992 exchange rate estimate uses actual exchange rates through September 1992, and assumes that the September rate applies throughout the months of October through December. The annual rate is estimated as the arithmetic mean of the 12 monthly rates. Exchange rates for historical years are available on request.

Table B-2 lists the exchange rates per dollar for Japanese yen and European currency units (ECUs) for the period from 1985 to 1991. Exchange rate variations should be kept in mind when interpreting yearly changes in the 1985 to 1991 data presented in this booklet. However, the forecast years (1992 to 1996) are assumed to have constant exchange rates.

Table B-1
Average 1992 Exchange Rates per U.S. Dollar

Country	1991 Rate	1992 Estimate	U.S.$ Expected Appreciation (%)
Austria (Schilling)	11.67	10.68	-8.4
Belgium (Franc)	34.13	31.26	-8.4
China (Renminbi)	5.33	5.49	2.8
Denmark (Krone)	6.39	5.87	-8.2
ECU	0.81	0.75	-7.6
Finland (Markka)	4.04	4.24	5.1
France (Franc)	5.64	5.14	-8.8
Germany (Mark)	1.66	1.52	-8.5
Great Britain (Pound)	0.57	0.54	-4.6
Greece (Drachma)	181.89	183.48	0.9
Hong Kong (Dollar)	7.77	7.74	-0.4
India (Rupee)	22.72	27.96	23.1
Ireland (Punt)	0.62	0.57	-7.9
Italy (Lira)	1,238.93	1,171.01	-5.5
Japan (Yen)	134.68	125.95	-6.5
Malaysia (Ringgit)	2.75	2.54	-7.8
Netherlands (Guilder)	1.87	1.71	-8.5
Norway (Krone)	6.49	5.99	-7.6
Portugal (Escudo)	144.02	130.55	-9.4
Singapore (Dollar)	1.73	1.62	-6.2
South Korea (Won)	730.90	784.00	7.3
Spain (Peseta)	103.81	97.86	-5.7
Sweden (Kroner)	6.04	5.54	-8.4
Switzerland (Franc)	1.43	1.36	-5.2
Taiwan (Dollar)	26.50	24.89	-6.1
Thailand (Baht)	25.52	25.36	-0.6

Source: Dataquest (December 1992)

Table B-2
Exchange Rates per Dollar for Japanese Yen and ECU: 1985-1991

	1985	1986	1987	1988	1989	1990	1991
Yen/$	238	167	144	130	138	144	135
Percent Change		-30	-14	-10	6	4	-6
ECU/$	1.31	1.02	0.87	0.84	0.92	0.79	0.81
Percent Change		-22	-15	-3	10	-14	8

Source: Dataquest (December 1992)

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Japanese Fab Database

October 28, 1992

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Note: All tables show estimated data.

Japanese Fab Database

Background

The material in this document applies to the Japanese portion of Dataquest's Semiconductor Equipment, Manufacturing, and Materials service wafer fab database. The wafer fab database is updated on an ongoing basis, employing both primary and secondary research methodologies. The tables included in this document highlight both production and pilot line wafer fabs.

Research Methodology

Dataquest takes a three-pronged approach to wafer fab database research. Information is gained through extensive annual primary research. This survey work is further supplemented with comprehensive secondary research conducted on an ongoing basis. The database is updated daily, which allows Dataquest to provide a snapshot of the marketplace at any time. The information gathered through primary and secondary research is then further supplemented and cross-checked with Dataquest's various other information sources.

General Definitions

Fab line: A fab line is a processing line in a clean room that is equipped to do all front-end wafer processing. Occasionally there are two separate product-specific fab lines or two different wafer sizes in a clean room. In this situation, a clean room will be documented as two fab lines if the equipment is dedicated to each wafer size or product line. There can be many fab lines at one location.

Front-end wafer processing: Front-end wafer processing is defined as all steps involved with semiconductor processing, beginning with initial oxide and ending at wafer probe.

Production fab: A production fab is defined as a wafer fab capable of front-end processing more than 1,250 wafers per week (type = F).

Pilot fab: A pilot fab is defined as a wafer fab capable of front-end processing less than 1,250 wafers per week (type = P).

Definition of Table Columns

The Products Produced column contains information for seven product categories. The information in this column can be very detailed, depending on its availability. The nomenclature used within the seven product groups of the fab database is as follows, with definitions where warranted:

- Analog
  - LIN—Linear/analog devices
  - A/D D/A—Analog-to-digital, digital-to-analog converters
  - AUTOMOTIVE—Dedicated to automobile applications
  - CODEC—Coder/decoder
  - INTERFACE—Interface IC
  - MESFET (GaAs)—Metal Schottky field-effect transistor
  - MODFET (GaAs)
  - MDIODE (GaAs)—Microwave diode
  - MFET (GaAs)—Microwave field-effect transistor
  - MODEM—Modulator/demodulator
  - MMIC—Monolithic microwave IC
  - OP AMP—Operational amplifier
  - PWR IC—Power IC
  - REG—Voltage regulator
  - SMART PWR—Smart power
  - SWITCHES—Switching device
  - TELECOM—Telecommunications chips
- Memory
  - MEM—Memory
  - RAM—Random-access memory
  - DRAM—Dynamic RAM

- SRAM 4 TR.—Static RAM uses a 4-transistor cell design
- SRAM 6 TR.—Static RAM uses a 6-transistor cell design
- VRAM—Video RAM
- ROM—Read-only memory
- PROM—Programmable ROM
- EPROM—Ultraviolet erasable PROM
- EEPROM or E2—Electrically erasable PROM
- FERRAM—Ferroelectric RAM
- FLASH—Flash memory
- NVMEM—Nonvolatile memory (ROM, PROM, EPROM, EEPROM, FERRAM)
- FIFO—First-in/first-out memory
- SPMEM—Other specialty memory (such as dual-port, shift-register, color lookup)

• Microcomponents

- ASSP—Application-specific standard product
- BIT—Bit slice (subset of MPU functions)
- DSP—Digital signal processor
- MCU—Microcontroller unit
- MPR—Microperipheral
- MPRCOM—MPR digital communication (ISDN, LAN, UART, modem)
- MPU—Microprocessor unit
- LISP—32-bit list instruction set processor for AI applications
- RISC—Reduced-instruction-set computing 32-bit MPU

• Standard logic

- LOG—Standard logic

• ASIC logic

- ASIC—Application-specific IC
- ARRAYS—Gate arrays
- CBIC—Cell-based IC
- CUSTOM—Full-custom IC (single user)
- PLD—Programmable logic device

• Discrete

- DIS—Discrete
- DIODE
- FET—Field-effect transistor
- GTO—Gate turn-off thyristor
- HEMT (GaAs)—High-electron-mobility transistor
- MOSFET—MOS-based field-effect transistor
- PWR TRAN—Power transistor
- RECTIFIER
- RF—Radio frequency
- SCR—Schottky rectifier
- SENSORS
- SST—Small-signal transistor
- THYRISTOR
- TRAN—Transistor
- ZENER DIODE

• Optoelectronic

- OPTO—Optoelectronic
- CCD—Charge-coupled device (imaging)
- COUPLERS—Photocouplers
- IED—Infrared-emitting diode
- IMAGE SENSOR
- LASER (GaP)—Semiconductor laser or laser IC
- LED—Light-emitting diode
- PDIODE—Photo diode
- PTRAN—Photo transistor
- SAW—Surface acoustic wave device
- SIT IMAGE SENSOR—Static induction transistor image sensor

The Process Technology column lists four major types of technologies. This column also lists a few uncommon technologies along with available information on levels of metal, type of well, and logic structure. Definitions of the nomenclature used in the Process Technology column are as follows:

- MOS (silicon-based)
  - CMOS—Complementary metal-oxide semiconductor
  - MOS—n-channel metal-oxide semiconductor (NMOS) and p-channel metal-oxide semiconductor (PMOS). (More than 90 percent of the MOS fabs use n-channel MOS.)
  - M1—Single-level metal
  - M2—Double-level metal
  - M3—Triple-level metal
  - N-WELL
  - P-WELL
  - POLY1—Single-level polysilicon
  - POLY2—Double-level polysilicon
  - POLY3—Triple-level polysilicon
- BiCMOS (silicon-based)
  - BiCMOS—Bipolar and CMOS combined on a chip
  - BIMOS—Bipolar and MOS combined on a chip
  - ECL I/O—ECL input/output
  - TTL I/O—TTL input/output
- Bipolar (silicon-based)
  - BIP—Bipolar
  - ECL—Emitter-coupled logic
  - TTL—Transistor-transistor logic
  - STTL—Schottky TTL
- Gallium arsenide and other compound semiconductor materials
  - GaAs—Gallium arsenide
  - GaAlAs—Gallium aluminum arsenide
  - GaAs on Si—Gallium arsenide on silicon
  - GaP-Gallium phosphide
  - HgCdTe—Mercuric cadmium telluride
  - InAs—Indium arsenide
  - InP—Indium phosphide
  - InSb—Indium antimony
  - LiNbO3—Lithium niobate
  - SOS—Silicon on sapphire

The number in the Minimum Linewidth column represents the minimum linewidth at the critical mask layers as drawn. This number is stated in microns and is defined in Dataquest's fab survey as being available in production volumes.

The Wafer Size column represents the wafer diameter expressed colloquially in inches. However, for wafers greater than 3 inches in diameter, the colloquial expression is inaccurate. When calculating square inches, the following approximations are used:

Stated Diameter	Approximate Diameter
4 inches (100mm)	3.938 inches
5 inches (125mm)	4.922 inches
6 inches (150mm)	5.906 inches
8 inches (200mm)	7.87 inches

Maximum Wafer Capacity is defined in the fab survey as the equipment-limited wafer start capacity per four-week period. Maximum capacity is not limited by current staffing or the number of shifts operating, it is limited only by the installed equipment in the fab and the complexity of the process it runs.

The Clean Room Class column represents the level of cleanliness in the cleanest part of the clean room. This area represents the true environment to which the wafer is exposed.

The Merchant or Captive column categorizes each fab line on the tables as one of these two types. Definitions are as follows:

- A Merchant fab line is a fab line that produces devices that end up available on the merchant market.
- A Captive fab line does not sell any of its devices on the merchant market. All production is consumed by the owner of the fab line.

Table 1
Japanese Existing Pilot and Production Fab Lines
(Including Fabs Going into Operation During 1992)

Company	City or District	Prefecture	Fab Name	Products Produced	Process Technology	Est. Minimum Line Width (Microns)	Wafer Diameter (Inches)	Est. Max. Wafer Capacity (4wk/Mo)	Clean Room (Square Meters)	Clean Room Class	Merchant or Captive
AISHIN SEIKI	HANDA-SHI	AICHI	HANDA	AUTOMOTIVE	NA	0	0	0	0	NA	M
AISHIN SEIKI	HEKINAN-SHI	AICHI	SHINKAWA	AUTOMOTIVE	NA	0	0	0	0	NA	M
CANON	HIRATSUKA-SHI	KANAGAWA	NA	AMORPHOUS IMAGE SENSORS	GaAs	0	3	0	0	NA	C
CANON	HIRATSUKA-SHI	KANAGAWA	NA	ASIC	CMOS	0	6	3,000	0	10	C
CANON DENSHI	CHICHIBU-SHI	SAITAMA	NA	CCD	MOS	3.00	5	5,000	0	NA	C
CASIO	HACHIOJI-SHI	TOKYO	NA	ASIC	NA	0	4	11,000	0	NA	C
CLARION	KORIYAMA-SHI	FUKUSHIMA	NA	SAW CUSTOM	NA	0	4	5,000	0	NA	C
FUJI ELECTRIC	MATSUMOTO-SHI	NAGANO	NA	CUSTOM ASSP	CMOS BICMOS BIP	1.00	6	20,000	0	10	M
FUJI ELECTRIC	MATSUMOTO-SHI	NAGANO	NA	DIODE PWR TRAN PWR MOSFET	MOS	2.00	4	20,000	0	100	M
FUJI FILM MICRODEVICE	KUROKAWA-GUN	MIYAGI	NA	CCD	CMOS	1.00	6	3,000	2,463	1	C
FUJI XEROX	SUZUKA-SHI	MIE	NA	PWR ICs IMAGE SENSOR LOG	CMOS	3.00	5	3,000	0	NA	C
FUJITSU	AIZU WAKAMATSU-SHI	FUKUSHIMA	BLDG. 1 #1	ARRAYS LOG	CMOS	1.50	6	30,000	0	10	M
FUJITSU	AIZU WAKAMATSU-SHI	FUKUSHIMA	BLDG. 1 #2	ARRAYS LOG	CMOS	1.20	6	16,000	0	10	M
FUJITSU	AIZU WAKAMATSU-SHI	FUKUSHIMA	BLDG. 2 #1	ARRAYS CBIC 32-bit MCU	CMOS	0.70	6	15,000	5,251	10	M
FUJITSU	AIZU WAKAMATSU-SHI	FUKUSHIMA	VLSI 1	DIS A/D D/A	BIP	2.00	5	30,000	0	NA	M
FUJITSU	AIZU WAKAMATSU-SHI	FUKUSHIMA	VLSI 2	256K DRAM SRAM EPROM MPU	MOS CMOS	1.50	5	40,000	0	NA	M
FUJITSU	AIZU WAKAMATSU-SHI	FUKUSHIMA	VLSI 3	1Mb DRAM SRAM ROM	CMOS MOS	1.00	6	20,000	0	10	M
FUJITSU	MINOKAMO-SHI	GIFU	MINOKAMO	PROTOTYPE ICs	CMOS	1.00	6	5,000	0	10	M
FUJITSU	IZAWA-GUN	IWATE	NO. 1	ARRAYS	BIP	1.20	6	15,000	0	10	M
FUJITSU	IZAWA-GUN	IWATE	NO. 2	ROM EPROM	MOS	1.50	5	32,000	0	10	M
FUJITSU	IZAWA-GUN	IWATE	NO. 3	1Mb DRAM 4Mb DRAM SRAM ROM	CMOS MOS POLY3	0.80	6	25,000	0	10	M
FUJITSU	IZAWA-GUN	IWATE	NO. 4	4Mb DRAM 16Mb DRAM SRAM ASIC	CMOS MOS POLY3	0.50	6	13,000	0	1	M
FUJITSU	KAWASAKI-SHI	KANAGAWA	NA	3D ICs JOSEPHSON JUNCTION	NA	0	5	15,000	0	NA	M
FUJITSU	KUWANA-GUN	MIE	NO. 1	ARRAYS	CMOS MOS	1.00	6	10,000	0	10	M
FUJITSU	KUWANA-GUN	MIE	NO. 2	LOG ARRAYS 4Mb DRAM	CMOS BIP	0.80	6	10,000	0	10	M
FUJITSU	KUWANA-GUN	MIE	NO. 3	4Mb DRAM 16Mb DRAM SRAM MPU	CMOS	0.80	6	500	0	NA	M
FUJITSU	NAKAKOMA-GUN	YAMANASHI	NA	FET LIN OPTO HEMT	GaAs	0	3	0	0	NA	M

(Continued)

Table 1 (Continued)
Japanese Existing Pilot and Production Fab Lines
(Including Fabs Going into Operation During 1992)

Company	City or District	Prefecture	Fab Name	Products Produced	Process Technology	Est. Minimum Line Width (Microns)	Wafer Diameter (Inches)	Est. Max. Wafer Capacity (4wk/Mo)	Clean Room (Square Meters)	Clean Room Class	Merchant or Captive
HAMAMATSU PHOTONICS	HAMAMATSU-SHI	SHIZUOKA	NA	OPTO	NA	0	3	15,000	0	NA	M
HITACHI	MOBARA-SHI	CHIBA	D1	ASIC MCU EPROM	MOS CMOS	1.50	5	30,000	4,182	NA	M
HITACHI	MOBARA-SHI	CHIBA	D2	1Mb DRAM 4Mb DRAM	CMOS	0.80	5	30,000	4,182	NA	M
HITACHI	MOBARA-SHI	CHIBA	D3	1Mb DRAM 4Mb DRAM	CMOS M2	0.80	6	30,000	4,182	10	M
HITACHI	TAKASAKI-SHI	GUNMA	NA	256K SRAM 4Mb DRAM MCU	CMOS BICMOS	0.80	6	20,000	0	NA	M
HITACHI	TAKASAKI-SHI	GUNMA	NO. 1	LIN EPROM PWR MOSFET SRAM	BIP MOS CMOS	2.00	5	20,000	0	100	M
HITACHI	CHITOSE-SHI	HOKKAIDO	CHITOSE	1Mb SRAM 4Mb DRAM MPU	CMOS	0.80	6	15,000	1,859	10	M
HITACHI	CHITOSE-SHI	HOKKAIDO	CHITOSE	4Mb DRAM 1Mb SRAM EEPROM ROM	CMOS	0.80	6	15,000	0	10	M
HITACHI	HITACHI-SHI	IBARAKI	NA	PWR GTO THYRISTERS	BIP STTL	4.00	5	20,000	0	NA	M
HITACHI	KATSUTA-SHI	IBARAKI	N-2	4Mb DRAM 16Mb DRAM	CMOS	0.50	8	10,000	0	NA	M
HITACHI	KATSUTA-SHI	IBARAKI	NA	1Mb DRAM 4Mb DRAM	CMOS	0.80	6	20,000	1,859	NA	M
HITACHI	KATSUTA-SHI	IBARAKI	N1-1	4Mb DRAM 1Mb SRAM	CMOS	0.80	6	15,000	0	NA	M
HITACHI	KOMORO-SHI	NAGANO	KOMORO	LASER TELECOM	CMOS GaAs	1.50	3	15,000	1,859	NA	M
HITACHI	KODAIRA-SHI	TOKYO	DDC	LOG LIN	BIP	2.00	4	15,000	0	NA	M
HITACHI	KODAIRA-SHI	TOKYO	NA	4-Bit MPU 8-Bit MCU	MOS	2.00	4	20,000	0	NA	M
HITACHI	KODAIRA-SHI	TOKYO	NA	4-bit 8-bit MCU	MOS	1.50	5	30,000	0	NA	M
HITACHI	KODAIRA-SHI	TOKYO	NA	4Mb DRAM 16Mb DRAM	CMOS	0.50	6	8,000	0	NA	M
HITACHI	KODAIRA-SHI	TOKYO	R&D	MPU SRAM DRAM ARRAYS CBIC	CMOS M2	1.30	6	15,000	0	NA	M
HITACHI	KODAIRA-SHI	TOKYO	R&D	MPU MEM CBIC	CMOS M2	1.20	5	15,000	0	10	M
HITACHI	NAKAKOMA-GUN	YAMANASHI	IMASUWA	4Mb DRAM 4Mb SRAM 16Mb PROTO DRAM	CMOS	0.60	6	25,000	0	NA	M
HITACHI	NAKAKOMA-GUN	YAMANASHI	K-2	4Mb DRAM 16Mb DRAM	CMOS	0	8	3,000	0	NA	M
HITACHI	NAKAKOMA-GUN	YAMANASHI	LSI	NA	MOS	3.00	4	30,000	0	NA	M
HITACHI	NAKAKOMA-GUN	YAMANASHI	NO. K2-1	NA	NA	2.00	4	15,000	0	NA	M
HITACHI	NAKAKOMA-GUN	YAMANASHI	NO. K2-2	NA	MOS	2.00	5	20,000	0	NA	M
HITACHI	NAKAKOMA-GUN	YAMANASHI	NO. K3	64K SRAM	MOS	1.50	5	15,000	3,997	NA	M
HITACHI	NAKAKOMA-GUN	YAMANASHI	NO. K4-1	MEM MPU LOG	MOS	2.00	5	20,000	0	NA	M
HITACHI	NAKAKOMA-GUN	YAMANASHI	NO. K4-2	1Mb DRAM	CMOS	1.00	6	20,000	0	NA	M

(Continued)

Table 1 (Continued)
Japanese Existing Pilot and Production Fab Lines
(Including Fabs Going into Operation During 1992)

Company	City or District	Prefecture	Fab Name	Products Produced	Process Technology	Est. Minimum Line Width (Microns)	Wafer Diameter (Inches)	Est. Max. Wafer Capacity (Wfrs/Mo)	Clean Room (Square Meters)	Clean Room Class	Merchant or Captive
HITACHI	NAKAKOMA-GUN	YAMANASHI	NO. K4-3	4Mb DRAM 1Mb SRAM EPROM	CMOS MOS	0.80	6	10,000	0	100	M
HONDA	HAGA-GUN	TOCHIGI	NA	ENG. CONTROL SENSORS MMIC	GaAs	0	3	0	0	NA	C
IBM	YASU-GUN	SHIGA	NA	4Mb DRAM 16Mb DRAM	CMOS	0.60	8	10,000	3,717	NA	M
IBM	YASU-GUN	SHIGA	NA	ARRAY 1Mb DRAM MPU ROM	CMOS	1.00	5	30,000	4,554	NA	M
IWATSU	HACHIOJI-SHI	TOKYO	NA	NA	CMOS	1.50	5	6,000	0	NA	C
JVC	YOKOSUKA-SHI	KANAGAWA	NA	1K ARRAYS DSP CUSTOM	CMOS	3.00	3	9,000	0	NA	C
KAWASAKI STEEL	UTSUNOMIYA-SHI	TOCHIGI	NA	256K SRAM CBIC ARRAYS	CMOS	0.80	6	10,000	0	NA	M
KODENSHI	UJI-SHI	KYOTO	PLANT 3	DIS DIODE TRAN	GaAs GaP	0	0	0	0	NA	M
KTI SEMICONDUCTOR	NISHIWAKI-SHI	HYOGO	NA	16Mb DRAM 4Mb DRAM	CMOS	0.50	8	9,000	0	1	C
KYOTO SEMICONDUCTOR	KYOTO-SHI	KYOTO	NA	LED TRAN IMAGE SENSOR	GaAs GaP	0	0	0	0	10,000	M
MATSUSHITA	HIOKI-GUN	KAGOSHIMA	NA	OPTO LED HEMT	GaP MOS	0	0	0	0	100	M
MATSUSHITA	KYOTO-SHI	KYOTO	LAB	16Mb DRAM	CMOS	0	8	1,000	0	NA	M
MATSUSHITA	NAGAOKAKYO-SHI	KYOTO	NA	PWR TRAN	BIP	3.00	4	20,000	0	1,000	M
MATSUSHITA	NAGAOKAKYO-SHI	KYOTO	NA	TTL LOG PWR TRAN CUSTOM	MOS	2.00	4	15,000	0	1,000	M
MATSUSHITA	NAGAOKAKYO-SHI	KYOTO	NA	TRAN CCD DIODE	MOS	0	5	18,000	0	NA	M
MATSUSHITA	NAGAOKAKYO-SHI	KYOTO	NA	LOG PWR TRAN CUSTOM	CMOS	2.00	4	15,000	0	NA	M
MATSUSHITA	ARAI-SHI	NIIGATA	FAB B-3	DRAM SRAM MPU	MOS	2.00	5	45,000	0	NA	M
MATSUSHITA	ARAI-SHI	NIIGATA	FAB C-1	CCD	MOS	1.50	4	15,000	0	100	M
MATSUSHITA	ARAI-SHI	NIIGATA	FAB C-2	DRAM SRAM MPU ROM	MOS	1.50	5	35,000	0	100	M
MATSUSHITA	ARAI-SHI	NIIGATA	FAB D	LOG LIN CCD	BIP	3.00	5	20,000	0	100	M
MATSUSHITA	UTSUNOMIYA-SHI	TOCHIGI	KIYAHARA	SST DIODE	MOS	0	4	8,000	0	NA	M
MATSUSHITA	UOZU-SHI	TOYAMA	FAB A-1	16-bit MPU ARRAYS	CMOS	1.50	5	15,000	0	100	M
MATSUSHITA	UOZU-SHI	TOYAMA	FAB A-2	MPU ROM EPROM EEPROM	MOS	1.50	5	15,000	0	100	M
MATSUSHITA	UOZU-SHI	TOYAMA	FAB B	MPU MCU EEPROM	CMOS	1.00	6	25,000	0	10	M
MATSUSHITA	UOZU-SHI	TOYAMA	FAB C-1	4Mb DRAM 1Mb DRAM	CMOS	0.80	6	20,000	0	10	M

(Continued)

Table 1 (Continued)
Japanese Existing Pilot and Production Fab Lines
(Including Fabs Going into Operation During 1992)

Company	City or District	Prefecture	Fab Name	Products Produced	Process Technology	Est. Minimum Line Width (Microns)	Wafer Diameter (Inches)	Est. Max. Wafer Capacity (4wk/Mo)	Clean Room (Square Meters)	Clean Room Class	Merchant or Captive
MATSUSHITA	UOZU-SHI	TOYAMA	FAB C-2	16Mb DRAM 64Mb DRAM SRAM	CMOS	0.80	6	8,000	0	1	M
MEIDENSHA	NUMAZU-SHI	SHIZUOKA	NA	GTO THYRISTOR	NA	0	5	7,000	0	NA	M
MITSUBISHI	SAIJO-SHI	EHIME	A-1F	4Mb DRAM 16Mb DRAM	CMOS M2	0.50	8	5,000	5,576	NA	M
MITSUBISHI	SAIJO-SHI	EHIME	A-2F	4Mb DRAM 16Mb DRAM	CMOS M2	0.50	6	20,000	5,576	NA	M
MITSUBISHI	SAIJO-SHI	EHIME	B	ASIC MCU MPU	CMOS M1	1.20	5	38,000	4,002	NA	M
MITSUBISHI	SAIJO-SHI	EHIME	C	8-BIT MCU MPU ASIC	CMOS M2	0.80	5	38,000	4,002	10	M
MITSUBISHI	FUKUOKA-SHI	FUKUOKA	#1	PWR TRAN DIODE	BIP	3.00	4	25,000	0	NA	M
MITSUBISHI	FUKUOKA-SHI	FUKUOKA	#2	LOG LIN A/D D/A DIS	BIP	2.00	6	25,000	0	NA	M
MITSUBISHI	ITAMI-SHI	HYOGO	NA	ARRAYS OPTO LASER	CMOS MOS	2.00	5	28,000	651	10	M
MITSUBISHI	ITAMI-SHI	HYOGO	NA	FET OPTO HEMT	GaAs	0	3	0	0	NA	M
MITSUBISHI	ITAMI-SHI	HYOGO	R&D	16Mb DRAM	CMOS	0.35	8	1,000	0	1	M
MITSUBISHI	KAMI-GUN	KOCHI	FAB A (TA-1F)	4Mb DRAM 1Mb SRAM	CMOS	1.00	6	25,000	0	NA	M
MITSUBISHI	KAMI-GUN	KOCHI	NA	8-bit MCU 16-bit MCU 32-bit MCU ASIC	CMOS	1.00	6	10,000	0	10	M
MITSUBISHI	KIKUCHI-GUN	KUMAMOTO	B-1F	EPROM	CMOS	1.50	5	30,000	0	NA	M
MITSUBISHI	KIKUCHI-GUN	KUMAMOTO	B-2F	ARRAYS	CMOS	2.00	4	42,000	0	NA	M
MITSUBISHI	KIKUCHI-GUN	KUMAMOTO	C-1F	EPROM	CMOS	1.50	5	25,000	0	NA	M
MITSUBISHI	KIKUCHI-GUN	KUMAMOTO	C-2F	1Mb SRAM 1Mb ROM ARRAYS	MOS CMOS	0.80	5	25,000	0	NA	M
MITSUMI	ATSUGI-SHI	KANAGAWA	NA	LOG DIS	BIP	0	4	30,000	0	100	M
MORIRICA ELECTRONICS	YOKOHAMA-SHI	KANAGAWA	NA	OPTO	GaP	0	0	0	0	NA	M
MOTOROLA	YAMA-GUN	FUKUSHIMA	MOS 7	CBIC MCU SRAM ROM PWR ICs	CMOS MOS M1	1.80	4	25,000	2,212	100	M
MURATA MANUFACTURING	KYOTO-SHI	KYOTO	NA	FET MMIC	GaAs	0.80	0	0	0	NA	M
NEC	HIGASHI HIROSHIMA-SHI	HIROSHIMA	PHASE 1	4Mb DRAM SRAM MPU 4Mb ROM	CMOS	0.60	6	30,000	3,602	1	M
NEC	IZUMI-SHI	KAGOSHIMA	NA	LIN TELECOM LASER	BIP GaAs	0.80	4	4,200	0	NA	M
NEC	KAWASAKI-SHI	KANAGAWA	NA	ASIC EPROM MCU MPU	CMOS MOS	1.40	5	20,000	0	NA	M
NEC	SAGAMIHARA-SHI	KANAGAWA	BLDG. UL	EPROM ASIC MPU MCU	CMOS	1.20	5	12,000	5,403	NA	M
NEC	SAGAMIHARA-SHI	KANAGAWA	G-1	4Mb DRAM ASIC MPU 4Mb ROM	CMOS BICMOS	0.80	6	10,000	4,302	10	M
NEC	KUMAMOTO-SHI	KUMAMOTO	FAB 3	EPROM ROM	MOS	2.00	5	20,000	0	NA	M
NEC	KUMAMOTO-SHI	KUMAMOTO	FAB 4	ASIC EPROM MCU MPU	CMOS MOS	1.40	5	20,000	4,182	100	M

(Continued)

Table 1 (Continued)
Japanese Existing Pilot and Production Fab Lines
(Including Fabs Going into Operation During 1992)

Company	City or District	Prefecture	Fab Name	Products Produced	Process Technology	Est. Minimum Line Width (Microns)	Wafer Diameter (Inches)	Est. Max. Wafer Capacity (4wk/Mo)	Clean Room (Square Meters)	Clean Room Class	Merchant or Captive
NEC	KUMAMOTO-SHI	KUMAMOTO	FAB 6	1Mb DRAM MPU ARRAYS	MOS POLY2	1.00	6	45,000	4,647	100	M
NEC	KUMAMOTO-SHI	KUMAMOTO	FAB 7	MCU 4Mb DRAM ASIC	CMOS BICMOS	1.00	6	30,000	6,506	10	M
NEC	OTSU-SHI	SHIGA	GaAs	PWR TRAN DIS CCD	GaAs	4.00	2	2,000	0	NA	M
NEC	OTSU-SHI	SHIGA	NO. 1	PWR TRAN DIS CCD	BIP	4.00	4	12,000	0	1,000	M
NEC	OTSU-SHI	SHIGA	NO. 2	LIN CCD	MOS	3.00	4	12,000	0	1,000	M
NEC	OTSU-SHI	SHIGA	NO. 3	ARRAYS SRAM 8-bit MPU	CMOS MOS	2.00	5	6,000	0	NA	M
NEC	OTSU-SHI	SHIGA	NO. 4	ARRAYS MCU SRAM 4Mb DRAM	CMOS	0.80	6	20,000	0	100	M
NEC	TSURUOKA-SHI	YAMAGATA	TSURUOKA W	LOG LIN DIS	BIP	3.00	4	20,000	0	NA	M
NEC	TSURUOKA-SHI	YAMAGATA	TSURUOKA W	LOG LIN	BIP	2.00	5	20,000	0	NA	M
NEC	ASA-GUN	YAMAGUCHI	PHASE 1	1Mb DRAM 4Mb DRAM	CMOS MOS	0.80	6	30,000	0	10	M
NEC	ASA-GUN	YAMAGUCHI	PHASE 2	4Mb DRAM 1Mb SRAM MPU	CMOS BICMOS	0.80	6	30,000	2,301	10	M
NEC	OTSUKI-SHI	YAMANASHI	NA	OPTO	NA	2.00	5	30,000	0	100	M
NEW JAPAN RADIO	KAMIFUKUOKA-SHI	SAITAMA	NA	OP AMP A/D D/A REG	BIP	0	4	17,000	0	1,000	M
NEW JAPAN RADIO	KAMIFUKUOKA-SHI	SAITAMA	NA	LED FET DIODE	GaAs GaAlAs	1.50	3	2,800	0	NA	M
NEW JAPAN RADIO	KAMIFUKUOKA-SHI	SAITAMA	NA	CUSTOM LOG A/D D/A OPTO	CMOS	1.20	5	20,000	0	10	M
NEW JAPAN RADIO	KAMIFUKUOKA-SHI	SAITAMA	NA	OP AMP	BIP	0	3	25,000	0	NA	M
NIHON INTER ELECTRONICS	HADANO-SHI	KANAGAWA	NA	MOSFET DIODE RECTIFIER	BIP	0	3	20,000	0	NA	M
NIHON SEMICONDUCTOR	TSUKUBA-SHI	IBARAKI	PHASE 1	ARRAYS CBIC	CMOS	1.00	6	4,700	4,423	10	M
NIPPONDENSO	KARIYA-SHI	AICHI	BLDG. 1	LOG CUSTOM MCU OPTO	MOS	1.50	5	2,000	0	NA	M
NIPPONDENSO	KARIYA-SHI	AICHI	NA	DIODE LOG CUSTOM MCU	BIP MOS	3.00	4	10,000	0	NA	M
NIPPON PRECISION CIRC.	NASU-GUN	TOCHIGI	NA	A/D D/A DSP LOG ASSP	CMOS	0.80	6	20,000	2,001	1	M
NIPPON PRECISION CIRC.	NASU-GUN	TOCHIGI	NA	LOG LIN A/D D/A MODEM	CMOS	2.00	4	13,000	3,001	1,000	M
NIPPON STEEL	SAGAMIHARA-SHI	KANAGAWA	SEMICONDUCTOR DEVICE R&D CTR.	ASIC	NA	0.80	6	0	0	NA	M
NISSAN	YOKOSUKA-SHI	KANAGAWA	NA	MCU CUSTOM	CMOS	2.00	5	500	1,501	10	C

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Table 1 (Continued)
Japanese Existing Pilot and Production Fab Lines
(Including Fabs Going into Operation During 1992)

Company	City or District	Prefecture	Fab Name	Products Produced	Process Technology	Est. Minimum Line Width (Microns)	Wafer Diameter (Inches)	Est. Max. Wafer Capacity (4wk/Mo)	Clean Room (Square Meters)	Clean Room Class	Merchant or Captive
NKK	AYASE-SHI	KANAGAWA	PHASE 1	1Mb SRAM 4Mb SRAM MASK ROM RISC 256K SRAM MPU ASIC	NA	0.80	8	6,000	0	1	M
NMB SEMICONDUCTOR	TATEYAMA-SHI	CHIBA	M1	256K DRAM 8-BIT MPU ASIC	CMOS	1.20	5	20,000	3,996	1	M
NMB SEMICONDUCTOR	TATEYAMA-SHI	CHIBA	M2	1Mb DRAM FLASH	CMOS MI	0.80	6	15,000	3,996	1	M
NMB SEMICONDUCTOR	TATEYAMA-SHI	CHIBA	M3	4Mb DRAM	CMOS	0.50	6	15,000	0	1	M
OKI	KUROKAWA-GUN	MIYAGI	NA	ARRAYS 1Mb DRAM VRAM LOG	CMOS	0.80	6	20,000	0	10	M
OKI	KUROKAWA-GUN	MIYAGI	S1	4Mb DRAM VRAM 1Mb SRAM	CMOS	0.60	6	25,000	0	NA	M
OKI	MIYAZAKI-GUN	MIYAZAKI	M1	DRAM SRAM ARRAYS MPU	CMOS	1.50	4	30,000	0	100	M
OKI	MIYAZAKI-GUN	MIYAZAKI	M2	DRAM EEPROM ASIC	CMOS	1.00	5	20,000	2,801	10	M
OKI	MIYAZAKI-GUN	MIYAZAKI	M3	4Mb DRAM 16Mb DRAM 90K ARRAYS	CMOS	0.50	6	15,000	8,400	NA	M
OKI	HACHIOJI-SHI	TOKYO	V-1	NA	MOS GaAs	0	3	50,000	0	NA	M
OKI	HACHIOJI-SHI	TOKYO	V-2	ARRAYS CBIC MPU	BIP BICMOS	2.00	4	40,000	0	100	M
OKI	HACHIOJI-SHI	TOKYO	V-3	16Mb DRAM 64Mb DRAM	CMOS BICMOS	0.30	8	500	2,601	NA	M
OLYMPUS	KAMIINA-GUN	NAGANO	NA	SIT IMAGE SENSOR	CMOS	3.00	5	5,000	0	NA	C
OMRON	KOUKA-GUN	SHIGA	NA	OPTO IMAGE SENSOR	BIP GaP	3.00	4	1,000	1,321	NA	M
OMRON	KOUKA-GUN	SHIGA	NA	OPTO IMAGE SENSOR	BIP GaP	0	4	20,000	4,622	NA	M
ORIGIN ELECTRIC	OYAMA-SHI	TOCHIGI	NA	TRAN DIODE DIS	BIP	0	4	17,000	0	NA	M
PIONEER VIDEO	KOFU-SHI	YAMANASHI	NA	ARRAYS LOG SAW CCD	CMOS	3.00	5	8,000	0	NA	C
RICOH	IKEDA-SHI	OSAKA	NA	ARRAYS ROM PLD LOG	BICMOS CMOS	2.00	4	15,000	1,421	100	M
RICOH	IKEDA-SHI	OSAKA	NA	256K ROM ARRAYS CBIC	CMOS MOS	1.30	6	7,000	0	100	M
RICOH	IKEDA-SHI	OSAKA	NA	ARRAYS	CMOS	1.00	6	10,000	0	NA	M
ROHM	CHIKUGO-SHI	FUKUOKA	NA	TRAN DIS	BIP	0	4	20,000	0	NA	M
ROHM	KYOTO-SHI	KYOTO	NA	MPU LASER MODEM TRAN LED	BIP GaAs	0	4	25,000	0	NA	M
ROHM	KYOTO-SHI	KYOTO	NA	MCU ARRAYS SRAM EEPROM	CMOS BICMOS	1.20	6	15,000	2,509	10	M
ROHM	KASAOKA-SHI	OKAYAMA	NA	TRAN DIODE LIN	BIP	0	4	20,000	0	1,000	M
SANKEN	NIIZA-SHI	SAITAMA	NA	PWR TRAN DIODE LED	NA	0	3	15,000	0	1,000	M
SANKEN	NIIZA-SHI	SAITAMA	NA	PWR TRAN DIODE LED	NA	0	5	6,000	0	NA	M

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Table 1 (Continued)
Japanese Existing Pilot and Production Fab Lines
(Including Fabs Going into Operation During 1992)

Company	City or District	Prefecture	Fab Name	Products Produced	Process Technology	Est. Minimum Line Width (Microns)	Wafer Diameter (Inches)	Est. Max. Wafer Capacity (4wk/Mo)	Clean Room (Square Meters)	Clean Room Class	Merchant or Captive
SANKEN	HIGASHINE-SHI	YAMAGATA	NA	PWR TRAN DIODE LED	NA	0	5	10,000	0	1,000	M
SANSHA	KATSUTA-GUN	OKAYAMA	NA	PWR TRAN PWR DIODE	BIP	0	4	25,000	0	NA	M
SANYO	ANPACHI-GUN	GIFU	F	CCD SRAM ARRAYS CBIC ROM	CMOS	1.00	5	25,000	0	10	M
SANYO	ANPACHI-GUN	GIFU	G	CCD ARRAY CBIC	CMOS	1.00	5	15,000	0	10	M
SANYO	OURA-GUN	GUNMA	NA	TRAN DIODE LIN	MOS	2.00	4	40,000	4,182	1,000	M
SANYO	OURA-GUN	GUNMA	NA	LIN	BIP	2.00	4	30,000	4,647	10	M
SANYO	OURA-GUN	GUNMA	R&D CENTER	SRAM DRAM	CMOS	0.80	6	5,000	0	10	M
SANYO	OJIYA-SHI	NIIGATA	A #1	LOG MPU MCU MPR	CMOS	1.20	5	30,000	0	10	M
SANYO	OJIYA-SHI	NIIGATA	A #2	LIN	BIP	2.00	5	25,000	3,502	1,000	M
SANYO	OJIYA-SHI	NIIGATA	B #3	1Mb DRAM 4Mb DRAM	CMOS	0.80	6	20,000	0	NA	M
SANYO	OJIYA-SHI	NIIGATA	C #4	ASIC PLD 1Mb SRAM 16-BIT MPU	CMOS BICMOS	1.00	6	20,000	0	NA	M
SANYO	OJIYA-SHI	NIIGATA	C #5	16-BIT MCU DSP 4Mb DRAM	CMOS BICMOS	1.00	6	20,000	0	NA	M
SANYO	TOTTORI-SHI	TOTTORI	NA	LASER LED	GaAs GaP	5.00	3	20,000	3,001	1,000	M
SEIKO EPSON	SUWA-GUN	NAGANO	BLDG. A	ARRAYS 256K SRAM EPROM	CMOS	1.50	5	30,000	0	100	M
SEIKO EPSON	SUWA-GUN	NAGANO	BLDG. B	ARRAYS CBIC SRAM EEPROM	CMOS MOS	2.00	4	40,000	0	100	M
SEIKO EPSON	SUWA-GUN	NAGANO	BLDG. D	1Mb SRAM ASIC	CMOS BICMOS	0.80	6	25,000	0	NA	M
SEIKO EPSON	SAKATA-SHI	YAMAGATA	NA	256K ARRAYS CBIC 1Mb SRAM	CMOS BICMOS	0.80	6	20,000	0	10	M
SEIKO INSTRUMENTS	MATSUDO-SHI	CHIBA	BLDG. B	TELECOM	CMOS	2.00	4	10,000	0	NA	C
SEIKO INSTRUMENTS	MATSUDO-SHI	CHIBA	NA	SRAM ARRAYS CBIC EEPROM	CMOS	1.25	6	3,000	0	10	C
SHARP	FUKUYAMA-SHI	HIROSHIMA	BLDG. 1	1Mb DRAM SRAM ARRAYS ROM	MOS	1.00	5	35,000	3,502	10	M
SHARP	FUKUYAMA-SHI	HIROSHIMA	BLDG. 2 #1	1Mb DRAM SRAM ROM ASIC	CMOS	0.80	6	24,000	4,182	1	M
SHARP	FUKUYAMA-SHI	HIROSHIMA	BLDG. 2 #2	4Mb DRAM 16Mb DRAM ROM ASIC	CMOS	0.80	6	24,000	4,182	NA	M
SHARP	KITA KATSURAGI-GUN	NARA	NA	DIODE TRAN COUPLERS	NA	0	4	25,000	0	NA	M
SHARP	TENRI-SHI	NARA	NO. 1	LOG LIN	BIP	3.00	4	20,000	0	NA	M
SHARP	TENRI-SHI	NARA	NO. 2	OPTO	CMOS MOS	2.00	4	20,000	0	NA	M

(Continued)

Table 1 (Continued)
Japanese Existing Pilot and Production Fab Lines
(Including Fabs Going into Operation During 1992)

Company	City or District	Prefecture	Fab Name	Products Produced	Process Technology	Est. Minimum Line Width (Microns)	Wafer Diameter (Inches)	Est. Max. Wafer Capacity (4wk/Mo)	Clean Room (Square Meters)	Clean Room Class	Merchant or Captive
SHARP	TENRI-SHI	NARA	NO. 3	ARRAYS CBIC	CMOS MOS BIP	1.20	5	20,000	0	NA	M
SHARP	TENRI-SHI	NARA	NO. 4	NA	MOS	1.50	5	10,000	0	NA	M
SHARP	TENRI-SHI	NARA	TRIAL LINE	ARRAYS	CMOS	0.80	6	1,650	0	10	M
SHARP	YAMATO KORIYAMA-SHI	NARA	NA	LASER LED OPTO	GaAs	0	3	22,000	0	NA	M
SHINDENGEN	HONJO-SHI	AKITA	BLDG. 1	DIODE THYRISTOR	BIP	0	4	20,000	0	NA	M
SHINDENGEN	HONJO-SHI	AKITA	BLDG. 2	DIODE THYRISTOR	BIP	0	5	30,000	1,801	NA	M
SHINDENGEN	HANNO-SHI	SAITAMA	NA	DIS LIN	BIP	0	4	10,000	0	1,000	M
SHINDENGEN	HANNO-SHI	SAITAMA	NA	PWR MOSFET LIN LOG	MOS BIP	2.00	5	22,000	1,861	100	M
SHINDENGEN	HIGASHINE-SHI	YAMAGATA	BLDG. 1	TRAN DIODE	NA	0	4	15,000	0	1,000	M
SHINDENGEN	HIGASHINE-SHI	YAMAGATA	BLDG. 2 MOS	CUSTOM	CMOS MOS	2.00	5	25,000	2,538	NA	M
SHINDENGEN	HIGASHINE-SHI	YAMAGATA	BLDG. 2 DIS.	TRAN DIODE LIN	BIP	0	5	30,000	2,538	NA	M
SONY	KOKUBU-SHI	KAGOSHIMA	#2	DIS	NA	3.00	4	15,000	0	NA	M
SONY	KOKUBU-SHI	KAGOSHIMA	#3	LIN A/D D/A	BIP	2.00	4	25,000	0	NA	M
SONY	KOKUBU-SHI	KAGOSHIMA	#4	SRAM MPU CCD	MOS CMOS	1.30	5	30,000	0	10	M
SONY	KOKUBU-SHI	KAGOSHIMA	#6	LOG MEM MPU LIN DIS OPTO	CMOS BICMOS	0.80	6	20,000	0	NA	M
SONY	KOKUBU-SHI	KAGOSHIMA	NA	CCD	MOS	1.50	4	20,000	0	NA	M
SONY	ATSUGI-SHI	KANAGAWA	NA	FET LASER CCD HEMT	GaAs	0	3	0	0	NA	M
SONY	ATSUGI-SHI	KANAGAWA	NA	EEPROM 4Mb VRAM 4Mb SRAM	CMOS	0.80	6	12,000	0	100	M
SONY	ATSUGI-SHI	KANAGAWA	NA	LIN	BIP	2.00	4	24,000	0	NA	M
SONY	ISAHAYA-SHI	NAGASAKI	1G	256K SRAM CCD	CMOS	1.00	6	20,000	2,323	10	M
SONY	ISAHAYA-SHI	NAGASAKI	2G	CCD 256K SRAM 1Mb SRAM	CMOS	0.80	6	20,000	0	NA	M
SONY	ISAHAYA-SHI	NAGASAKI	3G	1Mb SRAM 4Mb VRAM CCD	CMOS	0.80	6	40,000	0	NA	M
STANLEY	HADANO-SHI	KANAGAWA	NA	LASER LED	NA	0	4	10,000	0	NA	M
SUMITOMO METAL INDUSTRIES	AMAGASAKI-SHI	HYOGO	NA	4Mb DRAM ARRAYS	NA	0.80	6	300	0	NA	C
TEXAS INSTRUMENTS	INASHIKI-GUN	IBARAKI	MIHO 5	ASSP ASIC MCU DSP CBIC	MOS	1.00	5	25,700	3,532	10	M
TEXAS INSTRUMENTS	INASHIKI-GUN	IBARAKI	MIHO 6	1Mb DRAM 4Mb DRAM ASSP RISC	CMOS	0.80	6	21,600	5,576	1	M
TEXAS INSTRUMENTS	HAYAMI-GUN	OITA	HIJI 1	LOG LIN ARRAYS	BIP	1.00	5	8,000	1,673	100	M
TEXAS INSTRUMENTS	HAYAMI-GUN	OITA	HIJI 8	4Mb DRAM 16Mb DRAM	CMOS BICMOS	0.50	8	10,000	1,487	1	M
TEXAS INSTRUMENTS	HATOGAYA-SHI	SAITAMA	HATO	ASIC	CMOS NMOS	1.00	5	17,700	1,208	100	M

(Continued)

Table 1 (Continued)
Japanese Existing Pilot and Production Fab Lines
(Including Fabs Going into Operation During 1992)

Company	City or District	Prefecture	Fab Name	Products Produced	Process Technology	Est. Minimum Line Width (Microns)	Wafer Diameter (Inches)	Est. Max. Wafer Capacity (4wk/Mo)	Clean Room (Square Meters)	Clean Room Class	Merchant or Captive
TOHOKU SEMICONDUCTOR	SENDAI-SHI	MIYAGI	PHASE 1	1Mb DRAM MCU ARRAYS	CMOS	0.80	6	15,000	1,952	10	M
TOHOKU SEMICONDUCTOR	SENDAI-SHI	MIYAGI	PHASE 2	4Mb DRAM SRAM MPU ARRAYS	CMOS BICMOS	0.70	6	20,000	1,952	10	M
TOKIN	SENDAI-SHI	MIYAGI	NA	POWER SIT	BIP	0	3	10,000	0	NA	C
TOKO	IRUMA-GUN	SAITAMA	NA	A/D D/A TELECOM DIODE	BIP	3.50	5	20,000	0	NA	M
TOKO	IRUMA-GUN	SAITAMA	NA	NA	MOS	3.00	5	15,000	0	NA	M
TOREX SEMICONDUCTOR	IBARA-SHI	OKAYAMA	NA	NA	CMOS BIP	1.20	5	12,000	0	NA	M
TOSHIBA	KITA KYUSHU-SHI	FUKUOKA	KUBIC 1	LASER LED	GaAs	2.00	3	25,000	1,601	NA	M
TOSHIBA	KITA KYUSHU-SHI	FUKUOKA	KUBIC 2	ASIC OPTO LOG	BICMOS BIP	2.00	5	30,000	2,001	100	M
TOSHIBA	KITA KYUSHU-SHI	FUKUOKA	NA	LIN	BIP	3.00	5	30,000	4,002	NA	M
TOSHIBA	HIMEJI-SHI	HYOGO	NA	PWR FET GTO TRAN DIODE	CMOS BIP	1.00	5	45,000	0	NA	M
TOSHIBA	HIMEJI-SHI	HYOGO	NA	TRAN DIODE	BIP	3.00	4	30,000	0	NA	M
TOSHIBA	NOMI-GUN	ISHIKAWA	NA	DIS	NA	0	5	40,000	15,007	100	M
TOSHIBA	KITAKAMI-SHI	IWATE	BLDG. 1	ARRAYS CBIC MPU CUSTOM	CMOS	1.50	5	20,000	0	100	M
TOSHIBA	KITAKAMI-SHI	IWATE	BLDG. 2	4Mb ROM 4Mb EEPROM	CMOS	1.00	6	15,000	0	100	M
TOSHIBA	KITAKAMI-SHI	IWATE	BLDG. 2	ARRAYS CCD	CMOS	1.50	5	20,000	0	NA	M
TOSHIBA	KITAKAMI-SHI	IWATE	BLDG. 3	4Mb EPROM ROM 172K ARRAYS	BICMOS CMOS	0.80	5	24,000	0	NA	M
TOSHIBA	KITAKAMI-SHI	IWATE	BLDG. 3	ARRAYS CBIC	CMOS BICMOS	0.70	6	10,000	0	NA	M
TOSHIBA	KAWASAKI-SHI	KANAGAWA	FAB B	4Mb DRAM 16Mb DRAM	CMOS	0.50	8	1,300	0	NA	M
TOSHIBA	KAWASAKI-SHI	KANAGAWA	NA	1Mb DRAM 4Mb DRAM 16Mb DRAM	CMOS	0.80	6	10,000	0	NA	M
TOSHIBA	KAWASAKI-SHI	KANAGAWA	NA	LOG LIN	BIP	2.00	5	15,000	0	NA	M
TOSHIBA	YOKKAICHI-SHI	MIE	PHASE 1	4Mb DRAM 16Mb DRAM	CMOS	0.60	8	15,000	3,717	1	M
TOSHIBA	OITA-SHI	OITA	C-1	256K DRAM 1Mb DRAM	CMOS MOS	1.00	5	30,000	0	100	M
TOSHIBA	OITA-SHI	OITA	C-2	1Mb DRAM	CMOS	1.00	5	30,000	0	NA	M
TOSHIBA	OITA-SHI	OITA	C-3 #1	1Mb DRAM	CMOS	1.00	6	14,000	0	NA	M
TOSHIBA	OITA-SHI	OITA	C-3 #2	1Mb DRAM	CMOS	1.00	6	15,000	0	NA	M
TOSHIBA	OITA-SHI	OITA	C-4 #1	4Mb DRAM 256K SRAM ASIC	CMOS	0.80	6	15,000	0	NA	M

(Continued)

Table 1 (Continued)
Japanese Existing Pilot and Production Fab Lines
(Including Fabs Going into Operation During 1992)

Company	City or District	Prefecture	Fab Name	Products Produced	Process Technology	Est. Minimum Line Width (Microns)	Wafer Diameter (Inches)	Est. Max. Wafer Capacity (4wk/Mo)	Clean Room (Square Meters)	Clean Room Class	Merchant or Captive
TOSHIBA	OITA-SHI	OITA	C-4 #2	4Mb DRAM	CMOS	0.80	6	15,000	0	NA	M
TOSHIBA	OITA-SHI	OITA	LSI 1	MPU LOG	MOS	2.00	4	20,000	0	NA	M
TOSHIBA	OITA-SHI	OITA	LSI 2	MPU LOG ROM EPROM	CMOS MOS	1.50	5	45,000	0	NA	M
TOSHIBA	OITA-SHI	OITA	STEP 4	4Mb DRAM 16Mb DRAM VRAM	NA	0.50	6	40,000	0	1	M
TOSHIBA COMPONENTS	KIMITSU-SHI	CHIBA	PHASE 1	DIODE RECTIFIER THYRISTOR	BIP	0	4	20,000	0	NA	M
TOSHIBA COMPONENTS	KIMITSU-SHI	CHIBA	PHASE 2	DIODE RECTIFIER THYRISTOR	BIP	0	5	18,000	0	NA	M
TOYODA AUTOMATIC LOOM WORKS	OBU-SHI	AICHI	KYOWA	AUTOMOTIVE	NA	0	0	0	0	NA	M
TOYODA MACHINE WORKS	KARIYA-SHI	AICHI	HIGASHI KARIYA	AUTOMOTIVE	NA	0	0	0	0	NA	M
TOYOTA MOTOR	TOYOTA-SHI	AICHI	NA	MCU PWR ICs CUSTOM	CMOS BIP	2.00	5	500	0	100	C
UNIZON	ITAMI-SHI	HYOGO	NA	ZENER DIODE REG ARRAYS	BIP	0	5	15,000	0	NA	M
YAMAHA	AIRA-GUN	KAGOSHIMA	NA	LIN ROM CBIC ASSP MPR	CMOS MOS	1.20	5	8,000	0	NA	M
YAMAHA	AIRA-GUN	KAGOSHIMA	NA	ROM CBIC ASSP	CMOS	0.80	6	8,000	0	NA	M
YAMAHA	IWATA-GUN	SHIZUOKA	EE DEV CTR	CBIC LOG	CMOS	0.80	6	6,000	0	10	M
YOKOGAWA IMT	KAMIINA-GUN	NAGANO	NA	TRAN DIODE OPTO	BIP CMOS	3.00	4	7,000	0	100	M

NA = Not available
Source: Dataquest (October 1992)

Table 2
Japanese Future Pilot and Production Fab Lines
Planned Facilities by Year

Company	City or District	Prefecture	Fab Name	Products	Process Technology	Facility Type	Target Date Facility to Begin Operation	Est. Minimum Line Width (Microns)	Wafer Size (Inches)	Est. Wafer Start Capacity (4 Wk/ Month)	Clean Room (Square Meters)
Production Begins: 1993											
ASAHI KASEI	NOBEOKA-SHI	MIYAZAKI	NA	ASIC SRAM	CMOS	F	12/31/93	0.80	6	16,500	4,433
FUJITSU	AIZU WAKAMATSU-SHI	FUKUSHIMA	BLDG. 2 #2	ARRAYS CBIC 32-bit MCU	CMOS	F	NA	0.50	6	15,000	5,251
FUJITSU	IZAWA-GUN	IWATE	NO. 4-2	16Mb DRAM	CMOS	F	NA	0.50	8	15,000	0
MATSUSHITA	TONAMI-SHI	TOYAMA	FAB #1	4Mb & 16Mb DRAM ASIC MPU MCU	CMOS	F	06/01/93	0	6	20,000	0
NEC	KUMAMOTO-SHI	KUMAMOTO	FAB 8	16Mb DRAM 4Mb SRAM RISC MPU	CMOS	F	04/15/93	0.50	8	20,000	3,716
NEC	TSURUOKA-SHI	YAMAGATA	TSURUOKA W	ASIC MCU	CMOS	F	04/01/93	0.60	6	20,000	0
NIHON SEMICONDUCTOR	TSUKUBA-SHI	IBARAKI	PHASE 2	ARRAYS CBIC MPU 1Mb SRAM	NA	F	05/01/93	0.80	6	25,000	4,180
NIPPONDENSO	NUKATA-GUN	AICHI	NA	MCU CUSTOM	MOS	F	NA	0	6	10,000	0
SHARP	FUKUYAMA-SHI	HIROSHIMA	FAB 3	4Mb SRAM MASK ROM FLASH	CMOS	F	03/01/93	0.50	8	12,000	0
TOYODA GOSEI	NISHI KASUGAI-GUN	AICHI	NA	LED	COMPOUND SEMI-CONDUCTOR	F	12/31/93	25.00	2	0	0
Production Begins: 1994											
FUJITSU	NA		NA	EPROM FLASH	CMOS	F	12/31/94	0.50	8	20,000	0
MOTOROLA	SENDAI-SHI	MIYAGI	MOS 10	4Mb DRAM MPU CUSTOM	CMOS	F	04/01/94	0.80	6	25,000	2,323
Production Begins: 1995											
KAWASAKI STEEL	UTSUNOMIYA-SHI	TOCHIGI	PHASE 2	SRAM DRAM ARRAYS	CMOS	F	NA	0	6	20,000	0
NEC	HIGASHI HIROSHIMA-SHI	HIROSHIMA	PHASE 2	EPROM 4Mb DRAM 16Mb DRAM	CMOS	F	05/01/95	0.60	8	30,000	0
NIHON SEMICONDUCTOR	TSUKUBA-SHI	IBARAKI	PHASE 3	ASIC CBIC MPU SRAM MPR	CMOS BICMOS	F	NA	0.50	8	20,000	4,180
NISSAN	NA	NA	NA	CUSTOM	NA	FAT	NA	0	0	0	0
OKI	MIYAZAKI-GUN	MIYAZAKI	M4	16Mb DRAM	CMOS	F	03/31/95	0.50	8	20,000	8,400
SANYO	OJIYA-SHI	NIIGATA	D #6	16Mb DRAM 64Mb DRAM	CMOS	F	NA	0	8	15,000	0

(Continued)

Table 2 (Continued)
Japanese Future Pilot and Production Fab Lines
Planned Facilities by Year

Company	City or District	Prefecture	Fab Name	Products	Process Technology	Facility Type	Target Date Facility to Begin Operation	Est. Minimum Line Width (Microns)	Wafer Size (Inches)	Est. Wafer Start Capacity (4 Wk/ Month)	Clean Room (Square Meters)
SEIKO EPSON	SUWA-GUN	NAGANO	BLDG. E	SRAM ARRAYS	CMOS BICMOS	NFAT	NA	0	0	0	0
TOSHIBA	OITA-SHI	OITA	STEP 5	NA	NA	F	NA	0	8	20,000	0
Production Begins: 1999											
KAWASAKI STEEL	UTSUNOMIYA-SHI	TOCHIGI	PHASE 3	16Mb DRAM SRAM ARRAYS	CMOS	F	NA	0	6	15,000	0

NA = Not available
Notes:
F = Production fab
A = Assembly
T = Test
N = Nondedicated foundry
Source: Dataquest (October 1992)

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North American Fab Database

October 27, 1992

Source: Dataquest

Market Statistics

Semiconductor Equipment, Manufacturing, and Materials

SEMM-SVC-MS-9205

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North American Fab Database

October 27, 1992

Source: Dataquest

Market Statistics

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North American Fab Database

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Note: All tables show estimated data.

North American Fab Database

Background

The material in this document applies to the North American portion of Dataquest's Semiconductor Equipment, Manufacturing, and Materials service wafer fab database. The wafer fab database is updated on an ongoing basis, employing both primary and secondary research methodologies. The tables included in this document highlight both production and pilot line wafer fabs.

Research Methodology

Dataquest takes a three-pronged approach to wafer fab database research. Information is gained through extensive annual primary research. This survey work is further supplemented with comprehensive secondary research conducted on an ongoing basis. The database is updated daily, which allows Dataquest to provide a snapshot of the marketplace at any time. The information gathered through primary and secondary research is then further supplemented and cross-checked with Dataquest's various other information sources.

General Definitions

Fab line: A fab line is a processing line in a clean room that is equipped to do all front-end wafer processing. Occasionally there are two separate product-specific fab lines or two different wafer sizes in a clean room. In this situation, a clean room will be documented as two fab lines if the equipment is dedicated to each wafer size or product line. There can be many fab lines at one location.

Front-end wafer processing: Front-end wafer processing is defined as all steps involved with semiconductor processing, beginning with initial oxide and ending at wafer probe.

Production fab: A production fab is defined as a wafer fab capable of front-end processing more than 1,250 wafers per week (type = F).

Pilot fab: A pilot fab is defined as a wafer fab capable of front-end processing less than 1,250 wafers per week (type = P).

Definition of Table Columns

The Products Produced column contains information for seven product categories. The information in this column can be very detailed, depending on its availability. The nomenclature used within the seven product groups of the fab database is as follows, with definitions where warranted:

- Analog
  - LIN—Linear/analog devices
  - A/D D/A—Analog-to-digital, digital-to-analog converters
  - AUTOMOTIVE—Dedicated to automobile applications
  - CODEC—Coder/decoder
  - INTERFACE—Interface IC
  - MESFET (GaAs)—Metal Schottky field-effect transistor
  - MODFET (GaAs)
  - MDIODE (GaAs)—Microwave diode
  - MFET (GaAs)—Microwave field-effect transistor
  - MODEM—Modulator/demodulator
  - MMIC—Monolithic microwave IC
  - OP AMP—Operational amplifier
  - PWR IC—Power IC
  - REG—Voltage regulator
  - SMART PWR—Smart power
  - SWITCHES—Switching device
  - TELECOM—Telecommunications chips
- Memory
  - MEM—Memory
  - RAM—Random-access memory

- DRAM—Dynamic RAM
- SRAM 4 TR.—Static RAM uses a 4-transistor cell design
- SRAM 6 TR.—Static RAM uses a 6-transistor cell design
- VRAM—Video RAM
- ROM—Read-only memory
- PROM—Programmable ROM
- EPROM—Ultraviolet erasable PROM
- EEPROM or E2—Electrically erasable PROM
- FERRAM—Ferroelectric RAM
- FLASH—Flash memory
- NVMEM—Nonvolatile memory (ROM, PROM, EPROM, EEPROM, FERRAM)
- FIFO—First-in/first-out memory
- SPMEM—Other specialty memory (such as dual-port, shift-register, color lookup)

• Micrologic

- ASSP—Application-specific standard product
- BIT—Bit slice (subset of MPU functions)
- DSP—Digital signal processor
- MCU—Microcontroller unit
- MPR—Microperipheral
- MPRCOM—MPR digital communication (ISDN, LAN, UART, modem)
- MPU—Microprocessor unit
- LISP—32-bit list instruction set processor for AI applications
- RISC—Reduced-instruction-set computation 32-bit MPU

• Standard logic

- LOG—Standard logic

• ASIC logic

- ASIC—Application-specific IC
- ARRAYS—Gate arrays
- CBIC—Cell-based IC
- CUSTOM—Full-custom IC (single user)
- PLD—Programmable logic device

• Discrete

- DIS—Discrete
- DIODE
- FET—Field-effect transistor
- GTO—Gate turn-off thyristor
- HEMT (GaAs)—High-electron-mobility transistor
- MOSFET—MOS-based field-effect transistor
- PWR TRAN—Power transistor
- RECTIFIER
- RF—Radio frequency
- SCR—Schottky rectifier
- SENSORS
- SST—Small-signal transistor
- THYRISTOR
- TRAN—Transistor
- ZENER DIODE

• Optoelectronic

- OPTO—Optoelectronic
- CCD—Charge-coupled device (imaging)
- COUPLERS—Photocouplers
- IED—Infrared-emitting diode
- IMAGE SENSOR
- LASER (GaP)—Semiconductor laser or laser IC
- LED—Light-emitting diode
- PDIODE—Photo diode
- PTRAN—Photo transistor
- SAW—Surface acoustic wave device
- SIT IMAGE SENSOR—Static induction transistor image sensor

The Process Technology column lists four major types of technologies. This column also lists a few uncommon technologies along with available information on levels of metal, type of well, and logic structure. Definitions of the nomenclature used in the Process Technology column are as follows:

- MOS (silicon-based)
  - CMOS—Complementary metal-oxide semiconductor
  - MOS—n-channel metal-oxide semiconductor (NMOS) and p-channel metal-oxide semiconductor (PMOS). (More than 90 percent of the MOS fabs use n-channel MOS.)
  - M1—Single-level metal
  - M2—Double-level metal
  - M3—Triple-level metal
  - N-WELL
  - P-WELL
  - POLY1—Single-level polysilicon
  - POLY2—Double-level polysilicon
  - POLY3—Triple-level polysilicon
- BiCMOS (silicon-based)
  - BiCMOS—Bipolar and CMOS combined on a chip
  - BIMOS—Bipolar and MOS combined on a chip
  - ECL I/O—ECL input/output
  - TTL I/O—TTL input/output
- Bipolar (silicon-based)
  - BIP—Bipolar
  - ECL—Emitter-coupled logic
  - TTL—Transistor-transistor logic
  - STTL—Schottky TTL
- Gallium arsenide and other compound semiconductor materials
  - GaAs—Gallium arsenide
  - GaAlAs—Gallium aluminum arsenide
  - GaAs on Si—Gallium arsenide on silicon
  - GaP-Gallium phosphide
  - HgCdTe—Mercuric cadmium telluride
  - InAs—Indium arsenide
  - InP—Indium phosphide
  - InSb—Indium antimony
  - LiNbO3—Lithium niobate
  - SOS—Silicon on sapphire

The number in the Minimum Linewidth column represents the minimum linewidth at the critical mask layers as drawn. This number is stated in microns and is defined in Dataquest's fab survey as being available in production volumes.

The Wafer Size column represents the wafer diameter expressed colloquially in inches. However, for wafers greater than 3 inches in diameter, the colloquial expression is inaccurate. When calculating square inches, the following approximations are used:

Stated Diameter	Approximate Diameter
4 inches (100mm)	3.938 inches
5 inches (125mm)	4.922 inches
6 inches (150mm)	5.906 inches
8 inches (200mm)	7.87 inches

Wafer Start Capacity is defined in the fab survey as the equipment-limited wafer start capacity per four-week period. Start capacity is not limited by current staffing or the number of shifts operating, it is limited only by the installed equipment in the fab and the complexity of the process it runs.

The Clean Room Class column represents the level of cleanliness in the cleanest part of the clean room. This area represents the true environment to which the wafer is exposed.

The Merchant or Captive column categorizes each fab line on the tables as one of these two types. Definitions of the various categories are as follows:

- A Merchant fab line is a fab line that produces devices that end up available on the merchant market.
- A Captive fab line does not sell any of its devices on the merchant market. All production is consumed by the owner of the fab line.

Table 1
North American Existing Pilot and Production Fab Lines (Including Fabs Going into Operation During 1992)

Company	City	State	Fab Name	Products Produced	Process Technology	Est. Minimum Line Width (Microns)	Wafer Diameter	Est. Max. Wafer Capacity (4wk/Mo)	Clean Room (Square Feet)	Class Clean Room	Merchant or Captive
ADAMS-RUSSELL COMPANY	BURLINGTON	MA	NA	MESFET MMIC RAD-HARD	GaAs	0.50	3	400	2,500	10	M
ADVANCED POWER TECHNOLOGY INC.	BEND	OR	NA	POWER MOSFET	MOS	5.00	4	2,400	8,000	100	M
ALLIED SIGNAL AEROSPACE	COLUMBIA	MD	MICROELEC-TRONICS CTR	ASIC	CMOS	1.20	4	1,600	10,000	1	C
ALPHA INDUSTRIES	WOBURN	MA	NA	RF TRAN LIN	GaAs	0.50	2	200	10,000	100	C
AMD	AUSTIN	TX	FAB 10	SRAM PLD CUSTOM	CMOS MOS	1.00	5	20,000	20,000	1	M
AMD	AUSTIN	TX	FAB 14	4Mb EPROM FLASH MCU	CMOS	0.80	6	16,000	22,103	100	M
AMD	AUSTIN	TX	FAB 15	MPRCOM MPU MCU MPR	CMOS M2	0.70	6	11,000	22,000	10	M
AMD	SUNNYVALE	CA	SDC (FAB 17)	2Mb FLASH 4Mb FLASH 4Mb EPROM 1Mb EPROM	CMOS	0.50	6	10,000	36,000	1	M
ANADIGICS INC.	WARREN	NJ	NA	OP AMP MMIC	GaAs	0.50	3	1,200	6,400	100	M
ANALOG DEVICES	SANTA CLARA	CA	NA	LIN A/D D/A OP AMP	CMOS BIP BICMOS	2.00	4	7,000	15,000	10	M
ANALOG DEVICES	WILMINGTON	MA	WILMINGTON FAB	LIN LOG OP AMP A/D D/A ASIC DSP	BIP MOS	1.00	4	10,000	30,000	100	M
APPLIED MICROCIRCUITS CORPORATION	SAN DIEGO	CA	NA	ARRAYS CBIC MEM	BIP BICMOS	1.00	4	3,000	5,000	100	M
ARMY ETDL	FORT MONMOUTH	NJ	NA	NA	NA	0.00	5	5,000	0	NA	C
AT&T MICROELECTRONICS	ALLENTOWN	PA	BIC 2	ARRAYS CBIC CUSTOM	BIP	1.00	4	5,300	13,500	100	M
AT&T MICROELECTRONICS	ALLENTOWN	PA	MOS-2	ASIC LOG	CMOS MOS	1.75	4	17,600	21,000	10	M
AT&T MICROELECTRONICS	LEE'S SUMMIT	MO	NA	DIODE TRANS	BIP	2.00	4	5,000	25,000	100	M
AT&T MICROELECTRONICS	ORLANDO	FL	OR1	256K SRAM 1Mb SRAM CBIC ARRAYS	CMOS M2	0.80	5	22,000	40,000	10	M
AT&T MICROELECTRONICS	READING	PA	GaAs - I	MIL STD LOG MEM LIN OPTO	GaAs	0.70	3	400	10,500	1	C
AT&T MICROELECTRONICS	READING	PA	HIGH VOLTAGE - II	OPTO LIN POWER IC	BIP CMOS	4.00	4	9,000	14,000	100	M
AT&T MICROELECTRONICS	READING	PA	LINEAR - I	LIN POWER IC	BIP	1.50	4	11,000	32,400	100	M
ATMEL CORPORATION	COLORADO SPRINGS	CO	FAB 3	EPROM EEPROM FLASH ARRAYS PLD CUSTOM	CMOS	0.50	6	7,500	32,000	10	M
AVANTEK	NEWARK	CA	NA	MMIC FET DIS	GaAs	0.00	3	900	17,000	10	M
AVANTEK	SANTA CLARA	CA	NA	MMIC	BIP	0.00	4	5,000	10,000	10	M

(Continued)

Table 1 (Continued)
North American Existing Pilot and Production Fab Lines
(Including Fabs Going into Operation During 1992)

Company	City	State	Fab Name	Products Produced	Process Technology	Est. Minimum Line Width (Microns)	Wafer Diameter	Est. Max. Wafer Capacity (4wk/Mo)	Clean Room (Square Feet)	Class Clean Room	Merchant or Captive
BALL AEROSPACE	BOULDER	CO	NA	NA	NA	1.20	6	3,000	3,000	NA	C
BALL AEROSPACE	BOULDER	CO	NA	MIL STD AEROSPACE ICs	NA	0.00	4	5,000	0	NA	C
BIPOLARICS INC.	LOS GATOS	CA	NA	DIS TRA	BIP	0.00	4	0	0	NA	M
BIT	BEAVERTON	OR	NA	DSP	BIP	2.00	4	800	2,000	10	M
BURR-BROWN CORPORATION	TUCSON	AZ	NA	HYBRID LIN A/D D/A ASIC	BIP	4.00	4	12,000	10,000	NA	M
CALIFORNIA MICRODEVICES	TEMPE	AZ	MICRO DIV	PWR LIN MPU ASIC	BICMOS BIP CMOS	1.60	5	4,000	17,400	100	M
CALOGIC	FREMONT	CA	NA	A/D D/A	BIP MOS	3.00	4	3,600	5,000	100	M
CELERITEK INC.	SAN JOSE	CA	NA	FET AMP	GaAs	0.00	3	0	1,000	100	M
CHERRY SEMICONDUCTOR	EAST GREENWICH	RI	BIPOLAR	ARRAYS DIS CUSTOM LIN	BIP	3.00	3	6,400	75,000	100	M
COMLINEAR	URBANA	IL	NA	MONOLITHIC ICs HYBRID	GaAs	0.70	3	300	2,400	10	M
COMMODORE SEMICONDUCTORS	NORRISTOWN	PA	FAB 1	ASIC MEM	CMOS MOS	2.00	5	8,000	11,000	50	C
COMMODORE SEMICONDUCTORS	NORRISTOWN	PA	FAB 2	ASIC	CMOS	2.00	5	10,000	0	NA	C
COMPENSATED DEVICES	MELROSE	MA	NA	DIODE ZENER DIODE	BIP	0.00	4	10,000	0	NA	M
CYPRESS MINNESOTA INC.	BLOOMINGTON	MN	FAB 3	SRAM	CMOS	0.65	6	2,000	20,000	1	M
CYPRESS SEMICONDUCTOR	SAN JOSE	CA	FAB 1	64K SRAM LOG MPU MPR BIT	BIP CMOS	1.20	5	4,000	6,000	10	M
CYPRESS SEMICONDUCTOR TEXAS INC.	ROUNDROCK	TX	FAB 2	SRAM PLD RISC MPU	CMOS BICMOS	0.80	6	7,200	22,000	1	M
DALLAS SEMICONDUCTOR	DALLAS	TX	FAB 1	SRAM CCD	CMOS	1.20	6	4,500	15,000	1	M
DATA LINEAR	MILPITAS	CA	FAB 1	OP AMP CBIC CUSTOM	CMOS	4.00	4	1,600	3,500	100	M
DAVID SARNOFF LABS	PRINCETON	NJ	SILICON IC CENTER	ASIC ANALOG	BICMOS SOS	0.90	4	800	5,000	100	C
DELCO ELECTRONICS CORPORATION	KOKOMO	IN	FAB 1	LOG DISCRETE	BIP	2.00	4	5,200	43,000	10,000	C
DELCO ELECTRONICS CORPORATION	KOKOMO	IN	FAB 2	MCU MPU LOGIC DISCRETE	CMOS NMOS BICMOS	2.00	5	6,000	21,000	100	C
DELCO ELECTRONICS CORPORATION	KOKOMO	IN	FAB 3	ASIC MPU LINEAR	CMOS BIP	1.30	5	4,000	60,000	10	C
DIGITAL EQUIPMENT CORPORATION	HUDSON	MA	FAB 1	ARRAYS CUSTOM MPU LOG	BIP MOS TTL	2.50	4	4,480	8,000	10,000	C
DIGITAL EQUIPMENT CORPORATION	HUDSON	MA	FAB 2	CUSTOM	CMOS M2	1.20	5	2,700	6,000	1,000	C

(Continued)

Table 1 (Continued)
North American Existing Pilot and Production Fab Lines
(Including Fabs Going into Operation During 1992)

Company	City	State	Fab Name	Products Produced	Process Technology	Est. Minimum Line Width (Microns)	Wafer Diameter	Est. Max. Wafer Capacity (4wk/Mo)	Clean Room (Square Feet)	Class Clean Room	Merchant or Captive
DIGITAL EQUIPMENT CORPORATION	HUDSON	MA	FAB 3	MPU MPR CBIC CUSTOM	CMOS MOS	1.20	5	6,300	11,000	100	C
DIGITAL EQUIPMENT CORPORATION	HUDSON	MA	PILOT	MPU MCU MPR CBIC CUSTOM	CMOS	1.50	6	1,600	6,000	NA	C
DIONICS INC.	WESTBURY	NY	NA	PWR DIS OPTO HYBRID	BIP	2.00	4	1,600	4,000	10,000	M
ECI SEMICONDUCTOR	SANTA CLARA	CA	NA	ARRAYS CBIC CUST LIN DIS	BIP CMOS BICMOS	3.00	4	8,000	6,500	1,000	M
EG&G RETICON	SUNNYVALE	CA	NA	LIN	CMOS MOS	2.50	4	2,500	4,600	100	M
EG&G VACTEC	ST. LOUIS	MO	NA	PDIODE PTRAN	BIP	6.00	3	16,000	10,000	1,000	M
ELANTEC	MILPITAS	CA	NA	OP AMP	BIP	5.00	3	960	1,800	100	M
EXAR	SUNNYVALE	CA	KIFER PLANT	CUSTOM ASIC	BIP	3.00	4	14,500	15,000	100	M
EXEL	SAN JOSE	CA	NA	64K EEPROM PLD SRAM MCU	CMOS BIP	1.30	5	10,000	19,000	10	M
FEI MICROWAVE INC.	SUNNYVALE	CA	1	DIODE OPTO RAD-HARD	GaAs	1.00	2	200	3,000	100	M
FOXBORO ICT	SAN JOSE	CA	NA	DIS PRESSURE SENSORS	BIP	3.00	3	24,000	10,000	1,000	C
FREQUENCY SOURCES	CHELMSFORD	MA	NA	DIODE MMIC	BIP	0.00	3	15,000	0	NA	M
FUJITSU	GRESHAM	OR	NA	1Mb DRAM	CMOS	0.80	6	13,000	17,500	10	M
GE	UTICA	NY	NA	LIN	GaAs	0.00	3	300	10,000	NA	C
GE ELECTRONICS LAB	SYRACUSE	NY	MATERIAL	NA	NA	0.00	4	2,000	2,700	NA	C
GE ELECTRONICS LAB	SYRACUSE	NY	MMIC FAB	MMIC	GaAs	0.50	3	100	5,000	10	C
GENERAL DYNAMICS	FORT WORTH	TX	NA	NA	MOS	0.00	4	7,000	0	NA	C
GENERAL SEMICONDUCTOR	TEMPE	AZ	NA	DIODE	BIP	25.00	3	19,200	15,000	100	M
GENNUM CORP.	BURLINGTON, ONTARIO	CN	NA	OP AMP INTERFACE	BIP	6.00	3	2,000	1,750	100	M
GERMANIUM POWER DEVICES	ANDOVER	MA	NA	OPTO DIS	NA	0.00	3	10,000	0	NA	M
GI	HICKSVILLE	NY	NA	PWR SCR	BIP	0.00	4	4,800	0	NA	M
GOULD	POCATELLO	ID	NA	ARRAYS CBIC EEPROM LIN	CMOS BICMOS M2	1.50	5	14,400	20,000	10	M
HANSCORN AFB	LEXINGTON	MA	NA	CUSTOM MIL STD	BIP CMOS MOS	0.00	4	8,000	0	NA	C
HARRIS CORP.	MELBOURNE	FL	VHSIC	64K SRAM 256K SRAM	CMOS	0.80	4	5,000	0	NA	C
HARRIS SEMICONDUCTOR	FINDLAY	OH	FAB 1 & 2	16K SRAM LOG	CMOS SOS	3.00	4	27,200	22,000	1,000	M

(Continued)

Table 1 (Continued)
North American Existing Pilot and Production Fab Lines
(Including Fabs Going into Operation During 1992)

Company	City	State	Fab Name	Products Produced	Process Technology	Est. Minimum Line Width (Microns)	Wafer Diameter	Est. Max. Wafer Capacity (4wk/Mo)	Clean Room (Square Feet)	Class Clean Room	Merchant or Captive
HARRIS SEMICONDUCTOR	FINDLAY	OH	FAB 3 & 4	DSP LOG LIN MEM MIL STD	BIMOS CMOS MOS	1.50	4	28,900	31,000	100	M
HARRIS SEMICONDUCTOR	FINDLAY	OH	FAB 5	DSP MPR ASIC MIL STD	CMOS N-WELL M2	1.20	5	17,000	12,000	10	M
HARRIS SEMICONDUCTOR	MELBOURNE	FL	54E (FAB A)	SRAM PROM LIN ALL ASIC	BIP CMOS BICMOS	3.00	4	7,225	7,000	100	M
HARRIS SEMICONDUCTOR	MELBOURNE	FL	FAB 51 (FAB D)	LIN	BIP MOS BICMOS	3.00	4	9,000	18,000	1,000	M
HARRIS SEMICONDUCTOR	MELBOURNE	FL	FAB 54W (FAB C)	286 MPU CBIC SRAM PROM	CMOS BIP	1.80	4	6,000	7,000	100	M
HARRIS SEMICONDUCTOR	MILPITAS	CA	GAAS	GAAS FET MMIC	GaAs M2 M3	0.25	3	7,200	7,500	100	M
HARRIS SEMICONDUCTOR	MOUNTAINTOP	PA	FAB 1 POWER BIPOLAR	OPTO DIS	BIP M1	15.00	4	25,000	34,000	100	M
HARRIS SEMICONDUCTOR	MOUNTAINTOP	PA	FAB 2 POWER MOS	PWR DIS	MOS M1 POLY1	3.00	5	6,000	18,000	100	M
HARRIS SEMICONDUCTOR	MOUNTAINTOP	PA	FAB 3 POWER MOS	DIS	MOS M1 POLY1	2.00	6	5,200	22,000	10	M
HARRIS SEMICONDUCTOR	RESEARCH TRIANGLE PARK	NC	RTP FAB	ARRAYS CBIC CUSTOM 64K SRAM 8K SRAM	CMOS 1POLY	1.00	4	2,040	32,500	10	M
HEWLETT PACKARD	CORVALLIS	OR	4-INCH	CBIC	CMOS	1.00	4	12,000	19,000	10	M
HEWLETT PACKARD	CORVALLIS	OR	6-INCH	ASIC MPR DSP	CMOS M3	0.80	6	12,000	20,000	NA	M
HEWLETT PACKARD	FORT COLLINS	CO	4-INCH	RISC MPU ASIC MIL STD	CMOS BIPOLAR	0.80	4	5,000	20,000	100	M
HEWLETT PACKARD	SAN JOSE	CA	BIPOLAR	TRAN	GaAs	0.50	2	200	4,500	100	M
HEWLETT PACKARD	SAN JOSE	CA	DIODE	DIODE	BIP	3.00	2	2,400	12,500	1,000	M
HEWLETT PACKARD	SAN JOSE	CA	OED	OPTO	GaAs	5.00	3	2,050	25,000	100	M
HEWLETT PACKARD	SANTA CLARA	CA	NA	LOG ASIC	BIP	1.50	3	1,600	8,000	100	M
HEWLETT PACKARD	SANTA ROSA	CA	NA	DISC ASIC	GaAs	0.00	2	0	3,000	1,000	M
HEWLETT PACKARD	SANTA ROSA	CA	NA	DIS COUPLERS	BIP	0.00	2	4,000	2,500	1,000	M
HITACHI	IRVING	TX	PHASE 1	MPU MCU 256K SRAM 1Mb DRAM 4Mb DRAM	CMOS	0.80	6	16,000	25,000	10	M
HOLT INTEGRATED CIRCUITS	IRVINE	CA	NA	OP AMP EEPROM LOG ASIC	CMOS MOS	2.50	4	10,000	0	NA	M
HONEYWELL MICROSWITCH	FREEPORT	IL	NA	DIS	BIP	3.00	4	16,000	10,000	NA	M

(Continued)

Table 1 (Continued)
North American Existing Pilot and Production Fab Lines
(Including Fabs Going into Operation During 1992)

Company	City	State	Fab Name	Products Produced	Process Technology	Est. Minimum Line Width (Microns)	Wafer Diameter	Est. Max. Wafer Capacity (4wk/Mo)	Clean Room (Square Feet)	Class Clean Room	Merchant or Captive
HONEYWELL OPTO DIV.	RICHARDSON	TX	OPTO	OPTO PRESSURE SENSORS	BIP GaAs	5.00	3	4,000	7,000	10	M
HONEYWELL OPTOELECTRONICS	RICHARDSON	TX	MICRO SWITCH	ANALOG OPTO GaAs	BIP GaAs	3.00	4	4,000	7,000	10	M
HONEYWELL SOLID STATE	PLYMOUTH	MN	VHSIC	MIL STD CUSTOM	BIP CMOS	1.25	4	5,000	10,000	NA	C
HUGHES	CARLSBAD	CA	HTC	MIL STD OPTO ASIC LIN	BICMOS CMOS MOS	1.50	4	8,800	6,000	10	C
HUGHES	NEWPORT BEACH	CA	FAB 2	ASIC LIN	CMOS	3.00	4	4,000	3,000	10	M
HUGHES	NEWPORT BEACH	CA	FAB 3	ASIC	CMOS	2.00	4	2,240	5,000	100	M
HUGHES	TORRANCE	CA	NA	DIS	GaAs	0.00	2	500	2,250	100	C
HUGHES	TORRANCE	CA	NA	MMIC	GaAs	0.50	3	500	12,000	100	C
IBM	EAST FISHKILL	NY	NA	NA	NA	0.80	8	20,000	45,000	10	C
IBM	ESSEX JUNCTION	VT	BLDG. 963	1Mb DRAM	CMOS	1.00	8	16,000	35,000	10	C
IBM	ESSEX JUNCTION	VT	BLDG. 970	16Mb DRAM	CMOS	0.00	8	24,000	30,000	10	C
IBM	ESSEX JUNCTION	VT	BLDG. 973	1Mb DRAM	CMOS	1.00	8	20,000	40,000	10	C
IBM	HOPEWELL JUNCTION	NY	ASTC/LOG	LOG PROCESS VERIFICATION	BIP CMOS	0.80	8	10,000	20,000	1	C
IBM	HOPEWELL JUNCTION	NY	ASTC/MEM	MEM PROCESS VERIFICATION	CMOS	0.80	8	10,000	20,000	1	C
IBM	HOPEWELL JUNCTION	NY	BLDG. 323	ARRAYS LOG	BIP	1.50	5	32,000	50,000	10	C
IBM	HOPEWELL JUNCTION	NY	BLDG. 323	CPU CUSTOM	BIP	1.50	5	32,000	50,000	10	C
IBM	HOPEWELL JUNCTION	NY	BLDG. 323	ARRAYS LOG	BIP	1.50	5	32,000	50,000	NA	C
IBM	MANASSAS	VA	VHSIC	MPU MIL	MOS	0.50	5	12,000	31,000	1/10	C
IC SENSORS	MILPITAS	CA	NA	DIS	BIP	3.00	4	17,600	6,000	NA	M
IDT	SALINAS	CA	FAB 2	FAST 16K 64K 256K SRAM	CMOS	1.00	5	13,500	14,000	1	M
IDT	SANTA CLARA	CA	FAB 3	SRAM MPU RISC LOGIC	BICMOS CMOS	0.80	6	5,000	25,000	NA	M
IMP	SAN JOSE	CA	NA	CBIC CUSTOM LIN	BICMOS CMOS MOS	1.20	5	20,000	16,000	10	M
INSTITUTE FOR TECH. DVLPMNT	KANSAS CITY	MO	NA	NA	NA	0.00	5	5,000	0	NA	C
INTEGRATED CIRCUIT WORKS	SAN JOSE	CA	NA	3.3 VOLT SRAM	CMOS BICMOS	0.80	6	8,000	15,000	1	M
INTEL	ALOHA	OR	FAB 4	LOG	CMOS MOS	1.50	4	31,500	16,000	100	M

(Continued)

Table 1 (Continued)
North American Existing Pilot and Production Fab Lines
(Including Fabs Going into Operation During 1992)

Company	City	State	Fab Name	Products Produced	Process Technology	Est. Minimum Line Width (Microns)	Wafer Diameter	Est. Max. Wafer Capacity (4wk/Mo)	Clean Room (Square Feet)	Class Clean Room	Merchant or Captive
INTEL	ALOHA	OR	FAB 5 (D1)	486 MPU LOG 64K SRAM	CMOS BICMOS	0.80	6	0	22,000	1	M
INTEL	CHANDLER	AZ	FAB 6	MCU EPROM	CMOS MOS	1.00	6	31,000	38,000	100	M
INTEL	RIO RANCHO	NM	FAB 7	EPROM MPU	CMOS MOS	1.00	6	31,500	36,000	10	M
INTEL	RIO RANCHO	NM	FAB 9	386 MPU 486 MPU	CMOS	0.80	6	28,000	70,000	10	M
INTEL	SANTA CLARA	CA	D2	486 MPU 586 MPU	BICMOS	0.50	8	12,000	36,000	1	M
INTL. RECTIFIER	EL SEGUNDO	CA	PPD4	PWR ICs MOSFET SCR	CMOS MOS	5.00	4	13,000	13,000	100	M
INTL. RECTIFIER	RANCHO CALIFORNIA	CA	HEXFET	PWR ICs MOSFET	CMOS MOS	5.00	5	24,000	12,800	10	M
ITT	ROANOKE	VA	DARPA	LIN DIS MIL STD	GaAs	0.00	3	0	4,000	NA	C
ITT	SHELTON	CT	NA	CUSTOM	CMOS MOS	1.50	4	7,200	14,400	10	C
JOHN FLUKE MFG.	EVERETT	WA	NA	ASIC	CMOS BICMOS	2.00	4	1,400	9,500	10	C
KODAK	ROCHESTER	NY	NA	IMAGING ARRAYS CBIC CUST.	BIP CMOS MOS	1.50	4	5,000	25,000	NA	C
KULITE	LEONIA	NJ	NA	DIS	BIP	3.00	4	24,000	10,000	NA	M
LAWRENCE LIVERMORE LABS	LIVERMORE	CA	NA	NA	NA	0.25	6	5,000	0	NA	C
LINEAR TECHNOLOGY	MILPITAS	CA	FAB 1	LIN INTERFACE A/D D/A	BIP CMOS BICMOS	3.00	4	8,790	9,000	100	M
LINEAR TECHNOLOGY	MILPITAS	CA	FAB 2	LIN	BIP CMOS BICMOS	2.00	4	5,790	9,000	10	M
LITTON MICROWAVE	SAN JOSE	CA	NA	FET AMP	GaAs	0.00	3	0	0	NA	C
LITTON SOLID STATE	SANTA CLARA	CA	NA	MMIC CCD	GaAs	0.50	3	100	7,000	100	C
LOCKHEED	SUNNYVALE	CA	113	ASIC MIL STD RAD-HARD	CMOS	1.50	5	640	3,000	1	C
LSI LOGIC	SANTA CLARA	CA	R&D PILOT LINE	ARRAYS CBIC MCU MPU	BICMOS CMOS	0.50	6	1,000	15,000	100	M
LUCAS NOVASENSOR	FREMONT	CA	NA	SI BASED PRESSURE SENSORS	BIP	2.00	4	1,500	4,000	100	M
M/A-COM	BURLINGTON	MA	NA	MMIC DIODE TRAN	GaAs MOS	0.30	3	4,000	22,000	10	M
M/A-COM	BURLINGTON	MA	NA	NA	NA	0.00	4	10,000	0	NA	M
M/A-COM	LOWELL	MA	ADV. SEMICON-DUCTOR	MMIC	GaAs	0.25	3	800	15,000	10	M
MAGNAVOX	FORT WAYNE	IN	NA	ARRAYS CBIC HYBRID	CMOS	5.00	3	400	2,000	100	C
MARTIN MARIETTA	ORLANDO	FL	NA	LIN	GaAs	0.00	3	0	0	NA	C
MARTIN MARIETTA	ORLANDO	FL	VLSI PLT	AEROSPACE CBIC ARRAYS	CMOS	1.25	5	800	7,000	10	C

(Continued)

Table 1 (Continued)
North American Existing Pilot and Production Fab Lines
(Including Fabs Going into Operation During 1992)

Company	City	State	Fab Name	Products Produced	Process Technology	Est. Minimum Line Width (Microns)	Wafer Diameter	Est. Max. Wafer Capacity (4wk/Mo)	Clean Room (Square Feet)	Class Clean Room	Merchant or Captive
MASS. MICROELECTRONICS CENTER	WESTBOROUGH	MA	ICFF	ASIC	MOS BICMOS M2	2.00	5	1,200	7,000	10	C
MATSUSHITA	PUYALLUP	WA	NA	ARRAYS	BIP	2.50	4	8,000	20,000	10	M
MATSUSHITA	PUYALLUP	WA	NA	64K 256K FAST SRAM	BICMOS M2 ECL	1.00	5	4,000	40,000	10	M
MATSUSHITA	PUYALLUP	WA	NA	1Mb DRAM	CMOS	0.80	6	10,000	40,000	5	M
MAXIM INTEGRATED PRODUCTS	SUNNYVALE	CA	NA	OP AMPS A/D D/A	CMOS	3.00	4	4,000	13,500	10	M
MCDONNELL DOUGLAS	HUNTINGTON BEACH	CA	3"PILOT	4K 16K SRAM 6K ARRAY MPU	GaAs	1.00	3	400	6,000	100	C
MCDONNELL DOUGLAS	HUNTINGTON BEACH	CA	DVLPMNT	MPU LOG ASIC DIS	GaAs	1.00	3	0	4,000	100	C
MICRO POWER SYSTEMS	SANTA CLARA	CA	NA	LIN CUSTOM	BICMOS CMOS BIP	4.00	3	15,000	0	NA	M
MICRO QUALITY SEMICONDUCTOR	GARLAND	TX	NA	RECTIFIER MULTIPLIER	BIP	0.00	4	10,000	47,800	NA	M
MICRO SEMI	TORRANCE	CA	NA	MIL STD DIS	BIP	12.00	3	4,800	4,200	1,000	M
MICRO-CIRCUIT ENG	WEST PALM BEACH	FL	NA	CUSTOM	MOS	4.00	4	12,000	30,000	NA	M
MICRO-REL	TEMPE	AZ	NA	ASIC HI-REL	BIP CMOS	3.00	4	3,600	10,000	20	M
MICROCHIP TECHNOLOGY	CHANDLER	AZ	FAB B	EEPROM 8-bit MPU	MOS	5.00	3	16,000	0	1,000	M
MICROCHIP TECHNOLOGY	CHANDLER	AZ	FAB C	MPU 512K PROM 256K EEPROM	CMOS MOS	1.20	5	10,000	15,000	100	M
MICROCHIP TECHNOLOGY	CHANDLER	AZ	FAB E	16-bit MPU EEPROM DSP ROM	CMOS MOS	2.50	4	24,000	35,000	100	M
MICRON TECHNOLOGY	BOISE	ID	FAB 1	256K DRAM 1Mb DRAM 256K SRAM	CMOS MOS	1.20	6	32,000	36,000	10	M
MICRON TECHNOLOGY	BOISE	ID	FAB 2	1Mb DRAM 256K SRAM VRAM	CMOS	0.50	6	14,400	35,000	1	M
MICRON TECHNOLOGY	BOISE	ID	FAB 3	1Mb DRAM	CMOS	0.80	6	20,000	52,000	1	M
MICROPAC INDUSTRIES	GARLAND	TX	NA	MIL STD OPTO HYBRID	NA	0.00	4	3,000	3,000	NA	M
MICROSEMI CORP.	BROOMFIELD	CO	NA	SCHOTTKY DIODE RECTIFER	MOS	5.00	4	8,800	2,400	2,000	M
MICROWAVE TECH.	FREMONT	CA	NA	MMIC AMP FET	GaAs	0.50	2	0	7,000	1,000	M
MITEL SEMICONDUCTOR	BROMONT, QUEBEC	CN	FAB 1	TELECOM A/D D/A	CMOS	1.20	4	6,400	10,000	100	M
MITSUBISHI	NORTH DURHAM	NC	NA	1Mb DRAM	CMOS	0.90	5	7,800	11,000	10	M
MOTOROLA	AUSTIN	TX	MOS 2	LOG MPU A/D	CMOS MOS	1.00	4	21,600	22,000	100	M

(Continued)

Table 1 (Continued)
North American Existing Pilot and Production Fab Lines
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Company	City	State	Fab Name	Products Produced	Process Technology	Est. Minimum Line Width (Microns)	Wafer Diameter	Est. Max. Wafer Capacity (4wk/Mo)	Clean Room (Square Feet)	Class Clean Room	Merchant or Captive
MOTOROLA	AUSTIN	TX	MOS 3	MCU	CMOS MOS	1.50	4	10,830	14,900	100	M
MOTOROLA	AUSTIN	TX	MOS 8	MCU SRAM DSP LIN RISC A/D	CMOS M2	0.65	5	15,000	26,600	10	M
MOTOROLA	MESA	AZ	BIPOLAR 1	TELECOM OP AMP AUTOMOTIVE	BIP BICMOS	3.00	4	32,800	33,700	100	M
MOTOROLA	MESA	AZ	BIPOLAR 2	FAST PROM LOG STTL	BIP ECL TTL	2.50	4	34,800	30,500	100	M
MOTOROLA	MESA	AZ	BIPOLAR 3	ARRAYS FAST PROM STTL	BIP BICMOS M3	1.25	4	25,500	24,600	10	M
MOTOROLA	MESA	AZ	MOS 5	MCU	CMOS MOS	1.00	5	17,600	23,700	100	M
MOTOROLA	MESA	AZ	MOS 6	ASIC	BICMOS M2 CMOS	0.80	6	6,000	23,000	10	M
MOTOROLA	OAKHILL	TX	MOS 11	SRAM DSP MCU MPU	CMOS BICMOS	0.80	8	18,000	35,000	1	M
MOTOROLA	PHOENIX	AZ	PHOENIX POWER	PWR TRAN	BIP	10.00	5	20,000	22,000	100	M
MOTOROLA	PHOENIX	AZ	RF POWER	FR PWR	BIP	1.25	4	4,000	13,000	100	M
MOTOROLA	PHOENIX	AZ	TMOS FAB	MOSFET SMART PWR	BIP	3.00	6	9,200	15,000	100	M
MOTOROLA	PHOENIX	AZ	ZENER/ RECTIFIER	ZENER DIODE RECTIFIER	BIP	10.00	4	38,000	25,000	100	M
MOTOROLA	TEMPE	AZ	CS-1 PHASE 1	ANALOG RF	GAAS	0.35	4	0	0	10	M
NATIONAL SEMICONDUCTOR	ARLINGTON	TX	CMOS 1	ARRAYS MCU EEPROM MPRCOM	CMOS M2 POLY1	1.50	6	18,000	25,000	10	M
NATIONAL SEMICONDUCTOR	SANTA CLARA	CA	FRC (FAIR-CHILD RES.)	ASIC	CMOS	0.55	6	2,000	30,000	10	M
NATIONAL SEMICONDUCTOR	SANTA CLARA	CA	SFC (BIPLOG 5)	PROM ARRAYS MPR	BICMOS BIP M3	1.50	5	7,000	14,000	100	M
NATIONAL SEMICONDUCTOR	SOUTH PORTLAND	ME	BIPOLAR	LOG	BIP TTL ECL M2	2.50	4	43,520	38,000	100	M
NATIONAL SEMICONDUCTOR	SOUTH PORTLAND	ME	CMOS	LOG ARRAY	CMOS M2 POLY1	1.00	5	5,500	7,500	10	M
NATIONAL SEMICONDUCTOR	WEST JORDAN	UT	MOS 3	1Mb EPROM MPU SRAM ARRAYS	CMOS	0.80	6	8,000	30,000	5	M
NATL. SECURITY ADMIN.	FORT MEADE	MD	NA	CUSTOM MIL STD	BIP CMOS MOS	1.00	6	10,000	0	10	C
NATL. SECURITY ADMIN.	FORT MEADE	MD	NA	MIL STD	CMOS	0.80	6	5,000	0	NA	C
NAVAL OCEAN SYS. CTR.	SAN DIEGO	CA	NA	NA	NA	0.00	4	5,000	0	NA	C
NCR	COLORADO SPRINGS	CO	FAB 1	ARRAYS CUSTOM	CMOS	1.00	4	8,000	9,600	10	M

(Continued)

Table 1 (Continued)
North American Existing Pilot and Production Fab Lines
(Including Fabs Going into Operation During 1992)

Company	City	State	Fab Name	Products Produced	Process Technology	Est. Minimum Line Width (Microns)	Wafer Diameter	Est. Max. Wafer Capacity (4wk/Mo)	Clean Room (Square Feet)	Class Clean Room	Merchant or Captive
NCR	COLORADO SPRINGS	CO	FAB 2	CBIC MPU LOG MEM	CMOS	0.95	5	6,400	11,000	10	M
NCR	FORT COLLINS	CO	FT. COLLINS	MPU LOG ASIC	CMOS MOS	1.50	4	10,240	15,000	1,000	M
NEC	ROSEVILLE	CA	K-LINE	256K SRAM 256K DRAM ASIC MCU	NMOS CMOS	1.00	5	25,000	40,000	100	M
NEC	ROSEVILLE	CA	M-LINE	4Mb DRAM	CMOS	0.60	6	7,000	140,000	1	M
NORTHERN TELECOM	NEPEAN, ONTARIO	CN	MOD4	CBIC CUSTOM	MOS	0.00	6	6,000	0	10	C
NORTHERN TELECOM	SAN DIEGO	CA	RB	ASIC	CMOS BICMOS MOS	3.00	4	14,000	0	10	C
OPTEK TECHNOLOGY INC.	CARROLLTON	TX	FAB 1	MIL STD PWR ICs	MOS	0.00	4	15,000	0	NA	M
OPTEK TECHNOLOGY INC.	CARROLLTON	TX	FAB 2	MIL STD PWR ICs	MOS	0.00	5	15,000	0	NA	M
OPTO DIODE	NEWBURY PARK	CA	NA	OPTO DIODE	GaAs	0.00	0	0	0	NA	M
ORBIT SEMICONDUCTOR INC.	SUNNYVALE	CA	NA	LOGIC ARRAYS	CMOS BIP	1.20	4	9,600	8,000	10	M
PARADIGM TECHNOLOGY INC.	SAN JOSE	CA	NA	256K 1Mb SRAM FAST SRAM	CMOS M2 POLY2	1.00	5	2,500	10,000	NA	M
PERFORMANCE SEMICONDUCTOR	SUNNYVALE	CA	FAB 1	SRAM ARRAYS MIPS RISC MPU	CMOS	1.00	6	5,600	3,000	10	M
PERFORMANCE SEMICONDUCTOR	SUNNYVALE	CA	FAB 2	SRAM MPU ASIC	BICMOS CMOS	0.70	6	7,000	0	1	M
POWEREX	AUBURN	NY	NA	DIS SCR DIODE THYRISTOR	BIP	10.00	3	24,000	35,000	1,000	M
POWEREX	AUBURN	NY	NA	DIS SCR DIODE THYRISTOR	BIP	10.00	3	24,000	25,000	10	M
POWEREX	YOUNGWOOD	PA	POW BIPO	DIODE PWR TRAN THYRISTOR	BIP	0.00	3	10,000	0	NA	M
PRECISION MONO.	SANTA CLARA	CA	FAB 1	ASIC	CMOS	3.00	4	1,600	4,000	100	M
PRECISION MONO.	SANTA CLARA	CA	FAB 2	CUSTOM	BIP	2.50	4	3,200	3,500	100	M
RAMTRON	COLORADO SPRINGS	CO	NA	256K FRAM	CMOS M2	1.00	6	2,700	11,500	1	M
RAYTHEON	MOUNTAIN VIEW	CA	DIS TRAN	DIS TRAN SST	BIP	5.00	4	2,400	6,000	100	M
RAYTHEON	MOUNTAIN VIEW	CA	LINEAR	LIN ASIC	BIP	5.00	4	6,400	7,000	1,000	M
RAYTHEON	MOUNTAIN VIEW	CA	LSI ARAY	20K ARRAYS	BIP CMOS	1.00	4	10,000	0	NA	M
RAYTHEON	WALTHAM	MA	NA	MMIC	GaAs	0.00	3	400	11,000	NA	C
RAYTHEON MICROELECT.	ANDOVER	MA	GaAs	NA	GaAs	0.50	3	800	0	10	M
RAYTHEON MICROELECT.	ANDOVER	MA	NA	ARRAYS CUSTOM	CMOS	0.90	5	3,500	15,000	10	C
RAYTHEON SMDO	NORTHBOROUGH	MA	NA	MMIC PWR MESFET	GaAs	0.50	3	250	5,000	1,000	C

(Continued)

Table 1 (Continued)
North American Existing Pilot and Production Fab Lines
(Including Fabs Going into Operation During 1992)

Company	City	State	Fab Name	Products Produced	Process Technology	Est. Minimum Line Width (Microns)	Wafer Diameter	Est. Max. Wafer Capacity (4wk/Mo)	Clean Room (Square Feet)	Class Clean Room	Merchant or Captive
ROCKWELL	NEWBURY PARK	CA	DARPA	MESFET HBT MEM ASIC	GaAs	0.70	4	3,000	4,500	10	C
ROCKWELL	NEWPORT BEACH	CA	FAB 1	MODEM TELECOM	CMOS MOS	2.00	4	20,400	14,000	100	M
ROCKWELL	NEWPORT BEACH	CA	FAB 4	TELECOM INTERFACE	CMOS MOS	2.00	4	20,000	24,000	10	M
ROHM	SUNNYVALE	CA	PILOT	LIN ARRAYS	BIP	0.00	4	17,000	14,000	10	M
SANDERS ASSOCIATES	NASHUA	NH	GaAs	LIN MMIC	GaAs	0.50	3	400	7,000	10	C
SANDIA NATIONAL LABS	ALBUQUERQUE	NM	RHIC-I	MPU LOG SRAM ASIC	CMOS	1.50	4	1,200	6,000	100	C
SANTA BARBARA RSCH.	GOLETA	CA	SBRC	MIL STD INFRARED DETECTOR	HgCdTe InSb	0.00	4	1,000	200	10	C
SEMICOA	COSTA MESA	CA	NA	CUSTOM HI-REL PWR PHOTO	BIP	7.00	3	12,000	10,000	NA	M
SEMTECH CORPORATION	CORPUS CHRISTI	TX	NA	ANALOG	BIP	3.00	4	0	13,000	10	M
SEMTECH CORPORATION	NEWBURY PARK	CA	NA	RECTIFIER ZENER DIODE	BIP	0.00	2	9,600	5,000	10,000	M
SENSOR SOLID STATE	QUAKERTOWN	PA	NA	CUSTOM DIS SENSORS	MOS	4.00	3	480	2,000	1,000	M
SENSYM	SUNNYVALE	CA	NA	SI CUSTOM LIN SENSORS	BIP CMOS	3.00	4	2,000	1,500	100	C
SGS-THOMSON	CARROLLTON	TX	FAB 4	ARRAYS CBIC SRAM MCU MPR	CMOS MOS M2	2.00	4	22,400	20,000	100	M
SGS-THOMSON	CARROLLTON	TX	FAB 6	1Mb SRAM ARRAYS 256K DRAM	CMOS M2	0.70	6	14,400	20,000	10	M
SIEMENS	CUPERTINO	CA	NA	LED COUPLERS OPTO	GaAs MOS	0.00	0	0	0	NA	M
SIERRA	SAN JOSE	CA	NA	CBIC CUSTOM LIN	CMOS	1.50	5	1,600	3,000	10	M
SIERRA SEMICONDUCTOR	SAN JOSE	CA	NA	NA	NA	0.80	6	0	0	NA	M
SIGNETICS	ALBUQUERQUE	NM	FAB 22	EPROM MPU MCU CBIC PLD	CMOS BICMOS	1.50	4	20,900	10,000	10	M
SIGNETICS	ALBUQUERQUE	NM	FAB 23	256K 1Mb EPROM 8-bit MCU	CMOS BICMOS NMOS	1.00	6	14,000	10,000	10	M
SIGNETICS	SUNNYVALE	CA	FAB 1	LIN SMART PWR OP AMPS	BIP	2.50	4	20,000	18,000	50	M
SILICON GENERAL SEMICON	GARDEN GROVE	CA	NA	LIN ASIC	BIP BICMOS	4.00	4	6,800	9,000	100	M
SILICON SYSTEMS (TDK)	SANTA CRUZ	CA	FAB II	ASIC	BIP CMOS	2.00	4	8,000	12,000	10	M
SILICON SYSTEMS (TDK)	SANTA CRUZ	CA	FAB III	MPR ASIC A/D D/A	CMOS BICMOS BIP	0.80	6	6,000	27,000	1	M
SILICON SYSTEMS (TDK)	TUSTIN	CA	FAB 1	CUSTOM TELECOM	BIP CMOS	2.00	4	10,000	23,000	10	M
SILICON TRANSISTOR	CHELMSFORD	MA	NA	MIL STD DIS PWR	BIP	10.00	4	4,000	2,000	10,000	M

(Continued)

Table 1 (Continued)
North American Existing Pilot and Production Fab Lines
(Including Fabs Going into Operation During 1992)

Company	City	State	Fab Name	Products Produced	Process Technology	Est. Minimum Line Width (Microns)	Wafer Diameter	Est. Max. Wafer Capacity (4wk/Mo)	Clean Room (Square Feet)	Class Clean Room	Merchant or Captive
SILICONIX INCORPORATED	SANTA CLARA	CA	FAB 2	SMART PWR A/D D/A	CMOS	3.00	4	8,000	13,000	100	M
SILICONIX INCORPORATED	SANTA CLARA	CA	FAB 3	PWR SMART PWR	CMOS	1.50	6	4,000	10,400	1	M
SIMTEK CORPORATION	COLORADO SPRINGS	CO	NA	ADV. MEM EEPROM	CMOS	1.00	6	800	2,000	NA	M
SIPEX	SAN JOSE	CA	NA	ASIC	BIP	5.00	4	4,000	4,000	1,000	M
SOLID POWER CO.	FARMINGDALE	NY	NA	PWR TRAN	BIP	20.00	2	24,000	15,000	NA	M
SOLID STATE DEVICES	LA MIRADA	CA	NA	HI-REL CUSTOM	BIP	0.00	4	4,000	10,000	NA	M
SOLITRON	RIVIERA BEACH	FL	NA	PWR FET HYBRID	BIP	0.00	4	10,000	0	NA	M
SONY	SAN ANTONIO	TX	FAB 11	PLD	CMOS	1.50	5	16,000	14,000	10	M
SONY	SAN ANTONIO	TX	FAB 12	256K SRAM 1Mb SRAM LOG	CMOS BICMOS	0.80	6	12,800	17,500	10	M
SPECTRA DIODE LABS	SAN JOSE	CA	NA	LASER DIODE	GaAs GaAlAs	0.00	3	0	0	NA	C
SPECTRO LABS (HUGHES)	SYLMAR	CA	NA	SOLAR CELL ARRAYS	NA	0.00	4	24,000	10,000	100	M
SPRAGUE (ALLEGRO)	WILLOW GROVE	PA	NA	SRAM ROM PROM	CMOS	2.20	4	12,800	25,000	100	M
SPRAGUE (ALLEGRO)	WORCESTER	MA	NA	CUSTOM DIS	BICMOS BIP	4.00	4	19,200	25,000	100	M
STANDARD MICROSYSTEMS	HAUPPAUGE	NY	NA	CUSTOM CBIC	CMOS MOS	1.25	4	19,200	30,000	100	M
SUPERTEX	SUNNYVALE	CA	NA	PWR FET A/D D/A CUSTOM	CMOS MOS	5.00	4	2,400	10,000	NA	M
SYNERGY SEMICONDUCTOR	SANTA CLARA	CA	FAB 1	VERY FAST 4K 16K SRAM	BIP ECL	1.50	4	1,920	5,000	10	M
TANDEM	CUPERTINO	CA	MOS 1 LAB	ASIC ARRAYS	BIP CMOS	1.10	4	80	3,500	10	C
TECCOR ELECT	IRVING	TX	NA	LOG	BIP	5.00	3	16,000	15,000	NA	M
TECCOR ELECT	IRVING	TX	NA	THYRISTOR	NA	0.00	0	0	37,000	NA	M
TEKTRONIX	BEAVERTON	OR	BIPOLAR	OP AMP A/D ARRAYS CUSTOM	BIP	1.50	4	4,000	17,500	10	C
TEKTRONIX	BEAVERTON	OR	CCD	CCD A/D D/A	CMOS	1.50	4	3,200	6,000	10	C
TELCOM DEVICES	NEWBURY PARK	CA	NA	PDIODE LED	GaAs	0.00	1	0	2,500	10,000	M
TELEDYNE CRYSTALONICS	CAMBRIDGE	MA	NA	CAP REG DIODE HYBRID	BIP CMOS	3.00	4	2,000	3,000	100	M
TELEDYNE MICROELECTRONICS	LOS ANGELES	CA	NA	HI-REL HYBRID & A/D D/A	BIP	0.00	4	5,000	0	NA	M
TELEDYNE MICROWAVE	MOUNTAIN VIEW	CA	GaAs	FET	GaAs	0.50	3	80	6,000	10	M
TELEDYNE SEMICONDUCTOR	MOUNTAIN VIEW	CA	NA	POWER ICs POWER MOSFET	BIP BICMOS CMOS	0.00	4	5,000	0	NA	M
TEXAS INSTRUMENTS	DALLAS	TX	DLIN2	LIN	CMOS BIP	1.00	4	27,300	35,000	100	M
TEXAS INSTRUMENTS	DALLAS	TX	DLOGIC	ASSP DRAM	MOS CMOS	0.80	4	16,000	62,000	10	M

(Continued)

Table 1 (Continued)
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TEXAS INSTRUMENTS	DALLAS	TX	DMOS 4.1	256K 1Mb DRAM SRAM DSP	CMOS	0.80	6	29,200	71,000	5	M
TEXAS INSTRUMENTS	DALLAS	TX	MICROWAVE	SRAM MPU ASIC	GaAs M2	0.25	3	495	8,500	100	M
TEXAS INSTRUMENTS	HOUSTON	TX	ADV BIP5	ADV BIP ASSP ASIC	BIP CMOS	1.00	5	25,466	47,000	10	M
TEXAS INSTRUMENTS	LUBBOCK	TX	LMOS	EPROM LOGIC ASSP	NMOS CMOS	0.80	5	20,200	44,000	10	M
TEXAS INSTRUMENTS	SHERMAN	TX	SGPL	LOG MPR	BIP TTL	1.00	4	51,600	51,600	100	M
TEXAS INSTRUMENTS	SHERMAN	TX	SGPL	ADV SCHOTTKY	BIP	2.00	5	10,515	20,000	100	M
TRIQUINT	BEAVERTON	OR	NA	MMIC LIN OPTO CBIC ARRAYS	GaAs	0.70	4	2,300	12,000	50	M
TRW	MANHATTAN BEACH	CA	NA	LIN TRAN PWR TRAN HYBRD	MOS	0.00	4	5,000	0	NA	M
TRW	REDONDO BEACH	CA	D1	LIN TRAN PWR TRAN HYBRD	BIP CMOS	1.50	4	1,600	13,000	10	C
TRW	REDONDO BEACH	CA	D1	VHSIC MIL STD FERRAM	CMOS MOS	0.50	4	6,400	15,000	10	M
TRW	REDONDO BEACH	CA	NA	RF PWR	GaAs	0.50	3	200	0	NA	M
TRW SYSTEMS	LA JOLLA	CA	NA	A/D D/A MULTIPLIERS	CMOS BIP	0.00	4	5,000	8,000	NA	M
UNITRODE	MERRIMACK	NH	NA	LIN SMART PWR CUSTOM	BIP	5.00	4	4,000	4,000	100	M
UNITRODE	WATERTOWN	MA	NA	HYBRID DIS	BIP	0.00	4	10,000	0	NA	M
UNIVERSAL SEMICONDUCTOR	SAN JOSE	CA	NA	LIN ARRAYS RAM EPROM	CMOS MOS	1.50	4	850	3,000	10	M
UTMC	COLORADO SPRINGS	CO	UTMC	RISC MPU ARRAYS MIL STD	BIP CMOS	1.20	5	3,200	6,000	10	C
VITESSE SEMICONDUCTOR	CAMARILLO	CA	NA	CUSTOM ARRAYS 4K SRAM 1K SRAM 16K SRAM TELE	GaAs	0.60	4	3,000	10,000	10	M
VLSI TECHNOLOGY	SAN ANTONIO	TX	MODULE A	ARRAYS CBIC MPU MPR	CMOS	1.00	6	5,400	10,000	1	M
VLSI TECHNOLOGY	SAN ANTONIO	TX	MODULE B	ARRAYS CBIC MPU MPR	CMOS M3	0.80	6	5,400	10,000	1	M
VLSI TECHNOLOGY	SAN JOSE	CA	SAN JOSE	PLD ARRAYS CBIC MPR	CMOS MOS	1.00	5	13,600	16,500	10	M
WESTERN DIGITAL	IRVINE	CA	SPECTRUM LSI	CUSTOM	CMOS M2 BICMOS	0.90	6	7,200	37,000	1	M
WESTINGHOUSE	BALTIMORE	MD	GaAs	MMIC	GaAs	0.00	3	720	7,000	100	C
WESTINGHOUSE	BALTIMORE	MD	LSI	ASIC OPTO LIN MIL STD	BIP CMOS MOS	3.00	4	8,000	20,000	100	C

(Continued)

Table 1 (Continued)
North American Existing Pilot and Production Fab Lines
(Including Fabs Going into Operation During 1992)

Company	City	State	Fab Name	Products Produced	Process Technology	Est. Minimum Line Width (Microns)	Wafer Diameter	Est. Max. Wafer Capacity (4wk/Mo)	Clean Room (Square Feet)	Class Clean Room	Merchant or Captive
WESTINGHOUSE	BALTIMORE	MD	VLSI	ASIC OPTO LIN MIL STD	BIP CMOS MOS	1.00	4	8,000	15,000	10	C
WESTINGHOUSE	CHURCHILL	PA	R&D CENTER	NA	GaAs	0.00	0	0	0	NA	C
XEROX	EL SEGUNDO	CA	FAB 1	PLD CUSTOM	CMOS NMOS	2.00	4	4,000	10,000	10	C
XICOR	MILPITAS	CA	PHASE 2	1Mb EEPROM	CMOS M2 POLY2	0.70	6	5,000	30,000	1	M
ZENITH MICROCIRCUIT	ELK GROVE	IL	HVSR	HIGH-VOLT DIODE TRIODE	BIP	20.00	2	16,000	1,000	10,000	C
ZILOG	NAMPA	ID	MODULE 1	Z80 Z8000 16-bit MPU	NMOS	1.50	4	17,000	13,000	100	M
ZILOG	NAMPA	ID	MODULE 2	Z80,OOO MPU MCU CUSTOM	CMOS NMOS BICMOS	0.65	5	10,200	19,000	1	M

Source: Dataquest (October 1992)

Table 2
North American Future Pilot and Production Fab Lines
Planned Facilities by Year

Company	City	State	Fab Name	Products	Process Technology	Facility Type	Target Date Facility to Begin Operation	Est. Minimum Line Geometry (Microns)	Wafer Size (Inches)	Est. Wafer Start Capacity (4 Wk/ Month)	Clean Room Square Feet
Production Begins: 1993											
CRAY RESEARCH	CHIPPEWA FALLS	WI	NA	ARRAYS	BICMOS CMOS	P	NA	0.80	8	0	0
HEWLETT PACKARD	PALO ALTO	CA	NA	NA	CMOS M3 BICMOS	RP	02/01/93	0.55	6	2,000	18,000
HITACHI	IRVING	TX	PHASE 2	CBIC 16Mb DRAM 4Mb SRAM	CMOS BICMOS	F	NA	0.60	8	0	0
INTEL	ALOHA	OR	D1A	586 MPU	CMOS	RP	05/01/93	0.25	8	0	50,000
NATIONAL SEMICONDUCTOR	ARLINGTON	TX	FAB 2	NA	CMOS	FN	06/01/93	0.80	6	0	30,000
Production Begins: 1994											
AMD	AUSTIN	TX	FAB 25	NA	NA	F	NA	0.80	8	15,000	0
DIGITAL EQUIPMENT CORPORATION	HUDSON	MA	FAB 6	MCU ALPHA	CMOS M3	F	NA	0.50	8	0	0
OKI	TUALATIN	OR	NA	ASIC DRAM	NA	FAT	NA	0.00	6	15,000	0
VLSI TECHNOLOGY	SAN ANTONIO	TX	MODULE C	ARRAYS CBIC SRAM MPU	CMOS M3	F	NA	0.80	6	6,400	7,000
Production Begins: 1995											
MOTOROLA	AUSTIN (OAK HILL)	TX	MOS 11	SRAM, MPU, MCU	CMOS BICMOS	F	NA	0.00	8	0	35,000
ZILOG	NAMPA	ID	MODULE 3	NA	NA	F	NA	1.00	6	8,000	12,000
Production Begins: 1996											
VLSI TECHNOLOGY	SAN ANTONIO	TX	MODULE D	ARRAYS CBIC SRAM MPU	CMOS M3	F	NA	0.60	6	6,400	7,000

NA = Not Available
Source: Dataquest (October 1992)

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European Fab Database

October 19, 1992

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Market Statistics

Semiconductor Equipment, Manufacturing, and Materials

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European Fab Database

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Market Statistics

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Note: All tables show estimated data.

European Fab Database

Background

The material in this document applies to the European portion of Dataquest's Semiconductor Equipment, Manufacturing, and Materials service wafer fab database. Information pertaining to Eastern Europe and Israel has also been included in this document because of the close ties between these markets. The wafer fab database is updated on an ongoing basis, employing both primary and secondary research methodologies. The tables included in this document highlight both production and pilot line wafer fabs.

Research Methodology

Dataquest takes a three-pronged approach to wafer fab database research. Information is gained through extensive annual primary research. This survey work is further supplemented with comprehensive secondary research conducted on an ongoing basis. The database is updated daily, which allows Dataquest to be able to provide a snapshot of the marketplace at any time. The information gathered through primary and secondary research is then further supplemented and cross-checked with Dataquest's various other information sources.

General Definitions

Fab line: A fab line is a processing line in a clean room that is equipped to do all front-end wafer processing. Occasionally there are two separate product-specific fab lines or two different wafer sizes in a clean room. In this situation, a clean room will be documented as two fab lines if the equipment is dedicated to each wafer size or product line. There can be many fab lines at one location.

Front-end wafer processing: Front-end wafer processing is defined as all steps involved with semiconductor processing, beginning with initial oxide and ending at wafer probe.

Production fab: A production fab is defined as a wafer fab capable of front-end processing more than 1,250 wafers per week (type = F).

Pilot fab: A pilot fab is defined as a wafer fab capable of front-end processing less than 1,250 wafers per week (type = P).

Definition of Table Columns

The Products Produced column contains information for seven product categories. The information in this column can be very detailed, depending on its availability. The nomenclature used within the seven product groups of the fab database is as follows, with definitions where warranted:

- Analog
  - LIN—Linear/analog devices
  - A/D D/A—Analog-to-digital, digital-to-analog converters
  - AUTOMOTIVE—Dedicated to automobile applications
  - CODEC—Coder/decoder
  - INTERFACE—Interface IC
  - MESFET (GaAs)—Metal Schottky field-effect transistor
  - MODFET (GaAs)
  - MDIODE (GaAs)—Microwave diode
  - MFET (GaAs)—Microwave field-effect transistor
  - MODEM—Modulator/demodulator
  - MMIC—Monolithic microwave IC
  - OP AMP—Operational amplifier
  - PWR IC—Power IC
  - REG—Voltage regulator
  - SMART PWR—Smart power
  - SWITCHES—Switching device
  - TELECOM—Telecommunications chips
- Memory
  - MEM—Memory
  - RAM—Random-access memory

- DRAM—Dynamic RAM
- SRAM 4 TR.—Static RAM uses a 4-transistor cell design
- SRAM 6 TR.—Static RAM uses a 6-transistor cell design
- VRAM—Video RAM
- ROM—Read-only memory
- PROM—Programmable ROM
- EPROM—Ultraviolet erasable PROM
- EEPROM or E2—Electrically erasable PROM
- FERRAM—Ferroelectric RAM
- FLASH—Flash memory
- NVMEM—Nonvolatile memory (ROM, PROM, EPROM, EEPROM, FERRAM)
- FIFO—First-in/first-out memory
- SPMEM—Other specialty memory (such as dual-port, shift-register, color lookup)

• Micrologic

- ASSP—Application-specific standard product
- BIT—Bit slice (subset of MPU functions)
- DSP—Digital signal processor
- MCU—Microcontroller unit
- MPR—Microperipheral
- MPRCOM—MPR digital communication (ISDN, LAN, UART, modem)
- MPU—Microprocessor unit
- LISP—32-bit list instruction set processor for AI applications
- RISC—Reduced-instruction-set computation 32-bit MPU

• Standard logic

- LOG—Standard logic

• ASIC logic

- ASIC—Application-specific IC
- ARRAYS—Gate arrays
- CBIC—Cell-based IC
- CUSTOM—Full-custom IC (single user)
- PLD—Programmable logic device

• Discrete

- DIS—Discrete
- DIODE
- FET—Field-effect transistor
- GTO—Gate turn-off thyristor
- HEMT (GaAs)—High-electron-mobility transistor
- MOSFET—MOS-based field-effect transistor
- PWR TRAN—Power transistor
- RECTIFIER
- RF—Radio frequency
- SCR—Schottky rectifier
- SENSORS
- SST—Small-signal transistor
- THYRISTOR
- TRAN—Transistor
- ZENER DIODE

• Optoelectronic

- OPTO—Optoelectronic

• CCD—Charge-coupled device (imaging)

- COUPLERS—Photocouplers
- IED—Infrared-emitting diode
- IMAGE SENSOR
- LASER (GaP)—Semiconductor laser or laser IC
- LED—Light-emitting diode
- PDIODE—Photo diode
- PTRAN—Photo transistor
- SAW—Surface acoustic wave device
- SIT IMAGE SENSOR—Static induction transistor image sensor

The Process Technology column lists four major types of technologies. This column also lists a few uncommon technologies along with available information on levels of metal, type of well, and logic structure. Definitions of the nomenclature used in the Process Technology column are as follows:

- MOS (silicon-based)
  - CMOS—Complementary metal-oxide semiconductor
  - MOS—n-channel metal-oxide semiconductor (NMOS) and p-channel metal-oxide semiconductor (PMOS) (More than 90 percent of the MOS fabs use n-channel MOS.)
  - M1—Single-level metal
  - M2—Double-level metal
  - M3—Triple-level metal
  - N-WELL
  - P-WELL
  - POLY1—Single-level polysilicon
  - POLY2—Double-level polysilicon
  - POLY3—Triple-level polysilicon
- BiCMOS (silicon-based)
  - BiCMOS—Bipolar and CMOS combined on a chip
  - BIMOS—Bipolar and MOS combined on a chip
  - ECL I/O—ECL input/output
  - TTL I/O—TTL input/output
- Bipolar (silicon-based)
  - BIP—Bipolar
  - ECL—Emitter-coupled logic
  - TTL—Transistor-transistor logic
  - STTL—Schottky TTL
- Gallium arsenide and other compound semiconductor materials
  - GaAs—Gallium arsenide
  - GaAlAs—Gallium aluminum arsenide
  - GaAs on Si—Gallium arsenide on silicon
  - GaP-Gallium phosphide
  - HgCdTe—Mercuric cadmium telluride
  - InAs—Indium arsenide
  - InP—Indium phosphide
  - InSb—Indium antimony
  - LiNbO3—Lithium niobate
  - SOS—Silicon on sapphire

The number in the Minimum Linewidth column represents the minimum linewidth at the critical mask layers as drawn. This number is stated in microns and is defined in Dataquest's fab survey as being available in production volumes.

The Wafer Size column represents the wafer diameter expressed colloquially in inches. However, for wafers greater than 3 inches in diameter, the colloquial expression is inaccurate. When calculating square inches, the following approximations are used:

Stated Diameter	Approximate Diameter
4 inches (100mm)	3.938 inches
5 inches (125mm)	4.922 inches
6 inches (150mm)	5.906 inches
8 inches (200mm)	7.87 inches

Wafer Start Capacity is defined in the fab survey as the equipment-limited wafer start capacity per four-week period. Start capacity is not limited by current staffing or the number of shifts operating, it is limited only by the installed equipment in the fab and the complexity of the process it runs.

The Clean Room Class column represents the level of cleanliness in the cleanest part of the clean room. This area represents the true environment to which the wafer is exposed.

The Merchant or Captive column categorizes each fab line on the tables as one of these two types. Definitions of the various categories are as follows:

- A Merchant fab line is a fab line that produces devices that end up available on the merchant market.
- A Captive fab line does not sell any of its devices on the merchant market. All production is consumed by the owner of the fab line.

Table 1
European Existing Pilot and Production Fab Lines
(Including Fabs Going into Operation During 1992)

Company	City	Fab Name	Products Produced	Process Technology	Est. Minimum Line Width (Microns)	Wafer Diameter	Est. Max. Wafer Capacity (4wk/ Month)	Clean Room (Square Feet)	Class Clean Room	Merchant or Captive	Country
ABB SEMICONDUCTOR	LENSBURG	NA	DIS	BIP	0	4	0	0		M	SWITZERLAND
ABB-HAFO AB	JARFALLA	NA	ASIC LIN	BIP CMOS	1.50	4	3,000	12,900	1	M	SWEDEN
ABB-IXYS SEMICONDUCTOR	LAMPERTHEIM	ABB-IXYS	DIS DIODE	BIP	5.00	4	10,000	8,000	100	M	GERMANY
AEG AG (DAIMLER BENZ)	ULM	ULM RSCH	3D ICs mm-WAVE OPTO	GaAs MOS	0	0	0	0	NA	M	GERMANY
ANALOG DEVICES	LIMERICK	NA	LIN AD/DA TELECOM	CMOS BICMOS	1.00	4	20,000	30,000	10	M	IRELAND
ANSALDO TRASPORTI	GENOA	LINITA	PWR DIS	BIP 1M	2.00	4	6,000	0	10	M	ITALY
ASCOM MICROELECTRONICS	BEVAIX	NA	ARRAYS CUSTOM	BIP	6.00	4	4,000	21,520	10	M	SWITZERLAND
AT&T MICROELECTRONICS	MADRID	NA	CBIC CUSTOM	CMOS M2	1.00	6	8,400	30,000	1	M	SPAIN
ATMOS/ELPOL	WARSAW	NA	ASIC	NA	2.00	4	0	0	NA	M	POLAND
AUSTRIA MIKROSYSTEME GmbH	UNTERPREMSTATTEN	NA	ASIC	CMOS BICMOS	0.80	4	15,000	32,000	NA	M	AUSTRIA
BANEASA S.A. (IPRS)	BUCHAREST	NA	THYRISTOR DIODE LIN	BIP	0	0	0	0	NA	M	ROMANIA
BT&D TECHNOLOGIES	IPSWICH, SUFFOLK	NA	OPTO LASER		1.00	2	320	35,500	10,000		ENGLAND
DIGITAL EQUIPMENT CORPORATION	SOUTH QUEENSFERRY	NA	MPU FPU LOG ALPHA	CMOS M3 2POLY	0.75	6	3,000	28,000	1	C	SCOTLAND
ELMOS GmbH	DORTMUND	NA	ASIC	CMOS	1.50	4	4,000	15,000	1	M	GERMANY
EM MICROELECTRONICS-MARIN S.A.	NEUCHATEL	FAB 3		NA	2.00	6	4,200	18,292	10	M	SWITZERLAND
ERICSSON	KALMAR	NA	PWR DIS	BIP	0	4	25,000	92,000	NA	M	SWEDEN
ES2 EUROPEAN SILICON STRUCTURES S.A.	ROUSSET CEDEX	ES2/MTD	CBIC ARRAYS CUSTOM MIL STD 883	CMOS M2	0.80	5	1,500	12,912	2	M	FRANCE
FUJITSU	NEWTON AYCLIFFE	PHASE 1	4Mb DRAM ASIC	CMOS	0.80	6	5,600	45,000	1	M	ENGLAND
GEC PLESSEY SEMICONDUCTOR	LINCOLN	NA	LIN MPU ARRAYS SRAM CUST	CMOS MOS	1.50	4	13,000	12,000	10	M	ENGLAND
GEC PLESSEY SEMICONDUCTOR	LINCOLN	NA	THYRISTOR	BIP SOS	0	4	0	0	NA	M	ENGLAND
GEC PLESSEY SEMICONDUCTOR	ROBOROUGH	NA	ASIC DSP TELECOM	CMOS NMOS M3	0.70	6	6,000	19,906	1	M	ENGLAND
GEC PLESSEY SEMICONDUCTOR	SWINDON	NA	DIODES DIS LIN	BIP	5.00	5	12,000	29,000	NA	M	ENGLAND
GEC PLESSEY SEMICONDUCTOR	SWINDON	NA	LIN	BIP	3.00	4	14,000	0	NA	M	ENGLAND
GENERAL INSTRUMENTS	CRICKLADE	NA	DIS	BIP	0	4	10,000	0	NA	M	ENGLAND
HITACHI	LANDSHUT	NA	4Mb DRAM 1Mb SRAM	NA	0.80	8	16,000	0	NA	M	GERMANY
HMT	BRUGG	NA	CONSUMER ICs	MOS	0	3	15,000	15,000	NA	M	SWITZERLAND
HUGHES MICROELECTRONICS	GLENROTHES	NA	ARRAYS CBIC EPROM CUSTOM	CMOS MOS	3.00	4	6,400	28,000	100	M	SCOTLAND
IBM	CORBEIL-ESSONNES	NA	ARRAYS LIN CUSTOM	BIP	2.00	5	40,000	50,000	NA	C	FRANCE
IBM	CORBEIL-ESSONNES	NA	256K DRAM 64K SRAM	CMOS MOS	1.00	5	25,000	25,000	NA	C	FRANCE
IBM	CORBEIL-ESSONNES	NA	1Mb DRAM	CMOS	0	8	7,000	0	NA	C	FRANCE
IBM	HANNOVER	NA	DIS	BIP	0	4	20,000	0	NA	C	GERMANY
IBM	SINDELFINGEN	NA	PWR DIS HYBRID	BIP	0	4	20,000	0	NA	C	GERMANY
IBM	SINDELFINGEN	NA	ARRAYS	BIP	2.00	5	15,000	20,000	NA	C	GERMANY

(Continued)

Table 1 (Continued)
European Existing Pilot and Production Fab Lines
(Including Fabs Going into Operation During 1992)

Company	City	Fab Name	Products Produced	Process Technology	Est. Minimum Line Width (Microns)	Wafer Diameter	Est. Max. Wafer Capacity (4wk/Month)	Clean Room (Square Feet)	Class Clean Room	Merchant or Captive	Country
IBM	SINDELFINGEN	NA	1Mb DRAM 4Mb DRAM	CMOS	0.80	8	20,000	45,000	NA	C	GERMANY
IBM	SINDELFINGEN	NA	256K DRAM SRAM DSP MPU	MOS	1.50	5	25,000	20,000	NA	C	GERMANY
IBM	SINDELFINGEN	NA	CUSTOM	BIP	1.50	5	15,000	20,000	NA	C	GERMANY
IBM/SIEMENS	CORBEIL-ESSONNES	NA	16 Mb DRAM	CMOS	0.80	8	12,000	0		M	FRANCE
ICCE	BANEASA	NA	OPTO LIN	BIP	0	0	0	0	NA		ROMANIA
ICL	NA	NA	16K DRAM, 64K DRAM	NA	0	0	0	0	NA	M	BULGARIA
IMEC	LEUVEN	NA	NA	CMOS M2	0.70	0	0	0		R	BELGIUM
INST. SCIENCE & TECH.	TRENTO	NA	CCD	CMOS	0	4	10,000	0	NA	R	ITALY
INTEL	JERUSALEM	FAB 8	386 MPU 286 MPU	CMOS	0.80	6	21,000	24,000	10	M	ISRAEL
INTL. RECTIFIER	TURIN	BORGARO	RECTIFIER THYRISTOR	NA	0	4	15,000	13,000	100	M	ITALY
INTL. RECTIFIER	TURIN	VENARIA	RECTIFIER THYRISTOR	NA	0	4	10,000	0	NA	M	ITALY
ISKRA	TRBOVLJE	NA	DIS	BIP	0	3	5,000	0	NA	M	YUGOSLAVIA
ISOCOM	HARTLEPOOL	NA	OPTO	GaAs	0	0	0	0	NA	M	ENGLAND
ITALTEL	ROME	NA	NA	GaAs	0	0	0	0	NA	M	ITALY
ITT	FREIBURG	NA	PWR TRAN DIS	BIP MOS	5.00	4	42,000	0	100	M	GERMANY
ITT	FREIBURG	NA	DSP NVMEM CUSTOM	CMOS MOS	1.20	5	21,500	0	10	M	GERMANY
ITT	FREIBURG	NA	DIS CUSTOM	BIP	5.00	4	16,500	0	10	M	GERMANY
LUCAS	SUTTON COLDFIELD	NA	PWR DIS	GaAs	0	0	0	54,000	NA	M	ENGLAND
MATRA MHS S.A.	NANTES	FAB 1	256K SRAM MCU RISC MPI ASIC LIN	CMOS BICMOS M2	0.70	5	10,500	21,500	10	M	FRANCE
MICROELECT.-MARIN	MARIN	NA	CUSTOM	NA	0	4	10,000	0	NA	M	SWITZERLAND
MICROELECTRONICA S.A.	BANEASA	NA	MPU 16K DRAM	MOS	0	0	0	0	NA	M	ROMANIA
MICROELECTRONICS—IME LTD.	SOFIA	NA	LIN	CMOS BICMOS MOS	2.00	1	2,000	0		M	BULGARIA
MICROELECTRONICS—IME LTD.	SOFIA	NA	LIN	CMOS BICMOS MOS	2.00	5	9,000	0		M	BULGARIA
MICRONAS INC.	ESPOO	NA	LIN CBIC CUSTOM	CMOS M2	2.00	4	4,000	12,912	100	C	FINLAND
MIETEC ALCATEL	OUDENAARDE	FAB 1	CUSTOM CBIC ANA	MOS CMOS BICMOS	1.00	4	15,000	21,600	10	M	BELGIUM
MOTOROLA	EAST KILBRIDE	MOS 1	MCU LOG	CMOS MOS M1	3.00	4	43,200	25,600	100	M	SCOTLAND
MOTOROLA	EAST KILBRIDE	MOS 9	SRAM 1Mb DRAM MPU	CMOS M2	0.80	6	22,000	34,000	10	M	SCOTLAND
MOTOROLA	TOULOUSE	BIPOLAR 4	TELECOM OP AMP REG AUTO	BIP	2.00	4	25,000	22,000	100	M	FRANCE
MOTOROLA	TOULOUSE	TOULOUSE POWER	PWR TRAN	BIP	10.00	5	12,000	8,700	100	M	FRANCE
MOTOROLA	TOULOUSE	TOULOUSE RECTIFIER	DIS	BIP	0	4	3,600	5,800	NA	M	FRANCE
MTG (THESYS GmbH)	ERFURT	NA	ASIC	CMOS BICMOS	0	6	0	0	NA	C	GERMANY

(Continued)

Table 1 (Continued)
European Existing Pilot and Production Fab Lines
(Including Fabs Going into Operation During 1992)

Company	City	Fab Name	Products Produced	Process Technology	Est. Minimum Line Width (Microns)	Wafer Diameter	Est. Max. Wafer Capacity (4wk/ Month)	Clean Room (Square Feet)	Class Clean Room	Merchant or Captive	Country
NATIONAL SEMICONDUCTOR	GREENOCK	4"	LOG LIN	CMOS M1	2.50	4	25,000	0	100	M	SCOTLAND
NATIONAL SEMICONDUCTOR	GREENOCK	6"	LAN	BIP M2	2.00	6	21,000	18,700	10	M	SCOTLAND
NATIONAL SEMICONDUCTOR	GREENOCK	LINEAR 4"	LIN	BIP M1 M2	5.00	4	37,000	10,000	10	M	SCOTLAND
NATIONAL SEMICONDUCTOR	MIGDAL HAEMEK	NA	MPU MCU MPR DSP ARRAYS CUSTOM	CMOS M2 POLY1	0 70	6	5,500	18,000	10	M	ISRAEL
NEC	LIVINGSTON, WEST LOTHIAN	PHASE 1	1Mb DRAM 4Mb DRAM	CMOS M2 M3	0 70	5	9,000	19,500	1	M	SCOTLAND
NEC	LIVINGSTON, WEST LOTHIAN	PHASE 2	4Mb DRAM 256K SRAM MCU ASIC	CMOS	0 80	6	9,000	19,500	NA	M	SCOTLAND
NUOVA MISTRAL S.P.A.	SERMONETA (LATINA)	NA	ZENER DIODE DIODES SST	NA	3 00	4	15,000	10,760	1,000	M	ITALY
PHILIPS	CAEN	NA	CONSUMER ICS	BIPOLAR	1.50	5	18,000	0	100	M	FRANCE
PHILIPS	HAMBURG	CONSUMER	CON	BIP	1.20	5	18,000	16,140	100	M	GERMANY
PHILIPS	HAMBURG	DISCRETE	DIS	BIP	2.00	4	22,000	21,520	100	M	GERMANY
PHILIPS	HAMBURG	NA	8-BIT MCU 16-BIT MCU EEPROM ASI	CMOS NMOS M1 M2	1.00	5	12,500	32,280	10	M	GERMANY
PHILIPS	HAZELGROVE, STOCKPORT CHESHIRE	BIPOLAR	TRAN DIODE RECTIFIER	BIP	10.00	4	45,000	19,368	100	M	ENGLAND
PHILIPS	HAZELGROVE, STOCKPORT CHESHIRE	POWERMOS	DIODE SMART PWR	MOS 1M	3.00	4	10,000	11,836	10	M	ENGLAND
PHILIPS	NIJMEGEN	NA	LOG	CMOS	3.00	4	26,000	23,456	100	M	NETHERLANDS
PHILIPS	NIJMEGEN	NA	SRAM CON	CMOS NMOS M2	0.80	6	8,400	0	1	M	NETHERLANDS
PHILIPS	NIJMEGEN	NA	DIS	MOS BICMOS BIP	1.50	5	20,000	39,338	100	M	NETHERLANDS
PHILIPS	NIJMEGEN	NA	PWR DIS DIODES	NA	0.70	4	0	12,912	10,000	M	NETHERLANDS
PHILIPS	STADSKANAAL	NA	RECTIFIER	BIP M3	0	4	70,000	32,280	NA	M	NETHERLANDS
PHILIPS RTC	CAEN	NA	TRAN	NA	5.00	5	12,000	12,589	10	M	FRANCE
ROBERT BOSCH	REUTLINGEN	RtW/FAW	LIN DIS CUSTOM	BIP BICMOS	3.00	4	20,000	0	100	C	GERMANY
SEAGATE MICROELECTRONICS	LIVINGSTON	NA	LIN	BIP M2	3.00	4	5,000	16,140	100	C	SCOTLAND
SEMEFAB	GLENROTHES	NA	LIN DIS OPTO	BIP CMOS MOS	4.00	4	2,000	0	10	M	SCOTLAND
SEMIKRON	NURNBERG	NA	DIS	BIP	0	5	10,000	0	NA	M	GERMANY
SGS-THOMSON	AGRATE (MILAN)	FAB 9	64K 256K 1Mb EPROM PLD LIN ARRA	CMOS M2	0.70	6	28,000	22,000	10/1	M	ITALY
SGS-THOMSON	CATANIA	NA	DIS	NA	3.00	5	34,000	0	100	M	ITALY
SGS-THOMSON	CATANIA	NA	LOG LIN CUSTOM	CMOS	3.00	4	21,000	0	100	M	ITALY
SGS-THOMSON	COSTALETTO	NA	MPU	CMOS	0	5	0	0	NA	M	ITALY
SGS-THOMSON	GRENOBLE	NA	LIN PWR IC CUSTOM	BIP CMOS	1.50	4	20,000	21,520	100	M	FRANCE
SGS-THOMSON	RENNES	NA	LIN	BIP M2	5.00	5	16,000	0	10	M	FRANCE

(Continued)

Table 1 (Continued)
European Existing Pilot and Production Fab Lines
(Including Fabs Going into Operation During 1992)

Company	City	Fab Name	Products Produced	Process Technology	Est. Minimum Line Width (Microns)	Wafer Diameter	Est. Max. Wafer Capacity (4wk/ Month)	Clean Room (Square Feet)	Class Clean Room	Merchant or Captive	Country
SGS-THOMSON	ROUSSET	MODULE 5	EPROM EEPROM MPU MCU	CMOS MOS	1.50	5	22,000	33,356	1	M	FRANCE
SGS-THOMSON	TOURS	MESA	DIS	NA	20.00	4	60,000	0	100	M	FRANCE
SGS-THOMSON	TOURS	PLANAR	DIS	NA	5.00	4	15,000	0	100	M	FRANCE
SIEMENS	REGENSBURG	MEGA 1	1Mb DRAM 4Mb DRAM	CMOS	0.80	6	28,000	48,500	10	M	GERMANY
SIEMENS	VILLACH	VILLACH 1	TELECOM	BIPOLAR	2.00	4	26,000	24,748	100	M	AUSTRIA
SIEMENS	VILLACH	VILLACH 2	LOG	MOS	0.80	5	20,000	26,685	10	M	AUSTRIA
TAG	ZURICH	NA	DIS	NA	0	3	10,000	0	NA	M	SWITZERLAND
TELEFUNKEN	ECHING	NA	LOG MPU MCU ARRAYS CUST	CMOS	3.00	4	24,000	3,000	100	M	GERMANY
TELEFUNKEN ELECTRONIC	HEILBRONN	NA	CUSTOM LIN DIS MCU	BIP MOS CMOS	1.00	4	25,000	43,000	10	M	GERMANY
TEXET	NICE	NA	DIS	NA	0	4	10,000	25,000	NA	M	FRANCE
TI	AVEZZANO	PHASE 1	4Mb DRAM ASSP CBIC	CMOS	0.05	6	9,200	78,000	1	M	ITALY
TI	BEDFORD	PWR FAB	PWR DIS	BIP	3.00	4	24,000	9,000	100	M	ENGLAND
TI	FREISING	FRSI	LIN ASSP LOG	BIP CMOS BICMOS	0.80	5	19,300	10,000	10	M	GERMANY
TI	FREISING	FRSI	CBIC LIN ASSP LOG	CMOS BICMOS	0.80	5	10,000	17,000	10	M	GERMANY
TOMI	TORUN	NA	DIS	NA	0	0	0	0	NA	M	POLAND
VAISALA	VANTAA	NA	LIN	CMOS	5.00	3	200	0	100	M	FINLAND
VEB HALBLEITERWERK	FRANKFURT (ODER)	NA	NA	NA	0	6	10,000	0	NA	C	GERMANY
VEB ROEHRENWERK	NEUHAUS AM RENNWEG	NA	TRAN	NA	0	0	0	0	NA	C	GERMANY
VEB WERK FUER FERNSEHELEKTRONIK	BERLIN-OBERSCHOENEWEIDE	NA	SENSOR CCD	NA	0	0	0	0	NA	C	GERMANY
WESTCODE SEMICONDUCTOR	CHIPPENHAM	NA	DIS	BIP	0	2	10,000	0	NA	C	ENGLAND
ZETEX	OLDHAM	NA	DIS DIODE LIN	BIP MOS	1.50	4	10,000	26,000	100	M	ENGLAND

NA = Not available
Source: Dataquest (October 1992)

Table 2
European Future Pilot and Production Fab Lines
Planned Facilities by Year

Company	City	Fab Name	Products	Process Technology	Facility Type	Target Date Facility to Begin Operation	Est. Minimum Line Geometry (Microns)	Wafer Size (Inches)	Est. Wafer Start Capacity (4 Wk/ Month)	Clean Room Square Feet	Country
Production Begins: 1993											
INTEL	LEIXLIP, COUNTY KILDARE	FAB 10	486 MPU 586 MPU	BICMOS	F	NA	0.50	8	16,000	50,000	IRELAND
MIETEC ALCATEL	OUDENAARDE	FAB 2	ASIC	CMOS M2 POLY2	FAT		0.50	6	20,000	21,600	BELGIUM
NATIONAL SEMICONDUCTOR	GREENOCK	LINEAR	LIN	BIP	F	NA	0	6	0	0	SCOTLAND
SGS-THOMSON	CROLLES	PHASE 1	ASIC	CMOS BICMOS	RP	06/01/93	0.50	8	2,000	0	FRANCE
Production Begins: 1994											
FUJITSU	NEWTON AYCLIFFE	PHASE 2	16Mb DRAM	CMOS	F	NA	0.50	6	0	8,000	ENGLAND
MITSUBISHI	ALSDORF	NA	4Mb DRAM 16Mb DRAM	CMOS	F	NA	0.80	6	22,000	0	GERMANY

NA = Not Available
Source: Dataquest (October 1992)

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Asia/Pacific-Rest of World Fab Database

October 26, 1992

Source: Dataquest

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Semiconductor Equipment, Manufacturing, and Materials

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Asia/Pacific-Rest of World Fab Database

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Note: All tables show estimated data.

Asia/Pacific-Rest of World Fab Database

Background

The material in this document applies to the Asia/Pacific-Rest of World (ROW) portion of Dataquest's Semiconductor Equipment, Manufacturing, and Materials service wafer fab database. The wafer fab database is updated on an ongoing basis, employing both primary and secondary research methodologies. The tables included in this document highlight both production and pilot line wafer fabs.

Research Methodology

Dataquest takes a three-pronged approach to wafer fab database research. Information is gained through extensive annual primary research. This survey work is further supplemented with comprehensive secondary research conducted on an ongoing basis. The database is updated daily, which allows Dataquest to provide a snapshot of the marketplace at any time. The information gathered through primary and secondary research is then further supplemented and cross-checked with Dataquest's various other information sources.

General Definitions

Fab line: A fab line is a processing line in a clean room that is equipped to do all front-end wafer processing. Occasionally there are two separate product-specific fab lines or two different wafer sizes in a clean room. In this situation, a clean room will be documented as two fab lines if the equipment is dedicated to each wafer size or product line. There can be many fab lines at one location.

Front-end wafer processing: Front-end wafer processing is defined as all steps involved with semiconductor processing, beginning with initial oxide and ending at wafer probe.

Production fab: A production fab is defined as a wafer fab capable of front-end processing more than 1,250 wafers per week (type = F).

Pilot fab: A pilot fab is defined as a wafer fab capable of front-end processing less than 1,250 wafers per week (type = P).

Definition of Table Columns

The Products Produced column contains information for seven product categories. The information in this column can be very detailed, depending on its availability. The nomenclature used within the seven product groups of the fab database is as follows, with definitions where warranted:

- Analog
  - LIN—Linear/analog devices
  - A/D D/A—Analog-to-digital, digital-to-analog converters
  - AUTOMOTIVE—Dedicated to automobile applications
  - CODEC—Coder/decoder
  - INTERFACE—Interface IC
  - MESFET (GaAs)—Metal Schottky field-effect transistor
  - MODFET (GaAs)
  - MDIODE (GaAs)—Microwave diode
  - MFET (GaAs)—Microwave field-effect transistor
  - MODEM—Modulator/demodulator
  - MMIC—Monolithic microwave IC
  - OP AMP—Operational amplifier
  - PWR IC—Power IC
  - REG—Voltage regulator
  - SMART PWR—Smart power
  - SWITCHES—Switching device
  - TELECOM—Telecommunications chips
- Memory
  - MEM—Memory

- RAM—Random-access memory
- DRAM—Dynamic RAM
- SRAM 4 TR.—Static RAM uses a 4-transistor cell design
- SRAM 6 TR.—Static RAM uses a 6-transistor cell design
- VRAM—Video RAM
- ROM—Read-only memory
- PROM—Programmable ROM
- EPROM—Ultraviolet erasable PROM
- EEPROM or E2—Electrically erasable PROM
- FERRAM—Ferroelectric RAM
- FLASH—Flash memory
- NVMEM—Nonvolatile memory (ROM, PROM, EPROM, EEPROM, FERRAM)
- FIFO—First-in/first-out memory
- SPMEM—Other specialty memory (such as dual-port, shift-register, color lookup)

• Micrologic

- ASSP—Application-specific standard product
- BIT—Bit slice (subset of MPU functions)
- DSP—Digital signal processor
- MCU—Microcontroller unit
- MPR—Microperipheral
- MPRCOM—MPR digital communication (ISDN, LAN, UART, modem)
- MPU—Microprocessor unit
- LISP—32-bit list instruction set processor for AI applications
- RISC—Reduced-instruction-set computation 32-bit MPU

• Standard logic

- LOG—Standard logic

• ASIC logic

- ASIC—Application-specific IC
- ARRAYS—Gate arrays
- CBIC—Cell-based IC
- CUSTOM—Full-custom IC (single user)
- PLD—Programmable logic device

• Discrete

- DIS—Discrete
- DIODE
- FET—Field-effect transistor
- GTO—Gate turn-off thyristor
- HEMT (GaAs)—High-electron-mobility transistor
- MOSFET—MOS-based field-effect transistor
- PWR TRAN—Power transistor
- RECTIFIER
- RF—Radio frequency
- SCR—Schottky rectifier
- SENSORS
- SST—Small-signal transistor
- THYRISTOR
- TRAN—Transistor
- ZENER DIODE

• Optoelectronic

- OPTO—Optoelectronic
- CCD—Charge-coupled device (imaging)
- COUPLERS—Photocouplers
- IED—Infrared-emitting diode
- IMAGE SENSOR
- LASER (GaP)—Semiconductor laser or laser IC
- LED—Light-emitting diode
- PDIODE—Photo diode
- PTRAN—Photo transistor
- SAW—Surface acoustic wave device
- SIT IMAGE SENSOR—Static induction transistor image sensor

The Process Technology column lists four major types of technologies. This column also lists a few uncommon technologies along with available information on levels of metal, type of well, and logic structure. Definitions of the nomenclature used in the Process Technology column are as follows:

- MOS (silicon-based)
  - CMOS—Complementary metal-oxide semiconductor
  - MOS—n-channel metal-oxide semiconductor (NMOS) and p-channel metal-oxide semiconductor (PMOS). (More than 90 percent of the MOS fabs use n-channel MOS.)
  - M1—Single-level metal
  - M2—Double-level metal
  - M3—Triple-level metal
  - N-WELL
  - P-WELL
  - POLY1—Single-level polysilicon
  - POLY2—Double-level polysilicon
  - POLY3—Triple-level polysilicon
- BiCMOS (silicon-based)
  - BiCMOS—Bipolar and CMOS combined on a chip
  - BIMOS—Bipolar and MOS combined on a chip
  - ECL I/O—ECL input/output
  - TTL I/O—TTL input/output
- Bipolar (silicon-based)
  - BIP—Bipolar
  - ECL—Emitter-coupled logic
  - TTL—Transistor-transistor logic
  - STTL—Schottky TTL
- Gallium arsenide and other compound semiconductor materials
  - GaAs—Gallium arsenide
  - GaAlAs—Gallium aluminum arsenide
  - GaAs on Si—Gallium arsenide on silicon
  - GaP-Gallium phosphide
  - HgCdTe—Mercuric cadmium telluride
  - InAs—Indium arsenide
  - InP—Indium phosphide
  - InSb—Indium antimony
  - LiNbO3—Lithium niobate
  - SOS—Silicon on sapphire

The number in the Minimum Linewidth column represents the minimum linewidth at the critical mask layers as drawn. This number is stated in microns and is defined in Dataquest's fab survey as being available in production volumes.

The Wafer Size column represents the wafer diameter expressed colloquially in inches. However, for wafers greater than 3 inches in diameter, the colloquial expression is inaccurate. When calculating square inches, the following approximations are used:

Stated Diameter	Approximate Diameter
4 inches (100mm)	3.938 inches
5 inches (125mm)	4.922 inches
6 inches (150mm)	5.906 inches
8 inches (200mm)	7.87 inches

Wafer Start Capacity is defined in the fab survey as the equipment-limited wafer start capacity per four-week period. Start capacity is not limited by current staffing or the number of shifts operating, it is limited only by the installed equipment in the fab and the complexity of the process it runs.

The Clean Room Class column represents the level of cleanliness in the cleanest part of the clean room. This area represents the true environment to which the wafer is exposed.

The Merchant or Captive column categorizes each fab line on the tables as one of these two types. Definitions of the various categories are as follows:

- A Merchant fab line is a fab line that produces devices that end up available on the merchant market.
- A Captive fab line does not sell any of its devices on the merchant market. All production is consumed by the owner of the fab line.

Table 1
Asia/Pacific-ROW Existing Pilot and Production Fab Lines
(Including Fabs Going into Operation During 1992)

Company	City	Fab Name	Product(s) Produced	Process Technology	Est. Minimum Line Width (Microns)	Wafer Diameter	Est. Max. Wafer Capacity (4wk/ Month)	Room (Gross) (Square Feet)	Class Clean Room	Merchant or Captive	Country
ADVANCED MICROELECTRONICS PRODUCT	HSIN CHU	FAB 1	NA	CMOS	2.00	4	10,000	0	NA	M	TAIWAN
AMALGAMATED WIRELESS	SYDNEY	NA	ASIC	CMOS	1.50	6	7,000	0	NA	M	AUSTRALIA
BEIJING NO.2	BEIJING	NA	INTERFACE IC	BIP TTL	5.00	3	10,000	0	NA	C	CHINA
BEIJING NO.3	BEIJING	NA	LOG TRANS LIN MEM WATCH	CMOS MOS	5.00	3	15,000	0	NA	C	CHINA
BEIJING NO.5	BEIJING	NA	OP AMP LOG PWR TRAN	NA	5.00	3	10,000	0	NA	C	CHINA
BEIJING NO.878	BEIJING	NA	DIS	NA	5.00	3	8,000	0	NA	C	CHINA
BEIJING TUBE FACTORY	BEIJING	NA	DIS	NA	5.00	4	10,000	0	NA	C	CHINA
BEL	BANGALORE	NA	DIS	NA	4.00	4	10,000	0	NA	M	INDIA
BELLING IC CO.	SHANGHAI	NA	DIS	CMOS	2.40	0	0	0	NA	C	CHINA
BHARAT ELECTRONICS	BANGALORE	N/M		NA	0.00	0	0	0	NA	M	INDIA
CHARTERED SEMICONDUCTOR	SINGAPORE	Fab 1	ASIC LIN EEPROM	CMOS MOS	1.20	6	15,000	20,000	10	M	SINGAPORE
CONTINENTAL DEVICES	DELHI	NA	DIS DIODE TRAN PWR SCR	NA	0.00	3	10,000	0	NA	M	INDIA
DAEWOO	GURO-DONG, SEOUL	BIPOLAR LINE	LIN	BIP	3.00	4	9,000	0	NA	M	SOUTH KOREA
DAEWOO	GURO-DONG, SEOUL	MOS LINE	CUSTOM	CMOS MOS	1.70	4	9,000	0	NA	M	SOUTH KOREA
DONG GUANG PLANT	BEIJING	NA	LOG MPU	BIP TTL	5.00	3	5,000	0	NA	C	CHINA
ELECT. COMPONENTS INDIA	HYDERABAD	NA	DIS CONSUMER ICs	BIP	0.00	3	15,000	0	NA	M	INDIA
EPISIL TECHNOLOGIES INC.	HSIN CHU	NA	LIN	BICMOS	3.00	5	12,000	5,380	10	M	TAIWAN
FINE MICROELECTRONICS	HSIN CHU	NA	OPTO TRAN	NA	0.00	3	10,000	0	NA	M	TAIWAN
FUCHOU	FUCHOU	NA	NA	NA	5.00	3	4,000	0	NA	M	CHINA
GENERAL INSTRUMENTS	HSI TIEN CITY	NA	PWR DIS	BIP	0.00	3	12,000	0	10,0	M	TAIWAN
GOLDSTAR	CHONGJU-CITY, CHOONGBUK	PHASE 1	1Mb DRAM 4Mb DRAM	CMOS MOS	0.80	6	30,000	0	NA	M	SOUTH KOREA
GOLDSTAR	CHONGJU-CITY, CHOONGBUK	PHASE 2	4Mb DRAM	MOS CMOS M2 POLY3	0.70	6	30,000	0	NA	M	SOUTH KOREA
GOLDSTAR	GUMI-CITY, KYUNGBUK	GUMI BIPOLAR	LIN	BIP TTL	3.00	4	25,000	0	NA	M	SOUTH KOREA
GOLDSTAR	GUMI-CITY, KYUNGBUK	GUMI MOS	SRAM DRAM	CMOS MOS	1.50	5	15,000	0	NA	M	SOUTH KOREA

(Continued)

Table 1 (Continued)
Asia/Pacific-ROW Existing Pilot and Production Fab Lines
(Including Fabs Going into Operation During 1992)

Company	City	Fab Name	Products Produced	Process Technology	Est. Minimum Line Width (Microns)	Wafer Diameter	Est. Max. Wafer Capacity (4wk/ Month)	Room (Gross) (Square Feet)	Class Clean Room	Merchant or Captive	Country
HARBIN FACTORY	HARBIN	NA	TRAN	NA	5.00	3	10,000	0	NA	C	CHINA
HOLTEK	HSIN CHU	NA	ASIC LIN	CMOS	2.00	5	10,000	0	NA	M	TAIWAN
HUA KO ELECTRONICS	TAI PO	NA	MPU LIN ASIC LOG SRAM ROM	CMOS MOS	0.00	4	8,000	0	NA	M	HONG KONG
HUALON MICROELECTRONICS	HSIN CHU	FAB 1	ROM TELECOM CONSUMER MPU	CMOS MOS	1.00	5	30,000	0	10	M	TAIWAN
HYUNDAI	ICHUN, KYUNGKI-DO	FAB I-A	PLD EEPROM 16K SRAM	CMOS MOS	1.20	5	15,000	0	NA	M	SOUTH KOREA
HYUNDAI	ICHUN, KYUNGKI-DO	FAB I-B	256K DRAM 256K SRAM	MOS CMOS	1.00	5	8,000	0	NA	M	SOUTH KOREA
HYUNDAI	ICHUN, KYUNGKI-DO	FAB II	1Mb DRAM 1Mb SRAM	CMOS MOS	0.80	6	25,000	0	NA	M	SOUTH KOREA
HYUNDAI	ICHUN, KYUNGKI-DO	FAB III - A	4Mb DRAM	CMOS MOS	0.80	6	20,000	0	NA	M	SOUTH KOREA
HYUNDAI	ICHUN, KYUNGKI-DO	FAB III - B	4Mb DRAM 16Mb DRAM	CMOS	0.60	6	20,000	0	NA	M	SOUTH KOREA
INDIAN TELEPHONE	BANGALORE	NA	DIS	BIP	0.00	3	12,000	0	NA	C	INDIA
INTEL	JERUSALEM	FAB 8	MPU	CMOS	1.00	6	21,000	24,000	10	M	ISRAEL
JINAN NO.1	JINAN	NA	LOG OP AMP	NA	5.00	3	10,000	0	NA	C	CHINA
JINAN NO.2	JINAN	NA	1K SRAM 4K DRAM	MOS	5.00	3	8,000	0	NA	C	CHINA
KOREAN ELECTRONIC CO.	GUMI-CITY, KYUNGBUK	BIPOLAR LINE 1	LIN	BIP	2.50	4	20,000	0	NA	M	SOUTH KOREA
KOREAN ELECTRONIC CO.	GUMI-CITY, KYUNGBUK	BIPOLAR LINE 2	CUSTOM	BIP	1.50	5	10,000	0	NA	M	SOUTH KOREA
LIAONING FACTORY	JINZHOU	NA	TRAN	NA	5.00	3	12,000	0	NA	C	CHINA
MACRONIX INC.	HSIN CHU	FAB 1	EPROM FLASH 4Mb ROM	MOS	0.80	6	8,000	53,800	1	M	TAIWAN
MIN MACHINERY INDUSTRY	NA	NA	LOG PWR TRAN	MOS	5.00	3	5,000	0	NA	C	CHINA
MOSEL-VITELIC CORPORATION	TAI PO, N.T.	FAB 1	LIN 256K DRAM 16K SRAM	CMOS	1.50	4	14,000	10,000	10	M	HONG KONG
MOTOROLA	SEREMBAN	ISMF	PWR TRAN DIS SST	BIP	0.00	4	8,000	6,000	NA	M	MALAYSIA
NAINA SEMICONDUCTORS	HALDWANI	NA	DIODES	NA	0.00	0	0	0	NA	M	INDIA

(Continued)

Table 1 (Continued)
Asia/Pacific-ROW Existing Pilot and Production Fab Lines
(Including Fabs Going into Operation During 1992)

Company	City	Fab Name	Products Produced	Process Technology	Est. Minimum Line Width (Microns)	Wafer Diameter	Est. Max. Wafer Capacity (4wk/ Month)	Room (Gross) (Square Feet)	Class Clean Room	Merchant or Captive	Country
NATIONAL SEMICONDUCTOR	MIGDAL HAEMEK	NA	MPU MCU MPR DSP ARRAYS CUSTOM	CMOS M2 POLY1	0.70	6	5,500	18,000	10	M	ISRAEL
PHILIPS	SHANGHAI	NA	LIN DIGITAL IC FOR T.V.	CMOS BIP	0.00	5	10,000	0		M	CHINA
PHOTRONICS	NA	NA	OPTO	NA	0.00	3	10,000	0	NA	M	TAIWAN
QIANMEN SEMICONDUCTOR FACTORY	BEIJING	NA	DIG WATCH IC	NA	5.00	3	10,000	0	NA	C	CHINA
RAMAX	MELBOURNE	NA	FERRAM	CMOS GaAs	0.00	0	0	0	NA	M	AUSTRALIA
RCL SEMICONDUCTORS	TAI PO	NA	MEM MPU LOG LIN TRAN	CMOS	0.00	4	4,000	0	NA	M	HONG KONG
RECTRON LTD.	TAIPEI	NO. 1	DIS	NA	0.00	2	90,000	0	NA	M	TAIWAN
SAMSUNG	BUCHON-CITY, KYUNGKI-DO	BIPOLAR LINE	LIN	BIP	3.00	4	25,000	0	NA	M	SOUTH KOREA
SAMSUNG	BUCHON-CITY, KYUNGKI-DO	MOS LINE	MPU MCU LOG	CMOS MOS	2.00	5	20,000	0	NA	M	SOUTH KOREA
SAMSUNG	KIHEUNG-UP, KYUNGKI-DO	MOS 1	64K DRAM	MOS CMOS	1.50	4	35,000	0	NA	M	SOUTH KOREA
SAMSUNG	KIHEUNG-UP, KYUNGKI-DO	MOS 2	256K DRAM	CMOS MOS	1.20	6	35,000	0	NA	M	SOUTH KOREA
SAMSUNG	KIHEUNG-UP, KYUNGKI-DO	MOS 3	1Mb DRAM	MOS CMOS	0.80	6	35,000	0	NA	M	SOUTH KOREA
SAMSUNG	KIHEUNG-UP, KYUNGKI-DO	MOS 4	4Mb DRAM	CMOS	0.60	6	30,000	0	NA	M	SOUTH KOREA
SAMSUNG	KIHEUNG-UP, KYUNGKI-DO	MOS 5	16Mb DRAM	CMOS	0.50	8	6,000	0	NA	M	SOUTH KOREA
SGS-THOMSON	ANG MO KIO	BIPOLAR LINEAR	OP AMP TELECOM	BIP MOS	0.00	5	20,000	0	NA	M	SINGAPORE
SGS-THOMSON	ANG MO KIO	BIPOLAR POWER	PWR TRAN	BIP MOS	0.00	5	20,000	0	NA	M	SINGAPORE
SGS-THOMSON	ANG MO KIO	NMOS & CMOS	NA	CMOS	0.00	5	20,000	0	NA	M	SINGAPORE
SHANGHAI MICRO. R&D CENTER	SHANGHAI	NA	NA	NA	0.00	0	0	0			CHINA
SHANGHAI NO.5	SHANGHAI	NA	8080 MPU LOG MEM LIN DIS	CMOS	5.00	3	10,000	0	NA	C	CHINA
SHANGHAI NO.8331	SHANGHAI	NA	OP AMP PWR TRAN	BIP TTL	5.00	3	4,000	0	NA	C	CHINA

(Continued)

Table 1 (Continued)
Asia/Pacific-ROW Existing Pilot and Production Fab Lines (Including Fabs Going into Operation During 1992)

Company	City	Fab Name	Products Produced	Process Technology	Est. Minimum Line Width (Microns)	Wafer Diameter	Est. Max. Wafer Capacity (4wk/ Month)	Room (Gross) (Square Feet)	Class Clean Room	Merchant or Captive	Country
SHANGHAI PHILIPS NO.7	SHANGHAI	NA	OP AMP PWR TRAN DIS	BIP TTL CMOS	5.00	3	10,000	5,380	NA	M	CHINA
SHINDENGEN	NA	NA	TRAN DIODES	NA	0.00	0	0	0	NA	M	THAILAND
SID MICROELECTRONICS	CONTAGEM	NA	LIN PWR TRAN SST PWR ICs	BIP	30.00	3	12,000	15,000	NA	M	BRAZIL
SID MICROELECTRONICS	CONTAGEM	NA	PWR ICs	CMOS	2.00	4	13,000	15,000	NA	M	BRAZIL
SOUTH AFRICAN MICROELECTRONICS	PRETORIA	NA	A/D D/A TELECOM	BIP	5.00	3	10,000	0	NA	M	SOUTH AFRICA
SOUTH AFRICAN MICROELECTRONICS	PRETORIA	NA	A/D D/A TELECOM	CMOS	3.00	4	10,000	0	NA	M	SOUTH AFRICA
SPIC ELECTRONICS	GUINDY, MADRAS	NA	PHOTO VOLTAIC DIS	NA	3.00	3	15,000	0	NA	M	INDIA
SUZHOU PLANT	SUZHOU	NA	LOG OPTO CONSUMER	BIP TTL MOS	0.00	3	0	0	NA	C	CHINA
TI/ACER	HSIN CHU	FAB 1	4Mb DRAM	CMOS	0.80	6	25,000	45,000	NA	M	TAIWAN
TIAN GUANG FACTORY	SHAOXING	NA	LOG	BIP ECL TTL	5.00	4	14,000	0	NA	C	CHINA
TIANJIN NO.1	TIANJIN	NA	AUDIO IC	CMOS	5.00	3	10,000	0	NA	C	CHINA
TSMC	HSIN CHU	FAB 1	MEM MICRO LOG	CMOS M2 2POLY	1.00	6	14,000	7,637	10	M	TAIWAN
TSMC	HSIN CHU	FAB 2-A	SRAM EPROM LOG LIN	CMOS	0.80	6	25,000	40,000	1	M	TAIWAN
TSMC	HSIN CHU	FAB 2-B	SRAM	CMOS	0.80	6	4,000	40,000	NA	M	TAIWAN
UNITED MICROELECTRONICS	HSIN CHU	FAB 1	SRAM MCU LIN	CMOS MOS M2	1.50	4	45,000	0	NA	M	TAIWAN
UNITED MICROELECTRONICS	HSIN CHU	FAB 2-A	4Mb ROM EPROM	CMOS MOS M2	0.80	6	18,000	30,000	1	M	TAIWAN
UNITED MICROELECTRONICS	HSIN CHU	FAB 2-B	1Mb SRAM 4Mb ROM EPROM	CMOS	0.60	6	3,000	15,000	NA	M	TAIWAN
WINBOND	HSIN CHU	FAB 1	SRAM ROM MPU	CMOS MOS	1.00	5	20,000	0	10	M	TAIWAN
WINBOND	HSIN CHU	FAB 2	SRAM MPU	CMOS M2	0.80	6	8,000	0	1	M	TAIWAN
WUXI MICROELECTRONICS CORPORATION	WUXI JIANH SU	NA	TRAN DIODES LIN LOG MEM	MOS	5.00	4	15,000	0	NA	M	CHINA
YANHE RADIO FACTORY	XIAN	NA	LIN LOG	NA	5.00	3	7,000	0	NA	C	CHINA

NA = Not available
Source: Dataquest (October 1992)

Table 2
Asia/Pacific-Rest of World Future Pilot and Production Fab Lines
Planned Facilities by Year

Company	City	Fab Name	Products	Process Technology	Facility Type	Target Date Facility to Begin Operation	Est. Minimum Line Geometry (microns)	Wafer Size (Inches)	Est. Wafer Start Capacity (4 Wk/Month)	Clean Room Square Feet	Country
Production Begins: 1993											
GOLDSTAR	CHONGJU-CITY, CHOONGBUK	PHASE 3	16Mb DRAM 4Mb SRAM	CMOS	F	NA	0.50	8	45,000	0	SOUTH KOREA
MOSel/VITELIC CORPORATION	HSIN CHU	FAB 1	4Mb DRAM	CMOS MOS	F	08/01/93	0.60	6	13,000	22,000	TAIWAN
NEC CHINA	BEIJING	NA	TELECOM CONSUMER ICS	CMOS	F	NA	2.00	6	0	0	CHINA
SEMICONDUCTOR COMPLEX	NAGAR-CHANDIGARH	NA	LSI	NA	F	11/01/91	3.00	6	0	0	INDIA
TECH SEMICONDUCTOR SINGAPORE LTD.	NA	NA	16Mb DRAM	CMOS	F	03/01/93	0.60	8	10,000	0	SINGAPORE
WUXI MICROELECTRONICS CORPORATION	WUXI	NA	TELECOM ICS	MOS	F	02/01/91	3.00	5	25,000	0	CHINA
Production Begins: 1994											
HITACHI	PENANG	NA	1Mb DRAM 4Mb DRAM	CMOS	F	NA	0.00	6	0	0	MALAYSIA
HUA YUE MICROELECTRONICS CO. LTD.	SHAOXING	NA	NA	CMOS	F	05/01/94	1.00	6	7,000	0	CHINA
MOSel/VITELIC CORPORATION	HSIN CHU	FAB 2	16Mb DRAM	CMOS MOS	F	NA	0.50	8	20,000	22,000	TAIWAN
SAMSUNG	KIHEUNG-UP, KYUNGKI-DO	FAB 6	4Mb 16Mb DRAM	CMOS	F	06/01/93	0.60	8	20,000	0	SOUTH KOREA
SYNTEK	HSIN CHU	NA	NA	NA	F	NA	0.00	6	10,000	0	TAIWAN
UNITED MICROELECTRONICS	HSIN CHU	FAB 3	SRAM	NA	F	NA	0.00	8	30,000	0	TAIWAN

NA = Not available
Source: Dataquest (October 1992)

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Semiconductor Equipment, Manufacturing, and Materials Forecast

MarketTrends

Semiannual Edition

Dataquest®

Semiconductor Equipment, Manufacturing, and Materials
SEMM-SVC-MT-9201
August 17, 1992

Semiconductor Equipment, Manufacturing, and Materials Forecast

MarketTrends

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SEMM-SVC-MT-9201
August 17, 1992

Semiconductor Equipment, Manufacturing, and Materials MarketTrends is a report published twice a year by Dataquest. The report focuses on key semiconductor industry forecasts including semiconductor capital spending, wafer fabrication equipment, silicon wafer consumption, device production and device consumption. An accompanying discussion of the critical issues that we believe will drive future industry developments both from a micro and macro viewpoint is also included. Particular emphasis is paid to individual regional trends.

A more comprehensive discussion of historical trends in the wafer fab equipment market is included in another Dataquest MarketTrends report entitled *Wafer Fab Equipment Market 1991 in Review*. The historical equipment report complements the equipment forecast chapter contained in this report for those readers interested in more details on the semiconductor capital equipment market.

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Chapter 1
Executive Summary: More Moderate Growth

The semiconductor industry is passing from adolescence to a more mature stage. The incredible surge in semiconductor investment that took place from 1986 to 1991 is waning. Spurts in growth such as the industry experienced over the last six years are less likely to occur without new product drivers or the opening of new markets.

Dataquest believes that the end of the Japan-led boom marks a major turning point for the global semiconductor industry. Worldwide five-year growth rates in semiconductor production, capital spending, wafer fab equipment purchases, and silicon wafer consumption will decelerate from historical double-digit growth to single-digit levels.

Since 1986, semiconductor companies have dramatically increased their level of investment in new plants and equipment. The level of investment in 1991 was almost three times the investment level in 1986. Dataquest does not believe that the investment growth rate of the past five years is sustainable. We believe that capital spending will decline 9.5 percent worldwide in 1992.

The surge in capital spending over the past five years was largely attributed to an exceptionally strong investment boom in Japan, which was fueled by cheap money and double-digit growth in the global PC market. The spending binge has left several segments of the semiconductor industry with excess semiconductor fab capacity. With excess capacity hanging over the market, there is little opportunity to raise chip prices. Consequently, semiconductor company profits are being squeezed and capital spending budgets cut.

We expect a weak environment for capital spending to persist through 1993. Japanese companies, which account for 44 percent of worldwide capital spending, will cut their spending 24 percent in 1992. Japanese banks have difficult financial challenges because of asset deflation, and these problems are spilling over into the manufacturing sector of the economy in the form of tighter lending policies. We expect the problems in Japan to persist into next year, resulting in only a moderate semiconductor capital spending upturn in 1993.

On the other hand, growth in semiconductor device production is expected to bottom in 1992 and begin picking up steam in 1993. Production is tied very closely to a global recovery, which we believe will be weak in 1992 and well under way in 1993. However, Dataquest does not see any single product on the horizon that will boost IC demand as the PC did following the 1985 recession. Nor do we expect the demand for ICs in emerging markets such as Eastern Europe, China, or India to have much of an impact on global production over the next several years.

Therefore, we are forecasting semiconductor device production to grow at a 9.2 percent compound annual growth rate (CAGR) through 1996. This growth rate is well below the 13.1 percent CAGR achieved over the last five years and reflects the slower growth environment for the entire semiconductor industry.

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Chapter 2
Semiconductor Capital Spending Forecast

Chapter Highlights

- Worldwide capital spending down 9.5 percent in 1992
- Downturn led by sharp cuts by Japanese companies
- Korean companies push ahead with aggressive spending
- Modest spending cuts in the United States
- Spending in Europe continues to decline
- Dataquest forecasts modest worldwide upturn in 1993

This section presents data on worldwide semiconductor capital spending by region. Capital spending in a region includes spending by all semiconductor producers in that region, including spending by merchant and captive producers as well as foreign producers. For instance, capital spending in North America includes spending by Delco, IBM, and Japanese and European semiconductor companies building wafer fabrication, assembly, and test facilities in the United States.

Yearly exchange rate variations can have a significant effect on the 1985 through 1991 data in the following tables. Appendix B provides a more complete explanation of the exchange rates used in this document.

Capital Spending Forecast

Table 2-1 shows historical capital spending for the years 1985 through 1991, and Table 2-2 shows forecast spending for the period from 1991 through 1996. Table 2-3 shows the rankings for semiconductor capital spending for the top 10 companies.

Semiconductor Capital Spending Forecast: A Secular Change for the Market

Worldwide semiconductor capital spending is expected to decline 9.5 percent in 1992 (see Table 2-2) largely because of severe cuts in spending by Japanese companies. Dataquest believes that 1992 will mark the bottom of the spending cycle. However, we are only forecasting moderate growth in spending in 1993. Moreover, the five-year worldwide compound annual growth rate for spending through 1996 is estimated to be 6.9 percent (see Table 2-2). This rate is at an historic

Table 2-1
Worldwide Capital Spending by Region - Historical
Includes Merchant and Captive Semiconductor Companies
(Millions of U.S. Dollars)

	1985	1986	1987	1988	1989	1990	1991	CAGR (%) 1986-1991
North America	2,629	2,082	2,594	3,434	3,875	4,088	3,851	13.1
Percent Growth	-16.2	-20.8	24.6	32.4	12.8	5.5	-5.8	
Japan	3,336	1,845	2,432	4,610	5,473	5,425	5,636	25.0
Percent Growth	-11.5	-44.7	31.8	89.6	18.7	-0.9	3.9	
Europe	800	765	875	984	1,211	1,512	1,234	10.0
Percent Growth	4.8	-4.4	14.4	12.5	23.1	24.9	-18.4	
Asia-Pacific/ROW	534	437	534	1,060	1,905	1,495	2,274	39.1
Percent Growth	23.0	-18.2	22.2	98.5	79.7	-21.5	52.1	
Worldwide	7,299	5,129	6,435	10,088	12,464	12,520	12,995	20.4
Percent Growth	-10.0	-29.7	25.5	56.8	23.6	0.4	3.8	

Source: Dataquest (August 1992)

Table 2-2
Worldwide Capital Spending by Region - Forecast
Includes Merchant and Captive Semiconductor Companies
(Millions of U.S. Dollars)

	1991	1992	1993	1994	1995	1996	CAGR (%) 1991-1996
North America	3,851	3,559	3,754	4,344	4,883	5,688	8.1
Percent Growth	-5.8	-7.6	5.5	15.7	12.4	16.5	
Japan	5,636	4,312	4,601	5,107	5,551	6,634	3.3
Percent Growth	3.9	-23.5	6.7	11.0	8.7	19.5	
Europe	1,234	1,087	1,011	1,110	1,359	1,808	7.9
Percent Growth	-18.4	-11.9	-7.0	9.8	22.5	33.0	
Asia/Pacific-ROW	2,274	2,808	2,676	2,914	3,138	4,002	12.0
Percent Growth	52.1	23.5	-4.7	8.9	7.7	27.5	
Worldwide	12,995	11,765	12,042	13,475	14,932	18,131	6.9
Percent Growth	3.8	-9.5	2.4	11.9	10.8	21.4	

Source: Dataquest (August 1992)

Table 2-3
Estimated 1991 and 1992 Calendar Year Top 10 Rankings for Semiconductor Capital Spending (Millions of U.S. Dollars)

		1991 Rank	1991	1992 Rank	1992	Percentage Change
1	Intel	2	948.0	1	1,000.0	5.5
2	Fujitsu	1	1,147.2	2	769.6	-32.9
3	Samsung	8	530.0	3	730.0	37.7
4	NEC	4	752.2	4	654.2	-13.0
5	Toshiba	3	789.3	5	654.2	-17.1
6	Motorola	5	673.0	6	550.0	-18.3
7	Hitachi	7	646.0	7	500.3	-22.6
8	Mitsubishi	6	664.5	8	461.8	-30.5
9	Goldstar	11	410.0	9	380.0	-7.3
10	Sony	9	519.8	10	365.6	-29.7
11	Matsushita	10	462.6	11	344.8	-25.5

Source: Dataquest (August 1992)

low (see Table 2-1) and is caused in the short term by weak global economic conditions and an overhang in production capacity. Over the longer term, the slower growth scenario is attributable to weaker growth in the global economy and uncertainty about the emergence of a high-octane semiconductor application.

Worst-Case Scenario Unfolds for Japanese Semiconductor Capital Spending

Our recent survey of Japanese device makers reveals that capital spending on new plant and equipment will drop 24 percent in 1992. Sharp cuts in spending can be attributed to several factors, including a large production capacity overhang caused by the boom in spending in the late 1980s, weak domestic and export markets, and mounting trade friction with Western countries.

The vertically integrated Japanese computer makers will make on average the smallest cuts in semiconductor capital spending in 1992. Even so, we expect companies such as Fujitsu, NEC, and Toshiba to cut spending levels 13 to 30 percent (see Table 2-3). These companies face a weak domestic economic environment and poor returns on their 4Mb DRAM investment. Dataquest estimates that Japanese 4Mb lines are running at 60 to 65 percent capacity utilization.

The slow adoption of the 4Mb DRAM and an anticipated slow ramp up of the 16Mb DRAM has caused the computer makers to turn cautious on capital spending. In addition, Korean DRAM vendors are continuing to win a larger share of the market, thus adding to the competitive pressures in the memory segment.

Weak domestic consumer demand and weak export markets have prompted the large vertically integrated consumer electronic companies to deeply cut their spending on their semiconductor operations. Consumer electronic equipment inventories continue to mount, although companies such as Sony and Matsushita are doing a better job at managing the problem than they were at the beginning of the year. However, shrinking profit margins and quarterly losses suggest that capital spending by consumer electronic companies will not snap back in 1993.

Japanese steel companies such as Kawasaki Steel and NKK, which were late entrants to the semiconductor game, are in a more precarious position. In a scramble to diversify beyond the declining steel industry, the largest steel companies in Japan made investments in the semiconductor business in the late 1980s.

Dataquest believes that the production capacity brought on by the steel companies is currently running at less than 50 percent capacity utilization. Moreover, Japanese steel companies will face serious problems filling those factories if the weak economic environment persists because steel companies do not have a captive market for their devices.

Many Japanese companies announced delays in 200mm line investment plans late in 1991. Japanese companies have not earned a return on their 4Mb investment, and their strategy to achieve this return is to postpone the next round of investment in 16Mb lines. However, because of the severity of capital spending cuts in 1992, we now expect that some of these delayed lines will not be built at all.

Japanese spending on advanced semiconductor lines in the United States and Europe is also expected to decline. Though Japanese companies have completed most of their "green-field" investment in offshore fabs, many capacity additions to these facilities are not expected to proceed anytime soon.

U.S. Spending Pulled Down by Japanese Companies' Cuts

Capital spending in the United States will decline by 7.6 percent in 1992. The largest fall-off will be experienced by Japanese companies spending in the United States, from more than $400 million in 1991 to less than $200 million in 1992. This precipitous drop will be attributed to the completion of some major green-field projects by Japanese companies such as Fujitsu and NEC.

Spending by U.S. companies in the United States will be down slightly in 1992. Investment in new microprocessor lines by Intel, Digital Equipment Corporation, and Hewlett-Packard will prevent capital spending from decreasing steeply. Intel is building a new development line in Oregon and is converting its R&D line in Santa Clara, California to 200mm. There also are rumors that Intel has selected Austin, Texas as a site for a new green-field facility, on which construction will begin either at the end of the year or the beginning of 1993. Both Digital and HP are commercializing their RISC microprocessor technology and are investing in fabs to ramp device production.

Other new fab activity not in the MPU area includes National Semiconductor's expansion in Arlington, Texas and AT&T's new line in Orlando, Florida. IBM is also refurbishing buildings 322 and 323 in East Fishkill, New York.

Europe Expected to Decline through 1993

Capital spending in Europe is forecast to decline 11.9 percent in 1992 and sink another 7 percent in 1993. The bleak outlook for spending is based on steep cuts by European companies and cutbacks by Japanese companies that have recently completed a round of investment in new fabs. The situation would be much worse if it were not for the major projects being undertaken by IBM in France and Intel in Ireland.

However, Intel will complete the lion's share of its spending in 1992, leaving only the IBM project as the main driver for spending in 1993. Consequently, we are expecting 1993 to be a down year as well. Dataquest is more optimistic for 1994 and beyond because we expect the European economy to begin benefiting from unification. Even so, the timing on this upturn is still very speculative.

Korean Companies Place Some Big Bets

Dataquest believes that the Asia/Pacific region will be the one bright spot in terms of semiconductor capital spending in 1992. We are forecasting that spending will leap ahead 23.5 percent. The Korean chaebols (conglomerates) will account for the bulk of that spending. Investment in Korean fabs is expected to climb to U.S.$1.8 billion in 1992.

In the short term, with excess worldwide DRAM capacity, the gamble for the Korean companies rests on the strength and timing of the recovery in the U.S. and European economies. If the Western economies have a strong recovery over the next several years, DRAM demand will grow quickly and the Korean companies may exit the recession with more market share than they had prior to the recession. Toshiba pursued a similar strategy in the 1985 recession with the 1Mb DRAM and was very successful. On the other hand, if the Western economies limp out of recession and there is only moderate growth in DRAM demand, then these investments are not expected to pay off financially.

There is a more fundamental problem for the chaebols over the longer term. History has shown that the health of a company's commodity semiconductor operations cannot rest on merchant sales of devices alone, but is increasingly dependent on captive operations using those devices.

Yet, Korean electronic products are losing their competitive edge. Increases in wages are driving up the prices of Korean electronic products; at the same time, their quality still lags behind high-end Japanese and U.S. products. On the low end, developing countries such as China and Thailand, with much lower labor costs, are grabbing market share.

Dataquest believes that Asia/Pacific investment will decline 4.7 percent in 1993 as the three large Korean companies complete the current round of investment in 4Mb and 16Mb lines. However, we expect Asia/Pacific to remain the fastest-growing region in terms of capital spending. Much of the growth in capital spending will occur outside of Korea, which now dominates the semiconductor industry in the region. As countries such as China and India develop, we believe that semiconductor production capability will be a key strategy in building their industrial infrastructure.

Conclusions

Capital spending growth rates are expected to decline from the double-digit compound annual growth rates of the late 1980s to single-digit growth over the next five years. The biggest change in spending levels will happen in Japan as companies adjust to a more restricted capital environment. U.S. spending, on the other hand, will benefit from the region's strong position in the microprocessor market, although we do not expect capital spending levels to achieve the growth rates of the past decade. European spending will remain in a downward spiral through 1993, though we expect unification to kick life back into this market toward the middle of the decade. And finally, the Asia/Pacific region is expected to remain the star performer in terms of spending, although we strongly believe that there will be a rotation away from the current countries that dominate the capital spending roster in this region.

Chapter 3
Wafer Fab Equipment Forecast

Chapter Highlights

- Equipment market down 10 percent in 1992
- Moderate upturn in 1993; strong bounce in 1994
- Equipment prices move higher, forcing vendors to compete on cost of ownership
- CVD, PVD, and dry-etch thin-film markets outperform other categories

This section presents historical and forecast data on the worldwide wafer fabrication equipment market. Table 3-1 presents the historical data by equipment category for the years 1986 through 1991, and Table 3-2 shows forecast data by category for the years 1991 through 1996.

Yearly exchange rate variations can have a significant effect on the 1985 through 1991 data in the following tables. For more information about the exchange rates used and their effects, refer to Appendix B.

Wafer Fab Equipment Forecast: 1992 Market Decline Followed by Modest Growth

The go-for-broke capital spending spree of the late 1980s has left excess capacity hanging like a dark cloud over the semiconductor industry. A 2 percent decline in wafer fab equipment spending in 1990, followed by only 3 percent growth in 1991, clearly reflected the beginning of a capital spending slowdown. This year, however, many semiconductor manufacturers have slammed on the brakes and cut capital investment to such an extent that on a worldwide basis we anticipate a 10 percent decline in wafer fab equipment demand.

Dataquest evaluates its five-year forecast for wafer fabrication equipment demand about every six months. The midyear forecast outlook presented here does not substantially differ from that published at the end of 1991, at which time we anticipated an 8 percent decline in 1992 wafer fab equipment demand. As compared with our November 1991 forecast, we have moderated our expectations for growth in 1993 and 1994 downward by several percentage points. This modification is in

Table 3-1
Worldwide Wafer Fab Equipment Market - Historical, 1986-1991
(Millions of U.S. Dollars)

	1986	1987	1988	1989	1990	1991	CAGR (%) 1986-1991
World Fab Equipment Market	2,713	3,141	4,988	6,017	5,871	6,040	17.4
Lithography							
Contact/Proximity	31	25	22	23	24	21	-7.9
Projection	171	129	148	94	93	68	-16.7
Steppers	363	503	921	1,181	1,052	1,029	23.2
Maskmaking Lithography	51	68	62	69	47	46	-2.0
Direct-Write Lithography	68	67	69	70	76	55	-4.1
X-Ray	1	0	6	5	2	4	39.3
Total	685	791	1,228	1,442	1,295	1,224	12.3
Automatic Photoresist Processing Equipment	149	168	253	334	326	369	19.9
Etch and Clean							
Wet Process	161	167	277	377	400	405	20.3
Dry Strip	35	58	100	121	118	119	27.5
Dry Etch	237	307	533	670	690	705	24.3
Ion Milling	8	8	10	13	13	17	16.4
Total	441	540	920	1,180	1,221	1,246	23.1
Deposition							
Chemical Vapor Deposition	218	260	466	611	717	747	27.9
Physical Vapor Deposition	237	251	302	368	409	474	14.9
Silicon Epitaxy	46	36	86	75	68	89	13.9
Metalorganic CVD	31	35	42	45	44	51	10.4
Molecular Beam Epitaxy	66	68	81	74	58	59	-2.2
Total	599	649	977	1,173	1,296	1,420	18.9

(Continued)

Table 3-1 (Continued)
Worldwide Wafer Fab Equipment Market - Historical, 1986-1991
(Millions of U.S. Dollars)

	1986	1987	1988	1989	1990	1991	CAGR (%) 1986-1991
Diffusion	156	145	296	331	324	335	16.6
Rapid Thermal Processing	16	18	22	25	30	42	21.9
Ion Implantation							
Medium Current	55	61	118	131	114	108	14.6
High Current	55	107	241	301	250	218	32.0
High Voltage	10	18	18	25	7	18	12.4
Total	119	186	377	457	370	343	23.6
Process Control							
CD (Optical & SEM)	44	89	151	150	147	154	28.3
Wafer Inspection	42	58	101	117	91	90	16.3
Other Process Control	287	286	355	404	368	398	6.7
Total	374	432	607	672	605	641	11.4
Factory Automation	81	99	130	195	216	227	22.9
Other Equipment	96	112	177	210	189	193	15.1
Total World Fab Equipment	2,713	3,141	4,988	6,017	5,871	6,040	17.4
Percent Change	-19	16	59	21	-2	3	

Note: Some columns do not add to totals shown because of rounding.
Source: Dataquest (August 1992)

Table 3-2
Worldwide Wafer Fab Equipment Market - Forecast, 1991-1996
(Millions of U.S. Dollars)

	1991	1992	1993	1994	1995	1996	CAGR (%) 1991-1996
World Fab Equipment Market	6,040	5,431	6,036	7,145	8,218	9,354	9.1
Lithography							
Contact/Proximity	21	17	16	15	14	13	-9.0
Projection	68	55	57	62	67	75	1.9
Steppers	1,029	925	1,035	1,200	1,380	1,580	9.0
Maskmaking Lithography	46	51	63	76	91	101	17.1
Direct-Write Lithography	55	59	69	86	97	109	14.5
X-Ray	4	10	20	38	53	70	75.5
Total	1,224	1,117	1,260	1,477	1,702	1,948	9.7
Automatic Photoresist Processing Equipment	369	330	363	430	490	569	9.1
Etch and Clean							
Wet Process	405	355	390	465	530	600	8.2
Dry Strip	119	105	115	135	155	180	8.6
Dry Etch	705	640	710	850	990	1,125	9.8
Ion Milling	17	14	16	17	19	20	3.7
Total	1,246	1,114	1,231	1,467	1,694	1,925	9.1
Deposition							
Chemical Vapor Deposition	747	680	755	900	1,045	1,190	9.7
Physical Vapor Deposition	474	450	495	585	680	780	10.5
Silicon Epitaxy	89	60	53	68	60	63	-6.6
Metalorganic CVD	51	45	50	60	67	70	6.4
Molecular Beam Epitaxy	59	52	57	63	67	71	3.8
Total	1,420	1,287	1,410	1,676	1,919	2,174	8.9

(Continued)

Table 3-2 (Continued)
Worldwide Wafer Fab Equipment Market - Forecast, 1991-1996
(Millions of U.S. Dollars)

	1991	1992	1993	1994	1995	1996	CAGR (%) 1991-1996
Diffusion	335	288	325	380	445	510	8.8
Rapid Thermal Processing	42	40	48	58	74	85	15.3
Ion Implantation							
Medium Current	108	92	106	126	146	161	8.4
High Current	218	189	216	265	303	332	8.8
High Voltage	18	22	35	43	48	56	26.0
Total	343	303	357	434	497	549	9.9
Process Control							
CD (Optical & SEM)	154	135	146	172	198	229	8.3
Wafer Inspection	90	82	91	106	124	140	9.3
Other Process Control	398	365	400	475	540	600	8.6
Total	641	582	637	753	862	969	8.6
Factory Automation	227	200	220	255	290	345	8.7
Other Equipment	193	170	185	215	245	280	7.7
Total World Fab Equipment	6,040	5,431	6,036	7,145	8,218	9,354	9.1
Percent Change	3	-10	11	18	15	14	

Note: Some columns do not add to totals shown because of rounding.
Source: Dataquest (August 1992)

response to our decidedly conservative position on the industry, which we believe will continue to suffer from the problems of excess submicron capacity and weak global macroeconomic conditions.

Assumptions behind Our Forecast

In our November 1991 forecast for wafer fabrication equipment, we presented four assumptions that constituted the foundation of our five-year equipment forecast. Those assumptions are reviewed in the following paragraphs.

Macroeconomic Assumptions

Our assumptions today regarding global macroeconomic conditions remain consistent with our view six months ago. The global economy is clearly weaker in 1992 than it was in 1991. The Japanese and German economies are decelerating, the U.K. economy continues to have difficulties shaking off its recession, and the U.S. economy has entered a period of very weak recovery. Both the Japanese and European economies are expected to pick up in 1993, but we believe that, as with the U.S. economy, these recoveries will be modest. We expect all major regions of the world to return to healthy GNP growth in the 1994 through 1996 time frame.

Shifts in the Semiconductor Device Product Mix

Dataquest is forecasting that the combined MOS micro and MOS logic categories in the device revenue product mix will continue to increase as a percentage of the total market. MOS micro, the fastest-growing segment of the worldwide IC market, is being driven increasingly by system-on-a-chip ultralarge-scale integration (ULSI) trends and the adoption of application-specific standard product chip set solutions for many end-use markets. The high value-added, design-intensive nature of certain MOS micro segments, such as microprocessors and microperipherals, translates to higher average selling prices (ASPs) and lower unit volumes relative to the DRAM market. We do note that recent competitive market forces in the microprocessor arena are driving prices down. However, microprocessors have yet to achieve the status of commodity pricing that characterizes the DRAM marketplace.

Programmable logic devices, a subset of MOS logic, are similar to microcomponents in that they also represent high value-added, low-volume manufacturing, which requires proportionately less wafer fab equipment than DRAMs. Shifts in the semiconductor device product mix toward MOS micro and MOS logic segments characterized by high value-added, low-volume manufacturing will contribute to lower fabrication equipment unit demand and thus deceleration in the long-term growth rate for the wafer fab equipment market.

Cost of Process Development and Advanced Manufacturing Escalates

We believe that our premise still holds true that the rising cost of advanced technology is driving a number of semiconductor companies to pursue joint-development and/or manufacturing pacts as a strategy to control both the costs and risks associated with advanced technology development. We believe that such joint-development and manufacturing strategies and shared foundry facilities between semiconductor manufacturers will contribute to a smaller number of megafabs being built in the future.

Increased Wafer Fab Equipment Productivity

We maintain our position that wafer fab equipment will continue to get more expensive, reflecting the increasingly sophisticated technical requirements of advanced submicron manufacturing. In response to demands from semiconductor manufacturers for increased equipment productivity to offset higher equipment prices, wafer fab equipment companies will continue to aggressively compete on equipment cost of ownership. Increased equipment productivity will contribute to overall lower equipment unit demand. For example, the newer models of steppers have significantly improved wafer throughput as compared with tools available several years ago. Stepper manufacturers today offer leading-edge machines with throughput on the order of 60 wafers per hour, with some tools achieving 80-plus wafer-per-hour processing capability. This improvement in productivity has a direct impact of stepper unit demand and is a key consideration in our forecast for steppers over the next five years.

For the reasons cited, revenue growth in the wafer fab equipment market primarily will reflect escalating ASPs of advanced equipment technology. For a number of wafer fab equipment categories, unit demand in 1996 is expected to be essentially flat relative to shipment levels in 1991.

Wafer Fab Equipment Markets

As the semiconductor industry continues to push into the submicron era, process complexity and fabrication technology requirements continue to increase dramatically. Lithography, deposition, and etch/clean equipment continue to be the technology drivers that fuel the wafer fabrication equipment industry's growth (see Tables 3-1 and 3-2).

Dataquest anticipates i-line technology to dominate the stepper product mix for new system shipments between 1991 and 1996. I-line will be the stepper technology of choice as advanced microprocessor and ASIC designs push below 0.8-micron geometries. Advanced resolution techniques, such as phase shift masks and newly announced illumination modification techniques, push i-line resolution to the 0.35-micron regime with improved depth of focus. Although such techniques are suited only for highly repetitive device patterns such as memory products, conventional i-line lens systems are available that provide sub-0.5-micron lithographic capability regardless of the device pattern being printed. We expect excimer/deep-UV systems to continue to gradually increase as a percentage of new stepper shipments over the forecast period as device manufacturers pursue research and development programs for 64Mb and 256Mb DRAM processing.

The adoption of double-level metal technology for the 16Mb DRAM generation, together with the rapid move toward triple- and even four-level metal for MOS microprocessor and ASIC devices, will continue to push the CVD, PVD, and dry etch thin films markets to outperform the overall wafer fab equipment market. The dry etch equipment market will experience healthy growth because of the triple factors of increased dry etch process steps, complex new plasma source technologies, and rapid ASP increase caused by the need for tighter process control at sub-0.5 micron geometries.

In addition to the well-established low temperature, plasma-enhanced CVD reactor market, the thermal CVD market (including metal CVD and thermally driven atmospheric and low-pressure CVD) will experience healthy growth over the next five years because of the continuing need for planarized device topology. New organic CVD precursor sources will lead to precisely tailored metal and dielectric CVD films that exactly satisfy specific device topology requirements. Concurrently, new advances in PVD technology such as advanced barrier metallization, laser reflow, and planarization of sputtered aluminum will lend impetus to growth in the PVD market. Sputter equipment continues to offer excellent step coverage capability at a very attractive cost of ownership.

Dataquest Perspective

One significant trend we expect for the wafer fab equipment industry over the next five years will be the growth in the semiconductor manufacturing base in Asia/Pacific. Dataquest's capital spending estimates for 1991 show that Asia/Pacific represented about 12 percent of total worldwide capital spending. We are forecasting that in 1996 this region of the world will represent 22 percent of semiconductor capital investment and will gain its share of the capital spending pie at the expense of all other regions. This significant increase in capital spending activity in Asia/Pacific will translate to a substantially larger portion of worldwide wafer fab equipment expenditure in the future.

Asia/Pacific represents a significant market opportunity for wafer fabrication equipment companies because the barriers to entry for doing business in this regional market are fairly low. The cost structure for establishing local operations and providing service and support personnel is lower than in other regions of the world. U.S. and European companies benefit from close historical ties to the countries of Asia/Pacific, and English is widely spoken throughout the region.

Japanese wafer fab equipment companies have already aggressively targeted the Asia/Pacific region, and in 1991 they garnered an increase in regional market share of more than 10 percentage points. Several factors are behind their successful market penetration, including the relative proximity of Japanese companies to fabs in Asia/Pacific, their advanced technology product offerings focused on high-volume manufacturing, and the significant emphasis that Japanese vendors place on customer support. These factors have allowed Japanese equipment companies to expand their presence from a mere 10 percent share of the Asia/Pacific market in 1982 to more than 50 percent share last year.

Although some larger companies, such as Applied Materials, Lam, and Varian, have already established a direct presence in Asia/Pacific, many smaller wafer fab equipment companies use representatives and distributors to sell and support their products. We believe that more and more wafer fab equipment companies will need to have a local presence in order to stay close to their customers and effectively compete in this high-growth regional market.

Chapter 4
Silicon Wafer Forecast

Chapter Highlights

- The U.S. semiconductor industry is shaking off the recession. But for those that have been in the business a while, the recovery in silicon demand won't be anything to write home about.
- Silicon demand continues to deteriorate in Japan and the unnerving aspect is that the decline is accelerating. We expect the bottom of the silicon cycle in Japan to hit in late summer.
- Last year was so bad, European silicon demand had nowhere to go but up. But Dataquest remains positive about the long-term prospects for European Silicon demand.
- Asia/Pacific demand steams ahead, but there are some icebergs out there that could make the voyage rough.

U.S. Market Pulse

Recap 1991

The 1991 U.S. silicon market began on a weak note because of the Middle East crisis. Wafer demand picked up following the conclusion of the war and growth was moderate through May 1991. But as the industry moved into the summer months, typically a slow season for semiconductor manufacturers, wafer demand began declining more precipitously than could be explained by seasonal factors. The fourth quarter saw this summer decline turn into a full-fledged rout and the fall turned out to be the worst quarter of 1991.

At the end of the year, it was apparent that silicon consumption had experienced its first negative growth since 1986. Dataquest's market survey indicates that the total U.S. silicon market declined 4.5 percent in 1991 (see Table 4-1). Epitaxial wafers increased 4.0 percent (see Table 4-2), and prime, test, and monitor wafers decreased 5.9 percent (see Table 4-3).

Wafer demand dropped off at most semiconductor companies as business uncertainty, weak employment statistics, and plummeting consumer confidence stalled the economic recovery. Particularly hard hit were those device makers with sales tied to large mainframe computers, midrange computers, and military applications. Companies such as IBM, Texas Instruments, Digital Equipment Corporation, and Harris cut way back on their purchase of wafers at the end of 1991.

Table 4-1
Forecast of Captive and Merchant Silicon* and Merchant Epitaxial Wafers
(Units—Millions of Square Inches)

	1991	1992	1993	1994	1995	1996	5-Year CAGR (%)
United States	611	642	689	746	789	824	6.2
Percentage Growth	-4.5	5.0	7.3	8.2	5.8	4.6	
Japan	1,046	1,012	1,081	1,161	1,239	1,319	4.8
Percentage Growth	5.4	-3.2	6.9	7.4	6.7	6.5	
Europe	208	213	227	246	267	296	7.3
Percentage Growth	-11.7	2.3	7.0	8.0	8.8	10.5	
Asia/Pacific-ROW	194	218	248	283	316	353	12.7
Percentage Growth	7.5	12.2	13.6	14.3	11.6	11.8	
Total	2,059	2,085	2,245	2,436	2,611	2,793	6.3
	0.5	1.2	7.7	8.5	7.2	7.0	

*Includes prime, test, and monitor wafers
Source: Dataquest (August 1992)

Table 4-2
Forecast of Merchant Epitaxial Wafer Consumption by Region (Units—Millions of Square Inches)

	1991	1992	1993	1994	1995	1996	5-Year CAGR (%)
United States	92	99	111	123	130	137	8.4
Percentage Growth	4.0	8.0	11.8	11.4	5.8	5.0	
Japan	104	106	118	124	128	133	5.0
Percentage Growth	11.6	2.3	11.5	5.2	2.5	4.0	
Europe	20	21	26	30	33	36	12.1
Percentage Growth	7.4	5.4	21.5	16.4	9.0	9.0	
Asia/Pacific-ROW	7	8	9	10	13	17	20.6
Percentage Growth	43.5	17.9	16.7	11.7	27.9	30.0	
Total	222	234	264	288	304	322	7.7
	8.7	5.4	12.7	9.1	5.5	6.1	

Source: Dataquest (August 1992)

The turmoil in the PC industry because of pricing pressures did not slow down the demand for semiconductors in this segment. The real strength in the PC industry appeared to come from MOS logic and analog devices with workstations, high-end 486DX-based

Table 4-3
Forecast of Captive and Merchant Silicon* Wafer Consumption by Region (Units—Millions of Square Inches)

	1991	1992	1993	1994	1995	1996	5-Year CAGR (%)
United States	520	543	578	622	658	688	5.8
Percentage Growth	-5.9	4.5	6.4	7.6	5.8	4.5	
Japan	942	906	963	1,037	1,111	1,186	4.7
Percentage Growth	4.8	-3.8	6.3	7.7	7.2	6.7	
Europe	188	191	201	215	234	260	6.7
Percentage Growth	-13.3	1.9	5.4	6.9	8.8	10.8	
Asia/Pacific-ROW	188	210	239	273	303	336	12.4
Percentage Growth	6.6	12.0	13.5	14.4	11.0	11.0	
Total	1,837	1,850	1,981	2,148	2,307	2,470	6.1
	-0.4	0.7	7.1	8.4	7.4	7.1	

*Includes prime, test, and monitor wafers
Source: Dataquest (August 1992)

PCs, and low-end 386SX-based notebook PCs being the major driving forces. In fact, we believe that the collapse of desktop PC prices has slowed the decline in PC unit growth rates since more affordable machines are now on the market.

The weak market for semiconductors in 1991 and a fab overcapacity problem is prompting many companies to close marginal fabs. AMD, Intel, Seeq, and Western Digital have closed fabs or announced closings in 1991. Dataquest expects this trend to continue into 1992 with National already announcing the closure of three California lines. Our new silicon wafer forecast reflects this decrease in wafer start capacity, which is primarily in fabs running smaller-diameter wafers.

Forward to 1992

The first quarter of 1992 has seen wafer demand improve along with the rest of the U.S. economy. Dataquest's 1992 forecast calls for total silicon consumption to increase 5.0 percent; epi wafers by 8.0 percent; and prime, test, and monitor wafers by 4.5 percent. Nevertheless, these growth rates are very moderate by historical levels, especially for a postrecession year, which typically results in a surge in demand.

The strength of the recovery in the U.S. economy hinges on the consumer, who accounts for two-thirds of the U.S. gross domestic product. However, we believe that consumer spending will be modest because of the cloudy outlook for decent consumer income growth. We expect income to pick up moderately as the economy recovers. Rapid growth remains unlikely. The absence of fiscal stimulus (remember those big federal deficits), the slowdown in growth abroad—which will limit the growth of U.S. exports—and the reluctance of U.S. companies to hire new workers all should cap the rate of income gains in 1992 and keep the U.S. consumer cautious.

The U.S. Federal Reserve Board's discount rate cut in December 1991 laid the groundwork for a stronger first quarter. For the third consecutive month, both bookings and billings of semiconductors in April hit record highs.

Not surprisingly, semiconductor companies have reported first-quarter 1992 financials that look very good. Motorola's semiconductor revenue leaped 20.7 percent in the first quarter on a year-to-year comparison; the company's just-reported semiconductor revenue totaled $1.1 billion. AMD's microprocessor revenue (45 percent of total) was up 24 percent quarter to quarter, driven by 386SX and 386DX sales. Other AMD revenue (55 percent of total) was up 3.5 percent quarter to quarter.

These very bullish trends have caused us to raise our midyear forecast for silicon slightly. Even so, we are still cautious about 1992 semiconductor production in the United States, because the first-quarter burst in semiconductor ordering is largely attributable to inventory replenishment. Semiconductor distributor resales and orders have been strong—some of which is accounted for by seasonal factors.

On the other hand, OEM business, a much stronger indicator of a recovery, is firming but not as strong as distribution. Furthermore, over the last six years the annual book-to-bill has peaked in April four times and once in March and May. This historic trend may suggest that the industry has seen the strongest growth of the year in the first half. Until the OEM business gives a more positive signal, we will stick with our current forecast.

We also expect the U.S. 200mm market to be up moderately in 1992 (see Table 4-4). Intel is moving aggressively on 200mm projects at its Aloha, Oregon and Santa Clara, California sites, which will increase its demand mostly for test and monitor wafers. We are also more positive about wafer demand at IBM and have increased our epi forecast. On a negative note, Motorola's MOS 11 line is ramping very slowly.

On the 200mm supply side, we expect intensified Japanese competition in the United States because of the delays in the ramp of the Japanese 200mm market. Much of the 200mm wafer production capacity installed in Japan will now be searching for international markets.

Table 4-4
Forecast of 200mm Wafer Consumption by Region (Millions of Units)

	1991	1992	1993	1994	1995	1996	5 Year CAGR (%)
United States	0.5	0.6	0.8	1.2	1.4	1.8	30.2
Japan	0.3	0.4	0.6	2.4	3.3	3.5	61.9
Europe	0.2	0.2	0.3	0.4	0.7	0.8	34.7
Asia/Pacific-ROW	0.1	0.1	0.2	0.4	0.6	0.6	56.1
Total	1.1	1.4	1.9	4.3	6.0	6.7	44.9

Source: Dataquest (August 1992)

U.S. Silicon Market Conclusions

All in all, we expect U.S. wafer demand to be tepid in 1992. It is this climate that has historically produced fierce pricing pressures in the industry and we do not expect 1992 to be an exception to the rule. The distinguishing factor for successful wafer vendors in 1992 may be the quality of their customer base, as the rising tides of recovery are not expected to raise all boats.

Japanese Market Pulse

Recap 1991

The demand for silicon in Japan was robust through the first half of 1991. However, consumption began to fall off in the fourth quarter, and total consumption of silicon wafers in Japan grew 5.4 percent in 1991. The strongest demand was in epitaxial wafers, which grew 11.6 percent, pushed ahead by the power module market. The demand for prime, test, and monitor wafers grew 4.8 percent.

For most of 1991, Japan's economy appeared to have escaped the grip of recession that slowed Western economies. The Middle East crisis proved to be more of a political hot potato than a stumbling block for Japanese industry. Oil prices fluctuated widely before and during the crisis, causing a great deal of concern for Japanese industry. But with the successful conclusion of the crisis, the threat of higher oil prices faded and the unprecedented expansion of the Japanese economy appeared on track.

However, by summer the first cracks in the Japanese expansion could be seen. The Bank of Japan's tight monetary policy was having its intended effect on the excesses of the bubble economy. Real estate prices had collapsed, even if banks and investment companies failed to recognize the lower valuations. The stock market had fallen by more than a third from its historical peak, and consumer confidence was beginning to wane.

For the semiconductor industry, concern began to mount as electronic equipment inventories continued to build. Many companies had expected the Western export markets to shake off the recession and soak up the growing inventory of consumer products. But Christmas season demand fell short of the mark as consumer confidence sank to new lows in the West.

In addition, deflation in the Japanese real estate sector and the decline of Japanese equities kicked the wind out of Japanese business. Companies that depended on the growth of equities or real estate to prop up their balance sheets quickly found that the rules of the game had changed. Retained earnings derived from operating profits would now be required to sustain growth, but earnings in the current environment were difficult to generate. Something had to give and it was capital spending.

By the fourth calendar quarter Japanese companies began to cut their FY1991 capital spending. The cuts particularly hit computer and office equipment purchases, which exacerbated the already high electronic equipment inventory levels. During SEMICON/Japan in December 1991, it was quite evident to many silicon wafer vendors that 1992 was going to be a down year—the first since 1986.

Forward to 1992

Nearly halfway through calendar year 1992, there appears little chance that Japanese silicon demand will turn up sharply. Industrial production dropped a seasonally adjusted 2.8 percent in March from February, and fell 5.3 percent compared with levels of a year ago. March was the sixth consecutive month in which production fell on a year-over-year basis. Worse yet, these declines are accelerating. From November through March, production registered successive year-over-year declines of 1.0, 1.9, 4.0, 4.6, and 5.3 percent. For the entire first quarter, output plunged an adjusted 3.2 percent.

For April, the Ministry of International Trade and Industry (MITI) forecast a 0.9 percent decline in industrial output. MITI has described the outlook for industrial production as "considerably severe," saying that Japan is likely to see output drop in the second quarter of 1992.

On the positive side, Japanese electronic equipment manufacturers are cutting back production and are continuing to bring inventories into line. Inventories had been building up through January 1992 and have since been declining. From a fundamental point of view, this means that Japanese electronic manufacturers are turning the corner. Silicon demand, which has been down sharply in the first calendar quarter of 1992, is expected to bottom in summer and see modest growth in the second half of the year. Even so, demand in 1992 is expected to shrink 3.2 percent year-to-year.

Over the longer term, there is a chance that the downturn will impact Japanese semiconductor production more severely than other sectors of industry for two reasons. First, we expect trade friction caused by mounting trade deficits to aggravate the already weak export picture for semiconductors. Because Japan is a net exporter of devices, the mounting trade deficit with the United States, and especially Europe, is reigniting the call for protectionist measures. It is possible that this problem will haunt the Japanese semiconductor industry well past 1992 and cause slower growth in silicon demand once the general economy turns up.

Second, there is some risk that the downturn in capital spending is the beginning of a structural change in the Japanese semiconductor industry. Early in the last decade Japanese companies made a conscious decision to pursue the commodity memory market. It was a strategy that proved very successful because of the PC boom and abdication of the memory market by U.S. companies.

However, the Achilles heel of this strategy is becoming apparent. Squeezed from below by low-cost Asian memory producers and from above by the increasingly fragmented application-specific nature of the MOS microcomponents and MOS logic makers in the United States, Japanese device companies are scrambling for a strategy. Complicating their dilemma is the large capacity they have installed and the slower adoption of the advanced memory products in end-use applications.

These problems threaten the long-term growth of the Japanese silicon market, and consequently we have lowered our five-year compound annual growth rate for silicon in Japan to 4.8 percent.

We have also cut back our growth rate for 200mm wafer consumption in Japan. Many Japanese companies continue to push out their plans for adding 200mm capacity, and it is now likely that some of these fabs will not be built at all. We expect capital spending on 200mm lines to pick up in the fourth quarter of 1992 at reduced levels. Based on this timing, we are forecasting 200mm wafer demand to grow rapidly in 1994.

Japanese Silicon Market Conclusions

Japan will remain the largest market for silicon. However, structural problems threaten to derail the historical growth this market has enjoyed over the last 10 years. The dilemma for the Japanese semiconductor industry would be resolved if there was a surge in demand for consumer electronics, which would soak up the excess capacity in the electronic food chain. But slower economic growth in the industrialized nations and the lack of any product driving device demand has caused us to be more cautious about the Japanese silicon market.

European Market Pulse

Recap 1991

The demand for silicon in Europe started out on a weak note in 1991 and got worse. Silicon consumption declined 11.7 percent in 1991, the worst year on record since the 1985 recession. The domestic European companies whose semiconductor programs were suffering deep losses closed facilities and cut production, accounting for the lion's share of the decline in silicon demand.

In addition, slower silicon demand at transplant fabs hurt the demand for silicon. Texas Instruments' Avezzano, Italy line experienced delays and the ramp of the fab, beginning in the fall of 1991, was slow because of the global downturn in TI's business. The weak market for the 4Mb DRAM also caused Japanese operations such as NEC and Fujitsu to cut their silicon usage.

The European economy was arguably the biggest drag on silicon demand. At the beginning of 1991 only the United Kingdom was in recession, but as the year ground on the other Western European economies began to decelerate. Higher interest rates were the main culprit.

The true cost of German unification gradually became apparent to the Bonn government over the course of the year. In response to the inflationary pressures of unification, the Bundesbank pursued a tight monetary policy, driving interest rates to the highest levels in the European community. These high rates rippled across the rest of Europe because the currencies of other European community members are tied to the deutsche mark.

As a result, growth rates in most countries declined and the slower growth had a deleterious impact on the entire electronic food chain in Europe, including silicon.

Forward to 1992

The decline in 1991 silicon consumption was more severe than we had forecast. Consequently, we are revising our growth rate for 1992. At the beginning of the year we had estimated that silicon consumption would shrink 2.8 percent in 1992. However, because of the steep decline in 1991, we now expect consumption in 1992 to grow 3.2 percent.

It looks as if European silicon consumption has hit bottom and may eke out slight gains in 1992. We are encouraged by the improving signs in the economy, which will benefit industrial production. The headway made by the Bundesbank on inflation is at the top of the list. Consumer price inflation eased to 4.5 percent in April from 4.8 percent in March. The March inflation rate probably represents a peak, and we expect inflation to decline through most of 1992. A clear trend on inflation is one of several developments the Bundesbank will look for before easing monetary policy.

If German rates begin falling in the second half of 1992, then we would expect a moderately strong upturn in industrial production and silicon demand in 1993. As we look further out to the middle of the decade, we believe that Eastern Europe will become more of a positive factor in driving semiconductor demand.

If this were to happen, then it is reasonable to expect additional investment in new fab capacity, which would drive the demand for silicon higher. But it is necessary to emphasize that the timing of this trend on silicon demand is very speculative today.

European Silicon Market Conclusions

We remain positive about the long-term prospects for European silicon demand, even if we are less sure of its timing. Europe accounted for 17 percent of the worldwide semiconductor consumption in 1991 and 12.3 percent of the production. It is a net importer of devices. The European Community (EC) is expected to try to close this gap by encouraging additional investment in domestic production.

Though the formation of a unified Europe in 1992 is certainly not the compelling reason for investing in new fabs that many people thought it would be several years ago, we believe that it may yet prove to be a boon to European device production. Western Europe will certainly be a unified market larger than the United States, as has been well advertised by the EC. But more important, we believe, will be the European communities' access and cultural ties to Eastern Europe and the former Soviet states. As these regions begin to develop, we expect Western European semiconductor production to benefit.

Asia/Pacific Market Pulse

Recap 1991

The 1991 growth of silicon consumption in Asia/Pacific fell below our expectations. Demand posted a respectable 7.5 percent growth, though down from the historic double-digit growth rates. The deceleration can be attributed to recession in the Western economies, which this region's semiconductor manufacturers rely on for the export of devices.

Also contributing to the single-digit growth rate was the inventory buildup of wafers that took place in fall 1990. Several large Korean semiconductor device makers purchased large inventories at that time because the supply of silicon was tight. These inventories were then carried over into 1991, resulting in lower purchases of wafers, which did not reflect the actual production starts.

Even so, growth in Asia/Pacific silicon demand was the highest in the world. The region is highly leveraged on DRAM production and continues to make inroads into the major Western markets. Samsung, the largest device vendor in Asia/Pacific, increased market share in the flat U.S. market largely because of stronger penetration of the 1Mb market.

The primary silicon consuming countries—Korea, Taiwan, Hong Kong, and Singapore—sustained strong growth rates in 1991. The growth was fueled by a strong construction sector and a surge of internal consumption and exports to other Asian countries.

Korea's gross national product expanded by 8.6 percent last year. However, the strong growth hides some serious problems. Korea's trade deficit worsened, the won lost ground against other major currencies, and inflation stubbornly hovered in the 10 percent range. In addition, the European Community began investigating allegations that Korean companies were dumping DRAMS.

Taiwan's economy showed the most resilience among the four tigers. GNP is estimated to have grown 7.2 percent in 1991. The trade surplus widened to U.S.$13.3 billion. Many of Taiwan's industries benefited from strong exports to trading partners in Southeast Asia and China, which were not impacted by the recession in the West.

The export of electronic equipment did increase 4.7 percent to U.S.$7.8 billion, which is respectable considering the downturn in the worldwide computer industry. One industrial segment that saw its weak exports to the West offset by strong sales to other countries within Southeast Asia was Taiwan's low-cost clone manufacturers. As a result, silicon consumption held up throughout the year.

Trends in Hong Kong and Singapore have a very small effect on the Asia/Pacific silicon cycle. Hong Kong's economy is increasingly tied to the economic boom under way in the southern provinces of China, especially Guangdong. Hong Kong's GNP grew 3.9 percent in 1991.

Singapore, on the other hand, is tied much more closely to the United States; 21 percent of its nonoil exports go to the United States. In 1991 Singapore's GNP grew 6.5 percent. Both countries are increasing their participation in the PC clone and disk drive industry. We believe that the rate of investment in semiconductor fabs to support these system businesses also will increase.

Forward to 1992

Silicon consumption in Asia/Pacific is expected to pick up in 1992, benefiting from the stronger demand in the United States for semiconductors. We are estimating that the Asia/Pacific consumption of silicon will grow 12.4 percent in 1992. Capital investment in fabs continues at a breakneck pace, which bodes well for strong wafer demand over the next several years. Our five-year CAGR for Asia/Pacific silicon consumption is 12.4 percent.

The lion's share of the current capital spending on new fabs is taking place in Korea. This spending trend will benefit silicon consumption over the next several years. We are forecasting Korea consumption of silicon to grow 11.4 percent CAGR through 1996 (see Table 4-5).

But it is unlikely that the boom in capital spending can be maintained. It is becoming increasingly more difficult to maintain the huge capital outlays for new fabs with local interest rates in the 17 percent range and Korean equity prices tumbling. Even the overseas markets are backing away from Korean paper as Samsung realized recently when its convertible bond offering received a chilly reception in the Euromarkets.

Table 4-5
Asia/Pacific ROW Forecast Silicon Wafer Consumption (Millions of Square Inches)

	1991	1992	1993	1994	1995	1996	CAGR (%) 1991-1996
Total Prime, Test, and Monitor Wafers	187.8	210.3	238.7	273.1	303.2	336.5	12.4
Korea	126.0	137.0	157.0	180.0	199.0	216.0	11.4
Taiwan	39.0	48.0	52.0	55.0	57.0	58.0	8.3
ROW	22.8	25.3	29.7	38.1	47.2	62.5	22.3
Total Epitaxial Wafers	6.6	7.8	9.1	10.1	13.0	16.9	20.6
Total Silicon	194	218	248	283	316	353	12.7

Source: Dataquest (August 1992)

Korean electronic products are also losing their competitive edge. They lack the brand awareness and quality of Japanese and U.S. products and are no longer cost competitive with products coming out of Southeast Asia and China. In addition, the semiconductor industry is increasingly feeling the heat from trade friction. Micron Technology has just filed dumping charges against the major Korean DRAM makers, and Japanese companies are being more aggressive in negotiating royalty payments for intellectual property rights.

Perhaps the biggest detriment to the long-term growth of the Korean economy is the strong hand of the Korean economic planners. The government is favoring the high-technology sector with preferential rates for borrowing to the exclusion of other sectors of the economy. This policy has resulted in a capital spending boom on new semiconductor plants. But it is questionable whether exports and the local markets can absorb this capacity. Consequently we expect the capital investment boom to peak either this year or next.

Taiwan's market-driven economy is in many respects much healthier than is Korea's. Though its silicon consumption is much smaller than Korea's, its semiconductor industry is better balanced. Taiwan has a thriving computer market, which provides device makers a domestic market for their product. As a result we forecast silicon demand to grow at 8.3 percent over the next five years.

However, the real star performer in terms of growth in silicon consumption will be the group of countries that fall under the rubric rest of world (ROW). We estimate that silicon consumption for this group will push ahead at a 22.3 percent CAGR. Countries that will benefit from this growth are Hong Kong, Singapore, China, and the newly industrializing nations in the Pacific rim such as Thailand and Malaysia. Much of the growth in the ROW category will be fueled by investment and technology transfers from Japanese and to a lesser extent, U.S.-based companies.

Asia/Pacific Silicon Market Conclusions

The Asia/Pacific region remains the most vibrant in terms of growth rates in silicon consumption. However, we do expect some rotation in the growth of silicon consumption away from the current leaders within the region to those countries just beginning to build their industrial infrastructure. The ultimate growth opportunities will be China and India because of the sheer size of the markets. But political turmoil, fragile legal systems, and underdeveloped infrastructures make the timing of these opportunities difficult to gauge.

Chapter 5
Semiconductor Consumption Forecast

This section presents data on the worldwide semiconductor market by region. The regional semiconductor market, or regional semiconductor consumption, deals with where chips are consumed; this contrasts with regional semiconductor production, which deals with where chips are made. The data presented here are for the merchant market and do not include the value of chips made by captive semiconductor manufacturers for internal use.

Yearly exchange rate variations can have a significant effect on the 1985 through 1991 data in the following tables. For more information about the exchange rates used and their effects, refer to Appendix B.

Semiconductor Consumption

Table 5-1 shows the historical regional semiconductor consumption for the years 1985 through 1991; it also breaks down the merchant market by nationality of the merchant semiconductor companies. Table 5-2 shows forecast semiconductor consumption by region for the period from 1991 through 1996.

Table 5-1
Worldwide Semiconductor Consumption by Region—Historical
Includes Merchant ~~and Captive~~ Semiconductor Companies
(Millions of U.S. Dollars)

	1985	1986	1987	1988	1989	1990	1991	CAGR (%) 1986-1991
North America	9,418	10,844	12,858	15,844	17,070	16,540	16,990	9.4
Percent Growth	NA	15.1	18.6	23.2	7.7	-3.1	2.7	
Japan	8,149	11,855	14,927	20,772	21,491	20,257	22,496	13.7
Percent Growth	NA	45.5	25.9	39.2	3.5	-5.7	11.1	
Europe	4,795	5,587	6,498	8,491	9,498	10,415	11,014	14.5
Percent Growth	NA	16.5	16.3	30.7	11.9	9.7	5.8	
Asia-Pacific/ROW	1,979	2,548	3,968	5,752	6,280	7,333	9,194	29.3
Percent Growth	NA	28.8	55.7	45.0	9.2	16.8	25.4	
Worldwide	24,341	30,834	38,251	50,859	54,339	54,545	59,694	14.1
Percent Growth	NA	26.7	24.1	33.0	6.8	0.4	9.4	

NA = Not applicable
Source: Dataquest (August 1992)

Table 5-2
Worldwide Consumption by Region
Merchant Semiconductor Sales Only—Forecast
(Millions of U.S. Dollars)

	1990	1991	1992	1993	1994	1995	1996	CAGR (%) 1991-1996
North America	16,540	16,990	19,564	22,613	25,456	26,127	27,579	10.2
Percent Growth	-3.1	2.7	15.1	15.6	12.6	2.6	5.6	
Japan	20,257	22,496	20,371	22,975	25,870	27,810	29,645	5.7
Percent Growth	-5.7	11.1	-9.4	12.8	12.6	7.5	6.6	
Europe	10,415	11,014	11,809	13,663	15,603	16,493	17,828	10.1
Percent Growth	9.7	5.8	7.2	15.7	14.2	5.7	8.1	
Asia/Pacific-ROW	7,333	9,194	11,181	13,417	15,698	17,692	19,939	16.7
Percent Growth	16.8	25.4	21.6	20.0	17.0	12.7	12.7	
Worldwide	54,545	59,694	62,925	72,668	82,627	88,122	94,991	9.7
Percent Growth	0.4	9.4	4.5	15.6	14.0	6.7	8.1	

Source: Dataquest (August 1992)

Chapter 6
Semiconductor Production Forecast

This section presents data on worldwide semiconductor production by region. Semiconductor production is defined by the place where the wafers are fabricated, and regional semiconductor production includes all production in the region, including merchant and captive producers and all foreign producers. For instance, North American semiconductor production includes IBM and Delco fabs as well as Japanese and European fabs in the United States.

Yearly exchange rate variations can have a significant effect on the 1985 through 1991 data in the following tables. For more information about the exchange rates used and their effects, refer to Appendix B.

Semiconductor Production

Table 6-1 shows historical semiconductor production for the years 1985 through 1991, and Table 6-2 shows forecast production for the period from 1991 through 1996.

Table 6-1
Worldwide Semiconductor Production by Region—Historical Merchant and Captive Semiconductor Company Sales (Millions of U.S. Dollars)

	1985	1986	1987	1988	1989	1990	1991	CAGR (%) 1986-1991
Total North America	12,654	14,456	16,712	20,171	21,324	22,789	25,103	11.7
Percent Growth	NA	14.2	15.6	20.7	5.7	6.9	10.2	
Percent Worldwide	46.7	42.9	40.3	37.0	36.8	39.2	39.8	
Merchant	10,411	12,129	14,116	17,326	18,464	19,959	22,460	
Captive	2,243	2,327	2,596	2,845	2,860	2,830	2,643	
Total Japan	10,651	14,686	19,004	26,693	28,429	26,376	29,411	14.9
Percent Growth	NA	37.9	29.4	40.5	6.5	-7.2	11.5	
Percent Worldwide	39.3	43.5	45.8	49.0	49.0	45.4	46.7	
Merchant	10,500	14,524	18,824	26,388	28,119	26,069	29,121	
Captive	151	162	180	305	310	307	290	
Total Europe	3,403	3,831	4,674	5,789	6,290	6,780	6,086	9.7
Percent Growth	NA	12.6	22.0	23.9	8.7	7.8	-10.2	
Percent Worldwide	12.6	11.4	11.3	10.6	10.8	11.7	9.7	
Merchant	3,024	3,426	4,223	5,277	5,782	6,307	5,677	
Captive	379	405	451	512	508	473	409	
Total Asia/Pacific-ROW	406	756	1,087	1,868	1,974	2,210	2,435	26.4
Percent Growth	NA	86.2	43.8	71.8	5.7	12.0	10.2	
Percent Worldwide	1.5	2.2	2.6	3.4	3.4	3.8	3.9	
Merchant	406	756	1,087	1,868	1,974	2,210	2,435	
Captive	NA	NA	NA	NA	NA	NA	NA	
Worldwide	27,114	33,729	41,477	54,521	58,017	58,155	63,036	13.3
Merchant	24,341	30,835	38,250	50,859	54,339	54,545	59,694	
Percent Growth	NA	26.7	24.0	33.0	6.8	0.4	9.4	
Captive	2,773	2,894	3,227	3,662	3,678	3,610	3,342	
Percent Growth	NA	4.4	11.5	13.5	0.4	-1.8	-7.4	

NA = Not applicable
Source: Dataquest (August 1992)

Table 6-2
Worldwide Semiconductor Production by Region—Forecast
Merchant and Captive Semiconductor Company Sales
(Millions of U.S. Dollars)

	1991	1992	1993	1994	1995	1996	CAGR (%) 1991-1996
Total North America	25,103	27,695	31,136	34,542	36,063	38,592	9.0
Percent Growth	10.2	10.3	12.4	10.9	4.4	7.0	
Percent Worldwide	39.8	41.9	41.1	40.3	39.5	39.3	
Merchant	22,460	25,170	28,704	32,142	33,663	36,192	10.0
Captive	2,643	2,525	2,432	2,400	2,400	2,400	-1.9
Total Japan	29,411	29,161	33,734	36,193	38,319	40,621	6.7
Percent Growth	11.5	-0.9	15.7	7.3	5.9	6.0	
Percent Total	46.7	44.2	44.5	42.2	42.0	41.4	
Merchant	29,121	28,946	33,500	35,943	38,069	40,371	6.8
Captive	290	215	234	250	250	250	-2.9
Total Europe	6,086	6,294	7,018	8,631	9,324	10,292	11.1
Percent Growth	-10.2	3.4	11.5	23.0	8.0	10.4	
Percent Worldwide	9.7	9.5	9.3	10.1	10.2	10.5	
Merchant	5,677	5,915	6,613	8,180	8,812	9,784	11.5
Captive	409	379	405	451	512	508	4.4
Total Asia/Pacific-ROW	2,435	2,895	3,851	6,362	7,578	8,644	28.8
Percent Growth	10.2	18.9	33.1	65.2	19.1	14.1	
Percent Worldwide	3.9	4.4	5.1	7.4	8.3	8.8	
Merchant	2,435	2,895	3,851	6,362	7,578	8,644	28.8
Captive	NA	NA	NA	NA	NA	NA	
Worldwide	63,036	66,044	75,739	85,728	91,284	98,149	9.3
Merchant	59,694	62,925	72,668	82,627	88,122	94,991	9.7
Percent Growth	9.4	5.4	15.5	13.7	6.7	7.8	
Captive	3,342	3,119	3,071	3,101	3,162	3,158	-1.1
Percent Growth	-7.4	-6.7	-1.5	1.0	2.0	-0.1	

NA = Not applicable
Source: Dataquest (August 1992)

Appendix A
Regional Economic Outlook for Our Forecast

This appendix provides a discussion of the macroeconomic factors and trends affecting the major semiconductor consuming and producing regions. The focus is on the current and future general business environments in these regions and the assumptions used in our forecast.

The Regional Economic Outlook for Our Forecast

North America

The North American economy is moving into an extended period of slow growth following the heated expansion of the 1980s. We believe that the recovery will be subpar when compared with previous recoveries. U.S. Gross Domestic Product (GDP) is not expected to grow much higher than 2.6 percent between 1992 and 1996 (see Table A-1).

The main factor preventing more robust growth is the forecasted weak rebound in real income. The problems with income are attributable to lingering consumer and business debt overhang, weak productivity growth, high levels of business failures, weak demographic demand for housing, and the lack of fiscal stimulus. With unit consumer spending having a less than normal recovery, the rebound in industrial production is also certain to fall short of normal historic cyclical proportions.

Though domestic demand will be moderate, we believe that the export picture will continue to improve. Latin America is expected to become a key driver for the U.S. high-technology sector. Exports to these countries have almost doubled over the last two years. If the North American Free Trade Agreement is passed later this year, Mexico could easily exceed Japan as the second-largest customer of the United States by 1994.

The continued growth of exports is contingent on the ability of companies to invest in new plants and equipment. The U.S. Federal Reserve's easing monetary policies are helping. We believe that the Fed can maintain an accommodating policy through the first half of 1993. There will likely be a moderate firming of interest rates in the second half of 1993 as the economy picks up speed.

However, the fiscal budget deficit, which is expected to widen to about 6 percent of gross domestic product, threatens to crowd out private investment. The budget deficit continues to deteriorate, and the U.S. Government's claim on the savings of the country continue to rise. We are assuming that Washington will take measures to arrest the growth of the deficit over the next several years, though such an assumption has proved overly optimistic to date.

Japan

The Japanese economy is undergoing a fundamental shift. Very strong growth in the money supply during the second half of the 1980s fueled an unprecedented capital spending binge. Capital spending for all industries as a percent of GNP peaked in 1989 at 23.5 percent, which is unparalleled when compared with any other period in post-World War II history.

Dataquest believes that the rate of GDP growth will be slower over the next five years. We expect Japanese GDP growth to bottom in 1992 at 2 percent. We are forecasting a moderate rate of growth in GDP over the next five years, rising to 4 percent by 1995. However, these growth rates will be well below the 5 to 6 percent range of GDP growth experienced in the later half of the 1980s.

Perhaps, the biggest problem facing Japanese electronic manufacturers is the unwinding of the Japanese financial machine that funded the years of growth. Asset deflation has hit the Japanese banking sector hard. The bank's capital base has declined because of the fall in stock prices. At the same time, declining land prices are eroding the collateral for outstanding loans. As a result, banks have turned cautious on lending. It is a cycle that could take a long time to work out.

Though the financial problems add a great deal of downside uncertainty to our forecast, other indicators point to a stronger outcome. Inflation is well under control and will allow real disposable income to expand. Consequently, the Japanese consumer will remain a strong link in the economy.

Also, the recovery in the United States and the continued expansion of the Pacific Rim countries are good signs for Japanese exports. We expect large trade and current account surpluses to continue in Japan. This trend is a doubled-edged sword. In the short term, exports for Japanese industry will deaden the impact of decreasing industrial production. However, the growing surpluses over the long term will add to trade friction problems.

The current environment is difficult for the Japanese economy. It is very likely that the banks have not faced up to all their problems and therefore the financial uncertainties are very high. Capital spending, which has been the main economic engine for the economy, will certainly not snap back. But external surpluses and domestic consumption should enable Japanese GDP to continue growing at moderate levels.

Europe

The European economy, driven largely by Germany, will see weak growth in 1992. We expect GDP in Germany to grow only 1.1 percent in 1992. Despite negative growth last year, growth in the United Kingdom will be 0.5 percent, while growth in France will be 2.1 percent.

Germany, the main engine for the European economy, continues to struggle with problems associated with unification. Inflation is stuck in the 4.5 percent range, forcing the Bundesbank to hold the line on interest rates. Because the other European currencies are tied to the deutsche mark, interest rates throughout Europe remain stubbornly high.

Wages in eastern Germany will converge to western Germany's standards by 1995. Consequently, we expect that the ability of German companies to compete will deteriorate because productivity gains will not keep up with cost increases.

In the United Kingdom, evidence of a post-election recovery is still very thin. Inflation is subsiding. We do not believe that inflation will be much of a problem for the foreseeable future. Even with the gains on inflation, interest rates remain high. We do expect a significant move lower next year, assuming that German short rates are falling by then. The main problem for the United Kingdom is the deteriorating trade figures, fueled by the increase in domestic demand as the economy emerges from recession.

France avoided recession in 1991 and is moderately improving in 1992. The moderate recovery expected among its European trading partners and a strengthening competitive position vis-a-vis these partners will improve the export picture. But an upturn in domestic demand will most likely be slower coming because the pace of job creation is weak. A fiscal stimulus is unlikely because the government continues to target a lower budget deficit.

Over the long term, we are forecasting moderate growth for Western European countries. The central and northern countries are expected to grow in the 2 to 3 percent range. Portugal and Spain, which are less developed than most of their Western European neighbors, are forecast to grow slightly faster, in the 3 to 4 percent range. We believe that Eastern Europe will not have much of an impact on Western European GNP growth until the second half of the 1990s, if then.

Asia/Pacific

Most economists continue to forecast the fastest growth in the world for the Asia/Pacific region. We believe that annual GDP growth rates over the next five years will range from 5 percent to 8 percent for Hong Kong, Indonesia, Malaysia, Singapore, South Korea, Taiwan, and Thailand. Moreover, underdeveloped countries such as the People's Republic of China, India, and Vietnam will increasingly boost the economic activity of the Pacific basin as the decade wears on.

In 1991, many of the Pacific basin countries suffered from slow worldwide growth because the health of their economies is tied so closely to exports. Countries such as Korea and Singapore, which are heavily dependent on sales to the West, experienced a deceleration in GDP growth because of the slow U.S. and European economies.

But Taiwan's economy was more resilient. It benefited from strong exports to trading partners in Southeast Asia and China, which were not affected by the recession in the West. We believe that the intraregional trade theme is a trend that will increasingly impact not only Taiwan's economy but also the economies of other industrializing countries in the region.

The only dark cloud on the horizon is the threat of a slower rate of investment by Japanese companies because of the financial problems at home. If the Japanese banking system were to stumble, then the flow of investment to the Pacific basin would certainly suffer. But this downside has a low probability.

Table A-1
International Economic Forecasts
GDP/GNP Growth Rates

	Currently in or Near Recession	Last 1992-1993 GDP/GNP Change	1988	1989	1990	1991	1992	1993	1994	1995	1996
North America											
Canada	Yes	Down	4.7	2.5	0.5	-1.5	1.6	4.0	3.3	3.0	3.0
United States			3.9	2.5	1.0	-0.7	2.1	2.5	2.3	2.6	2.6
Western Europe											
Austria			4.0	3.7	4.6	3.0	2.3	3.0	3.9	3.6	3.6
Belgium	Yes		4.6	3.9	3.5	1.9	1.9	2.7	2.7	2.9	2.9
Denmark	Yes	Down	0.5	1.2	1.7	1.0	1.7	2.5	3.0	3.3	3.3
Finalnd	Yes	Down	5.4	5.4	0.4	-6.0	-0.5	2.0	3.5	3.8	3.8
France		Up	4.6	4.7	2.3	0.9	2.1	2.7	3.3	3.3	3.3
Germany*	Yes		3.5	3.9	4.7	3.2	1.1	2.8	4.2	3.8	3.8
Ireland			3.9	5.9	5.6	1.7	2.3	3.0	3.4	3.3	3.3
Italy	Yes	Down	4.2	2.9	2.2	1.4	1.5	2.2	2.4	2.2	2.2
Netherlands	Yes		2.8	4.2	3.9	2.1	1.5	2.5	3.1	2.9	2.9
Norway			-0.5	0.4	1.7	1.6	2.1	2.8	3.0	3.0	3.0
Portugal			3.9	5.4	4.3	3.0	2.8	3.3	4.0	4.0	4.0
Spain		Down	5.2	4.9	3.7	2.5	3.0	3.3	3.9	4.0	4.0
Sweden	Yes		2.3	2.3	0.6	-1.4	0.0	1.9	2.7	3.3	3.3
Switzerland	Yes		2.8	3.7	2.2	-0.4	1.1	2.1	2.4	2.0	2.0
United Kingdom	Yes	Down	4.1	2.2	1.0	-2.4	0.5	2.2	2.9	3.0	3.0
Central Europe											
Hungary	Yes	Up	2.7	3.8	-4.0	-6.7	-1.0	2.0	4.0	5.0	5.0
Poland	Yes	Down	2.5	-0.1	-11.6	-9.0	-2.0	1.5	3.0	4.0	4.0

(Continued)

Table A-1 (Continued)
International Economic Forecasts
GDP/GNP Growth Rates

	Currently in or Near Recession	Last 1992-1993 GDP/GNP Change	1988	1989	1990	1991	1992	1993	1994	1995	1996
Asia/Pacific											
Australia		Down	3.6	4.3	1.3	-2.0	2.5	3.4	3.7	3.3	3.3
Hong kong			8.3	2.7	2.8	3.9	5.1	5.0	5.0	5.0	5.0
Indonesia			6.5	7.5	7.4	5.8	6.0	6.5	6.5	6.5	6.5
Japan		Down	6.3	4.8	5.3	4.4	2.0	3.3	3.5	4.0	4.0
Malaysia			9.1	8.6	9.8	8.8	7.9	7.5	7.5	7.5	7.5
New Zealand	YES	Up	-1.4	1.2	1.1	-0.2	1.7	2.6	2.5	2.5	2.5
Singapore			11.1	9.2	8.3	6.7	6.6	7.0	7.0	7.0	7.0
South Korea		Down	11.5	6.2	9.0	8.4	70.0	7.0	7.0	7.0	7.0
Taiwan			7.3	7.4	4.9	7.3	7.0	7.5	8.0	8.5	8.5
Thailand		Down	13.2	12.0	10.0	7.9	4.0	9.0	7.5	7.0	7.0
Central/Latin America											
Argentina			-2.6	-4.5	0.4	4.6	4.9	4.1	4.0	2.5	2.5
Brazil	YES		-0.1	3.3	-4.1	-1.9	1.6	3.0	4.0	4.0	4.0
Mexico			1.3	2.9	3.9	4.3	4.5	5.0	5.0	5.0	5.0
Venezuela			5.8	-8.9	5.7	9.2	4.0	7.0	5.5	4.0	4.0

*West Germany prior to 1993, unified Germany data therafter.
Source: Dataquest (July 1992), Economic Analysis Department, The Dun & Bradstreet Corporation

Appendix B
Exchange Rates

Table B-1 lists the exchange rates per dollar for Japanese yen and European currency units (ECUs) for the period from 1985 to 1991. Exchange rate variations should be kept in mind when interpreting yearly changes in the 1985 to 1991 data presented in this booklet. However, the forecast years (1992 to 1996) are assumed to have constant exchange rates.

Table B-1
Exchange Rates per Dollar for Japanese Yen and ECU: 1985-1991

	1985	1986	1987	1988	1989	1990	1991
Yen/$	238	167	144	130	138	144	135
Percent Change		-30	-14	-10	6	4	-6
ECU/$	1.31	1.02	0.87	0.84	0.92	0.79	0.81
Percent Change		-22	-15	-3	10	-14	8

Source: Dataquest (August 1992)

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Wafer Fabrication Equipment 1991 Market in Review

MarketTrends

Semiconductor Equipment, Manufacturing, and Materials

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Chapter 1
Executive Summary

This *MarketTrends* report focuses on the 1991 worldwide wafer fabrication equipment market and presents Dataquest's analysis of the general trends in the marketplace and those specific technology issues and company activities that characterize the market for each major segment of wafer fab equipment. Dataquest's research and analysis of the 1991 wafer fabrication equipment market led to the conclusions discussed in the following paragraphs.

Regional Market Trends

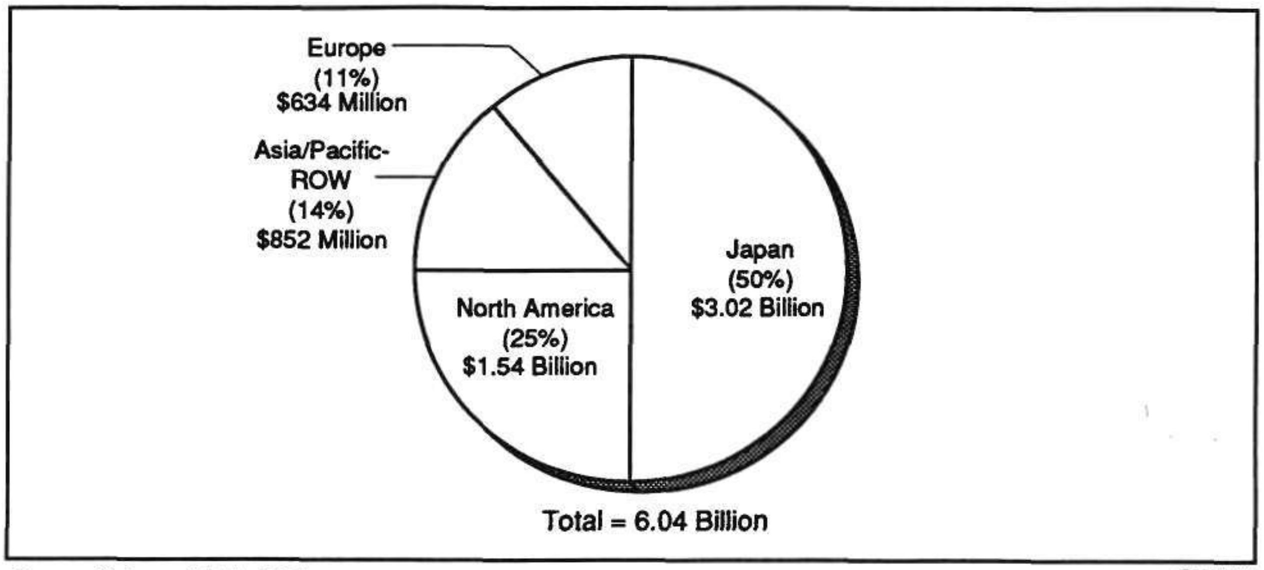
In 1991, the worldwide market for wafer fab equipment was $6.04 billion, up 3 percent from its 1990 level of $5.87 billion. Japan and North America both experienced a sluggish market environment in 1991, with growth of 1 percent and a decline of 4 percent, respectively, from 1990 levels. Substantially weaker business conditions in Europe contributed to a 17 percent decline for that region's wafer fab equipment spending in 1991. The one bright spot in worldwide wafer fab activities in 1991 was Asia/Pacific-ROW, which grew a healthy 64 percent from its 1990 level. Figure 1-1 presents the regional wafer fab equipment markets by percentage share for 1991. Even with its sluggish market environment in 1991, Japan still accounted for 50 percent of the worldwide wafer fab equipment market.

Equipment Segment Trends

The three major segments of the wafer fab equipment market are lithography, deposition, and etch and clean equipment. These three segments represented more than 70 percent of total equipment spending in 1991 (see Figure 1-2). Lithography equipment provides the critical patterning technology necessary to produce smaller and smaller device features on advanced semiconductor chips. Deposition equipment represents the key technology enabler for depositing thin films of insulating and conducting materials to produce the increasingly complex chip interconnect structures. Etch and clean equipment is used to selectively remove different films and materials from the wafer or to remove particulate contamination so as to maintain an ultraclean processing surface. These three segments of equipment represent not only the largest segments of the market but also the most technologically sophisticated equipment used to fabricate advanced semiconductor devices.

Although the wafer fab equipment market is becoming more and more global, it is not entirely homogeneous with respect to equipment

Figure 1-1
1991 Regional Wafer Fab Equipment Markets (Millions of Dollars)



Source: Dataquest (July 1992)

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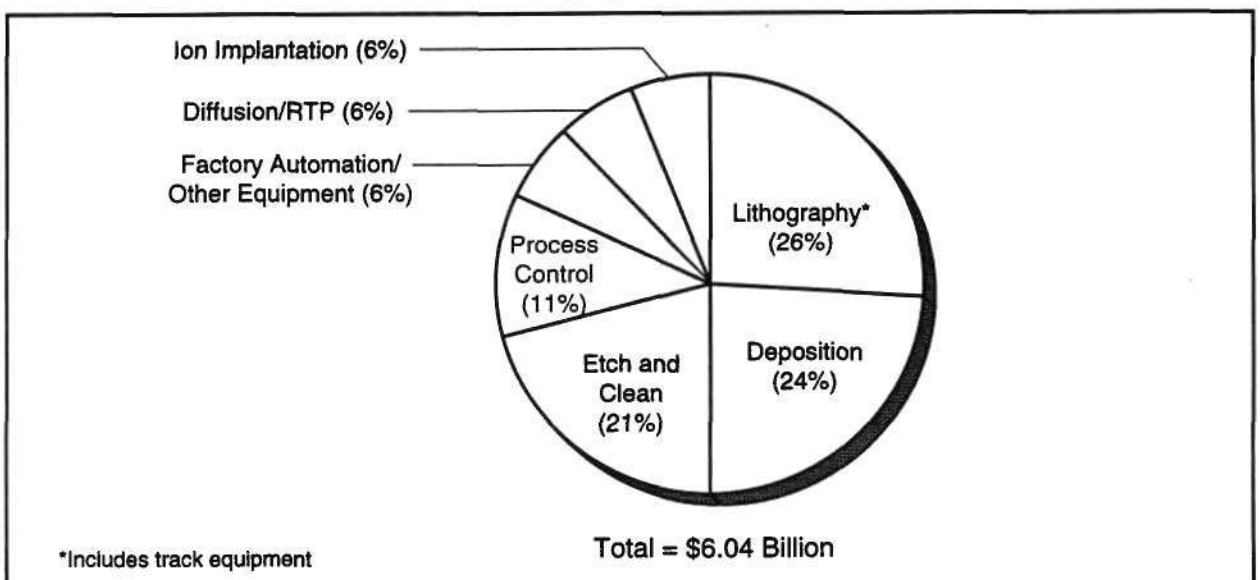
Figure 1-2
1991 Worldwide Wafer Fabrication Equipment Market by Major Segment



*Includes track equipment

Source: Dataquest (July 1992)

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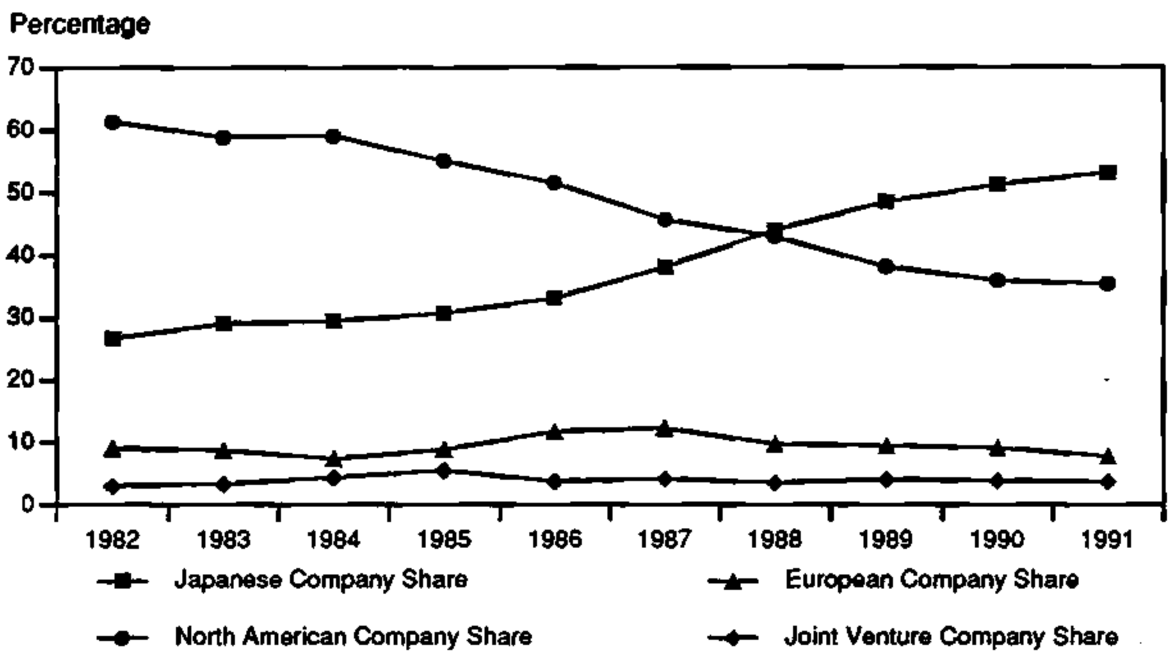
usage. Wafer fab equipment demand in Japan represented 50 percent of the worldwide wafer fab equipment market in 1991. However, semiconductor manufacturers in Japan accounted for more than 50 percent of worldwide demand for several categories of equipment. Such variations in equipment demand can occur on a regional basis because of a concentration of activity in a specific region or because of a specific manufacturing philosophy that favors a given type of tool technology. An especially strong domestic supplier base in a given tool technology can also influence the regional market dynamics for a specific equipment segment. For the majority of equipment segments, however, regional demand trends for individual segments of equipment are fairly similar to the percentage share represented by each of the total regional wafer fab equipment markets.

Regional Company Market Share Trends

Trends in regional company market share are a perennial topic of interest in the semiconductor industry, be it for devices, equipment, or materials. Figure 1-3 shows that the steady increase in market share by Japanese companies throughout the 1980s was mirrored by a similar

Figure 1-3
Worldwide Market Share of Regional Companies for Key Equipment Segments, 1982-1991 (Percentage of Revenue in Dollars)



Note: Wafer fab equipment segments include lithography, automatic photoresist, processing equipment, wet processing, dry etch, dry strip, deposition, diffusion, rapid thermal processing, ion implantation, critical dimension, and wafer inspection tools.

Source: Dataquest (July 1992)

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loss in share by North American companies for key segments of wafer processing equipment. Although North American companies still lost market share last year, the pattern of market share erosion appears to have slowed somewhat in 1991.

Japanese wafer fab equipment companies increased their share of the 1991 worldwide market to 53 percent at the expense of both European and North American wafer fab equipment manufacturers. Japanese companies gained share in the 1991 world market because increased penetration in both the North American and Asia/Pacific-ROW markets more than compensated for lost share in Europe and their home market of Japan. Exactly opposite of the trend observed in Japanese company share, North American companies gained market share position in Japan and Europe, and lost share in Asia/Pacific and their home market of the United States. Overall, North American company share declined half a percentage point to about 35 percent, a noticeably smaller decline than the average 3 percentage point decline observed throughout the 1980s. European company share declined by more than a percentage point to about 8 percent on a worldwide basis, while joint venture companies essentially maintained their 1990 share level with about 4 percent of the worldwide market in 1991.

1991 Top 10 Wafer Fab Equipment Suppliers

Table 1-1 identifies the top 10 suppliers of wafer fabrication equipment in 1991. Seven of the top ten companies are Japanese while the other

Table 1-1
1991 Top 10 Wafer Fab Equipment Company Ranking (Revenue in Millions of Dollars)

1	Nikon	557
2	Applied Materials	493
3	Tokyo Electron Ltd.	397
4	Hitachi	328
5	Canon	292
6	Varian	181
7	Silicon Valley Group	180
8	Anelva	155
9	Kokusai Electric	138
10	Dainippon Screen	138
	Total	2,859
	Total Market	6,039
	Percentage Top 10	47

Note: Revenue estimates reflect the major categories of wafer fabrication equipment including lithography, automatic photoresist processing equipment (track), etch and clean, deposition, diffusion, rapid thermal processing, ion implantation, optical CD and CD SEM tools, and wafer inspection equipment. Revenue associated with service and spares is not included.
Source: Dataquest (July 1992)

three companies are based in the United States. Together, these ten companies supplied 47 percent of the worldwide demand for wafer fab equipment in 1991.

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Contributors: Kunio Achiwa, Mark FitzGerald, Krishna Shankar

Chapter 2
Introduction

Scope of This Report

In its research of the wafer fabrication equipment industry, Dataquest tracks the worldwide activities of more than 150 companies that participate in 40 different segments of front-end wafer fab equipment. Our *MarketTrends* report presents a discussion of the significant trends and issues that characterized the 1991 wafer fabrication equipment environment. The report is divided into a series of chapters that focus on both general industry trends as well as equipment-specific issues.

In Chapter 3, regional market and ownership trends are discussed for the wafer fab equipment industry as a whole. In Chapters 4 through 8, an analysis of 1991 regional market and ownership trends and a discussion of the activities of key companies participating in the market are presented for specific segments of equipment. These segments include the following:

- Steppers
- Automatic photoresist processing equipment
- Wet process
- Dry etch
- Chemical vapor deposition (CVD)
- Sputter equipment
- Silicon epitaxial reactors
- Diffusion furnaces
- Ion implantation equipment
- Critical dimension measurement systems
- Wafer inspection equipment

Three appendixes at the conclusion of the report present detailed historical worldwide market statistics by segment of wafer fabrication equipment. These historical market statistics cover the three-year period from 1989 through 1991 and as background information are meant to supplement the analysis and discussion presented in the body of the report. Dataquest's estimates of individual company worldwide revenue by year by equipment segment are presented in Appendix C for the 35 equipment segments identified as follows:

- Lithography
  - Contact/Proximity
  - Projection Aligners
  - Steppers
  - Direct-Write Lithography
  - Maskmaking Lithography
  - X-Ray
- Automatic Photoresist Processing Equipment
- Etch and Clean
  - Wet Process
    - Integrated Wet Stations
    - Manual Wet Benches
    - Rinsers/Dryers
    - Acid Processors
    - Megasonic Cleaners
  - Dry Strip
  - Dry Etch
- Deposition
  - Chemical Vapor Deposition
    - Tube CVD
      - Horizontal LPCVD
      - Vertical LPCVD
      - Horizontal PECVD
    - Nontube CVD
      - LPCVD
      - PECVD
      - APCVD
      - ECR CVD
  - Physical Vapor Deposition (PVD)
    - Sputter
    - Evaporation
  - Silicon Epitaxy
  - Metalorganic CVD
  - Molecular Beam Epitaxy
- Diffusion
  - Horizontal Tube Diffusion
  - Vertical Tube Diffusion
- Rapid Thermal Processing (RTP)
- Ion Implantation
  - Medium Current
  - High Current
  - High Voltage

Critical Dimension (CD)
  Optical CD
  CD SEM

Wafer Inspection

Dataquest's Wafer Fab Equipment Forecast

The focus of this *Market Trends* report is a historical perspective of recent activities in the wafer fab equipment industry. Twice a year Dataquest also evaluates the anticipated future demand for wafer fabrication equipment. Our five-year forecast of wafer fab equipment demand by equipment segment is contained within a second *MarketTrends* report that discusses the economic and market drivers that underlie future demand throughout the semiconductor industry. The report, *Semiconductor Equipment, Manufacturing, and Materials Forecast,* focuses on several key semiconductor industry forecasts including semiconductor device consumption, semiconductor device production, capital spending, wafer fabrication equipment, and silicon wafer consumption. Our report of key semiconductor industry forecasts complements the detailed market share and historical perspective of the wafer fab equipment industry presented within this report. Please contact Dataquest for further information on this as well as other reports that focus on activities in the semiconductor industry.

Chapter 3
Overview of the 1991 Wafer Fab Equipment Market

The material in this section focuses on the 1991 wafer fab equipment market.

1991 Wafer Fab Equipment Market in Review
The wafer fab equipment market is decidedly in a slump. This section discusses several key characteristics of the wafer fab equipment market in 1991.

An "All-in-One" Summary Snapshot of the 1991 Wafer Fabrication Equipment Market
The wafer fabrication equipment market is not a single homogeneous entity but rather is made up of a large number of individual equipment segments. In order to simplify a complex and fragmented market, this section presents summary regional and ownership market statistics for each of the key segments of the wafer fab equipment market in 1991.

Slide in U.S. Company Share Slows in 1991: Wafer Fab Equipment Market by Company Ownership
Trends in regional company market share are a perennial topic of interest in the semiconductor industry, be it for devices, equipment, or materials. This section examines several of the underlying reasons for the changes in regional company market share for wafer fab equipment in 1991.

1991 Wafer Fab Equipment Market in Review

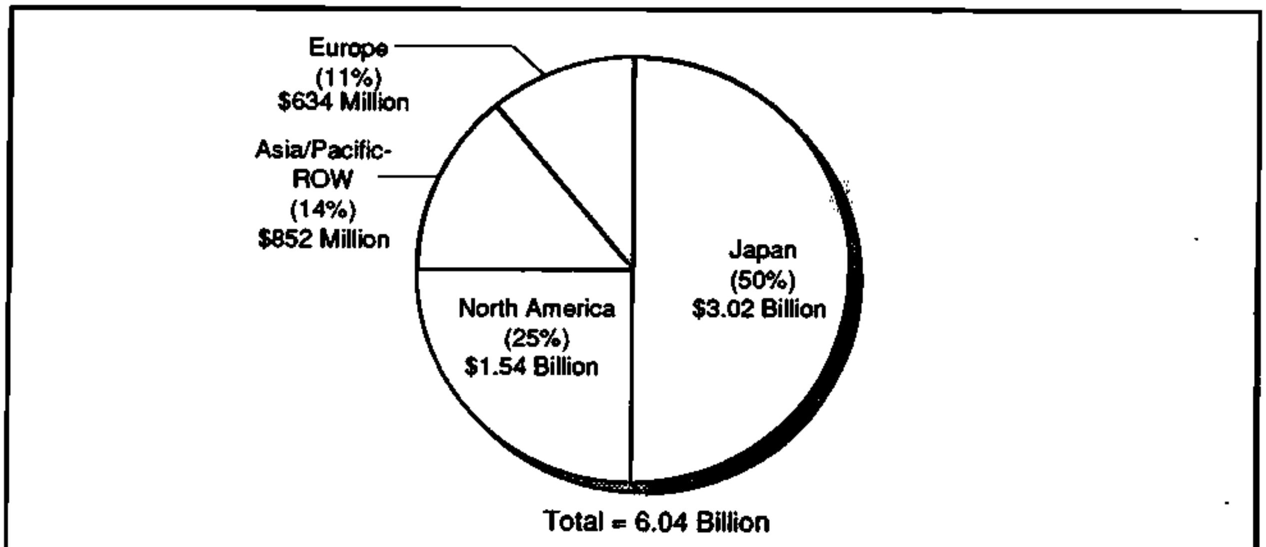
In 1991, the worldwide market for wafer fab equipment was $6.04 billion, up 3 percent from its 1990 level of $5.87 billion. Japan and North America each experienced a sluggish market environment in 1991, with growth of 1 percent and a decline of 4 percent, respectively, from 1990 levels. Substantially weaker business conditions in Europe contributed to a 17 percent decline for that region's wafer fab equipment spending in 1991. The one bright spot in worldwide wafer fab activities in 1991 was Asia/Pacific-ROW, which grew a healthy 64 percent from its 1990 level. Figure 3-1 presents the regional wafer fab equipment markets by percentage share for 1991. Even with its sluggish market environment in 1991, Japan still accounted for 50 percent of the worldwide wafer fab equipment market.

The wafer fab equipment market is decidedly in a slump. The market declined 2 percent in 1990 and was followed by only modest 3 percent growth in 1991. We expect the 1992 market, fed by a significant slowdown in the latter half of 1991, to be weaker yet and experience a decline of 8 percent from its 1991 level.

1991 Market Highlights

The following paragraphs detail several key characteristics of the wafer fab equipment market in 1991.

Figure 3-1
1991 Regional Wafer Fab Equipment Markets (Millions of Dollars)



Source: Dataquest (July 1992)

G2000141

The mood of cautious optimism expressed by wafer fab equipment manufacturers at SEMICON/West in May 1991 turned to frank pessimism in the latter half of the year as the wafer fab equipment industry fell victim to the weakening condition of the world's major economies. The Japanese and German economies began to decelerate while the U.S. and U.K. economies remained firmly entrenched under their mantles of recession. The weakening macroeconomic climate had a significant impact on the capital spending plans of the world's semiconductor manufacturers. Many equipment companies saw orders being pushed out by as much as several quarters while some new business was canceled altogether.

One major factor that influenced the flat equipment market in Japan in 1991 was a growing concern regarding the profit pressures, overcapacity, and end-market uncertainty associated with the 4Mb and 16Mb DRAM. These concerns, coupled with the weakening macroeconomic climate in Japan, resulted in 16 of the 24 existing or planned 200mm fab lines being downsized or delayed. By the end of 1991, only 38 percent of the originally planned 200mm capacity had come online. These large DRAM facilities require significant equipment expenditure, thus the reduced capacity additions for 200mm fabs took a toll on the Japanese equipment market.

The European wafer fab equipment market was the weakest regional market in 1991. Much of the hype associated with the economic unification of Europe in 1992 had led to expectations that semiconductor companies would make significant investment in new fabs in order to meet local content rules. The anticipated growth spurt in the years prior to 1992 fizzled miserably. The European wafer fab equipment market grew only a modest 9 percent in 1989, followed by a mere 6 percent in 1990. The market declined 17 percent last year.

Asia/Pacific, growing an impressive 64 percent over its 1990 level, was a hotbed of activity for wafer fab equipment companies in 1991. Semiconductor manufacturers in Asia/Pacific are on an aggressive campaign to gain market share in DRAMs and other advanced semiconductor devices and thus are adding the necessary capacity to support this strategy. However, it is important to place the feverish 1991 market growth in perspective. This same equipment market suffered a decline of 37 percent just one year prior. These roller coaster market dynamics highlight the fact that, with only a few major semiconductor companies in this region, a change in plans for just a handful of fabs can swing market growth wildly in either direction.

To add to the competitive quagmire in the wafer fab equipment industry, it is now clear that the Korean government is beginning to nurture its own embryonic domestic equipment industry to complement its strategy in semiconductors and silicon. Clearly, the potential of a new kid on the block won't have any impact on wafer fab equipment market dynamics in the short term, but it does contribute a whole new dimension to the future competitive market environment for wafer fab equipment.

The market environment for wafer fab equipment companies has probably never been tougher. Companies must cope with the presence of significant global competitors and the ever-escalating costs of advanced technology development on top of sluggish market conditions that have prevailed for more than two years. The companies that successfully emerge from this downturn in the industry with new product offerings and an increased emphasis on cost of ownership and aftersale service and support will be well positioned to take advantage of future growth opportunities in the wafer fab equipment market.

An "All-in-One" Summary Snapshot of the 1991 Wafer Fabrication Equipment Market

Dataquest's research of the wafer fabrication equipment market tracks the activities of more than 150 companies that participate in 40 different segments of the front-end equipment market. We have designed Table 3-1 to be an easy-to-use reference for summary market statistics of the 1991 wafer fabrication equipment market. Table 3-1 also reports our estimates of the 1991 worldwide markets for key segments of equipment and the percentage change of the size of each market relative to its 1990 level. The table also presents the percentage share for each market segment by region and by regional supplier.

Although the wafer fab equipment market is becoming more and more global, it is not entirely homogeneous with respect to equipment usage. Wafer fab equipment demand in Japan represented 50 percent of the worldwide wafer fab equipment market in 1991. However, semiconductor manufacturers in Japan accounted for 63 percent of worldwide CD SEM equipment demand, 65 percent of worldwide maskmaking equipment demand, and 83 percent of the 1991 worldwide demand for ECR etch equipment.

These variations in equipment demand can occur on a regional basis because of a concentration of activity in a specific region, such as maskmaking in Japan, or because of a specific manufacturing philosophy that favors a given type of tool technology, such as the preference by Japanese device manufacturers for CD SEM rather than optical CD systems. An especially strong domestic supplier base in a given tool technology can also influence the regional market dynamics for a specific equipment segment. Japanese companies account for 98 percent of the worldwide ECR etch equipment market, and thus, it is no surprise that semiconductor manufacturers in Japan purchase a disproportionately larger amount of this equipment because of their proximity to this strong domestic vendor base. Overall, though, Table 3-1 shows that for the majority of wafer fab equipment categories, regional trends for individual segments of equipment are quite similar to the percentage share represented by each of the regional wafer fab equipment markets.

Table 3-1
Summary Regional and Ownership Market Statistics of the 1991 Wafer Fabrication Equipment Market (Millions of Dollars)

Equipment	1991 World ($)	(%) Change from 1990	Percentage Regional Markets: North America	Japan	Europe	Asia-Pacific/ROW	Percentage Regional Ownership: North American Comps.	Japanese Comps.	European Comps.	Joint Ventures
Contact/Proximity	21	-13	13	38	34	16	0	38	62	0
Projection Aligners	68	-27	22	45	11	22	31	69	0	0
Steppers	1,029	-2	27	49	9	15	11	82	7	0
Direct-Write	55	-27	13	64	13	9	0	81	19	0
Maskmaking	46	-3	21	65	7	8	56	39	5	0
X-Ray	4	163	57	43	0	0	57	0	43	0
Total Lithography	1,224	-5	26	50	10	15	13	79	8	0
Automatic Photoresist Processing Equipment	369	13	30	49	9	12	28	62	5	5
Wet Processing	405	1	26	51	9	15	30	67	3	0
Dry Etch	567	-2	30	43	13	15	63	31	3	3
BCR Etch	138	23	3	83	4	10	0	98	2	0
Dry Strip	119	1	27	52	8	13	33	50	0	18
Total Etch and Clean	1,229	2	25	51	10	14	42	52	2	3
Horizontal Tube CVD	85	-27	26	38	17	19	21	16	60	2
Vertical Tube CVD	192	34	17	57	6	20	13	71	12	4
Nontube CVD	471	3	28	48	11	12	80	10	5	6
Total CVD	747	4	25	49	10	15	56	26	13	5
Sputter	438	22	27	50	9	14	37	59	4	0
Evaporation	36	-26	40	37	14	9	30	35	35	0
Silicon Epitaxy	89	30	28	52	12	8	40	21	39	0
MOCVD	51	16	27	45	18	10	36	33	31	0
MBE	59	2	18	51	18	14	9	42	49	0
Total Deposition	1,420	10	26	49	11	14	46	37	15	3

(Continued)

Table 3-1 (Continued)
Summary Regional and Ownership Market Statistics of the 1991 Wafer Fabrication Equipment Market (Millions of Dollars)

			Percentage Regional Markets				Percentage Regional Ownership			
Equipment	1991 World ($)	(%) Change from 1990	North America	Japan	Europe	Asia-Pacific/ ROW	North American Comps.	Japanese Comps.	European Comps.	Joint Ventures
Horizontal Diffusion	135	-18	27	34	16	22	38	44	14	4
Vertical Diffusion	200	25	21	54	7	18	19	72	5	4
Total Diffusion	335	3	24	46	11	19	26	61	9	4
Rapid Thermal Processing	42	41	44	34	17	5	85	7	8	0
Medium Current Implant	108	-5	15	55	13	17	53	36	0	11
High Current Implant	218	-13	18	59	12	11	55	10	0	35
High Voltage Implant	18	159	16	65	19	0	83	17	0	0
Total Implant	343	-7	17	58	13	12	56	19	0	26
Optical CD*	59	1	33	33	22	12	65	21	14	0
CD SEM	94	8	19	63	6	13	14	86	0	0
Wafer Inspection	90	-1	29	46	17	7	45	42	13	0
Subtotal Wafer Fab Equip.	5,205	2	25	50	11	14	35	53	8	4
Macro Categories										
Ion Milling	17	28	23	42	13	23	NA	NA	NA	NA
Other Process Control	398	8	30	45	11	14	NA	NA	NA	NA
Factory Automation	227	5	16	58	10	16	NA	NA	NA	NA
Other Equipment	193	2	25	50	11	14	NA	NA	NA	NA
Total Wafer Fab Equipment	6,040	3	25	50	11	14	NA	NA	NA	NA

NA = Not applicable
*Includes dedicated registration measurement tools.
Percentage figures for regional markets and ownership may not add to 100 percent because of rounding.
Source: Dataquest (July 1992)

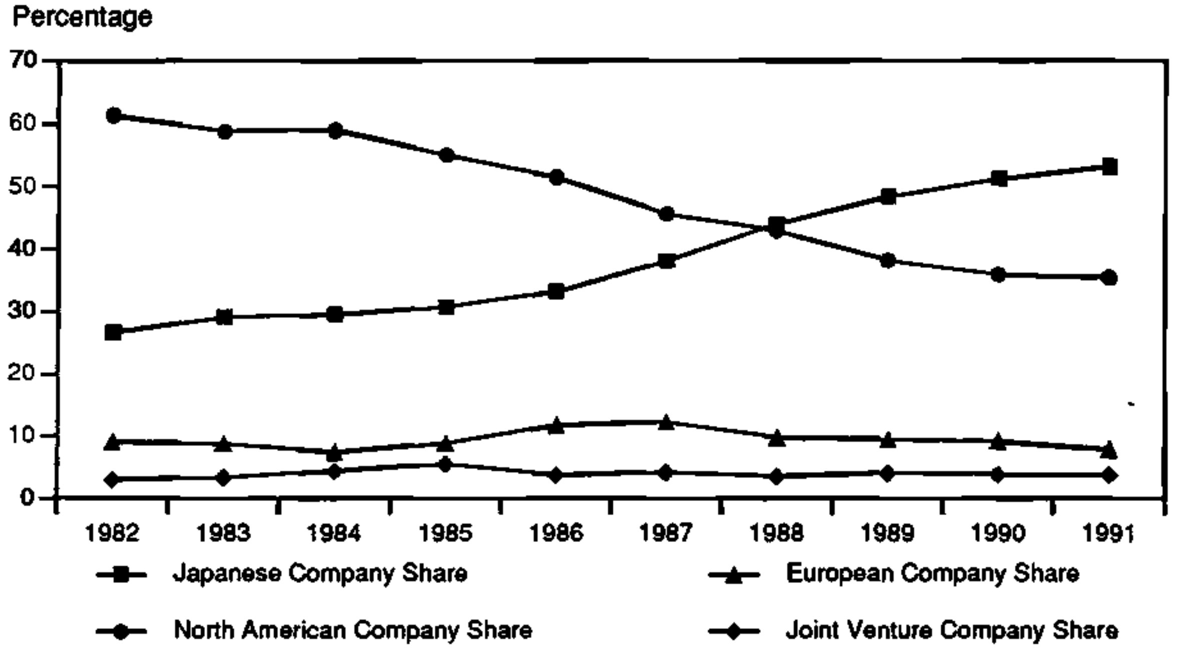
Slide in U.S. Company Share Slows in 1991: Wafer Fab Equipment Market by Company Ownership

Trends in regional company market share are a perennial topic of interest in the semiconductor industry, be it for devices, equipment, or materials. Figure 3-2 shows that the steady increase in market share by Japanese companies throughout the 1980s was mirrored by a similar loss in share by North American companies for key segments of wafer processing equipment. Although North American companies still lost market share last year, the pattern of market share erosion appears to have slowed somewhat in 1991. In this section we examine several of the underlying reasons for the changes in regional company market share in 1991.

Changes in Regional Market Share

Japanese wafer fab equipment companies increased their share of the worldwide market to 53 percent at the expense of both European and North American wafer fab equipment manufacturers in 1991 (see Table 3-2). European company share declined by more

Figure 3-2
Worldwide Market Share of Regional Companies for Key Equipment Segments, 1982-1991 (Percentage of Revenue in Dollars)



Note: Wafer fab equipment segments include lithography, automatic photoresist, processing equipment, wet processing, dry etch, dry strip, deposition, diffusion, rapid thermal processing, ion implantation, critical dimension, and wafer inspection tools.

Source: Dataquest (July 1992) G2000192

Table 3-2
Changes in Regional Company Market Share in the 1991 Wafer Fab Equipment Market
(Percentage Dollar Revenue)

Region	1991 World Share (%)	Changes in Regional Company Share as Compared with 1990: North America	Japan	Europe	Asia/Pacific-ROW	World
North American Companies	35.4	-4.6	2.8	5.4	-9.4	-0.5
Japanese Companies	53.1	3.8	-1.5	-2.5	10.5	1.9
European Companies	7.8	-0.4	-0.2	-4.1	-1.8	-1.3
Joint Venture Companies	3.7	1.3	-1.0	1.2	0.6	-0.1
Total	100.0					

Source: Dataquest (July 1992)

than a percentage point to about 8 percent, while U.S. company share declined half of a percentage point to about 35 percent. Joint venture companies (the majority of which are joint ventures between U.S. and Japanese corporations) essentially maintained their 1990 share level with about 4 percent of the worldwide market in 1991.

Japanese Companies

In 1991, Japanese companies gained share in the world market because increased penetration in both the North American and Asia/Pacific-ROW markets generated enough of a balance to compensate for lost share in Europe and their home market of Japan. The gain in market share in North America was due primarily to increased sales of lithography equipment into a market that was actually experiencing an overall decline in wafer fab equipment sales. The Asia/Pacific region was a hotbed of activity in 1991 and Japanese companies enjoyed particularly strong revenue growth, more than doubling their sales from the prior year. Revenue increases were noted in every major category of wafer fab equipment. Through this higher sales volume, Japanese companies garnered an increase of more than 10 percentage points in share to achieve an overall position of 53 percent share in this region of the world.

The relative proximity of Japanese companies to semiconductor fabs in Asia/Pacific, coupled with advanced technology product offerings focused on high-volume manufacturing, and the significant emphasis that Japanese vendors place on customer support have allowed the Japanese equipment industry to grow its presence in this market from 10 percent share in 1982 to a dominant position of 53 percent in 1991. During this same time span, North American companies' share dropped from 78 percent to 36 percent share.

North American Companies

The worldwide market share of North American companies declined only a half of a percentage point in 1991, in contrast to the average 3 percentage point decline observed throughout the 1980s. Exactly opposite of the trend observed in Japanese company share, North American companies gained market share position in Japan and Europe, and lost share in Asia/Pacific and their home market of the United States. The gain in wafer fab equipment market share in Japan has garnered much interest in light of the market access disputes and trade friction that currently characterize U.S./Japanese relations. While the total Japanese equipment market experienced only modest growth of 1 percent in 1991, North American companies increased their sales in Japan by 19 percent. This increased sales activity covered a broad number of equipment categories including lithography, CVD, PVD, silicon epitaxy, ion implantation, and rapid thermal processing equipment.

Dataquest believes that North American company share gains in the Japanese market in the categories of CVD and PVD equipment are of particular interest. The Japanese semiconductor industry is currently diversifying its manufacturing product mix away from the heavily dominated high-volume DRAM manufacturing to include more ASIC and advanced logic products. DRAM manufacturing is driven to a significant extent by trends in advanced lithography. ASIC and advanced logic products, however, are strongly design-dependent on multilevel metallization, which is achieved through the advanced thin film processing techniques of CVD and PVD equipment. In contrast, it is only at the 4Mb DRAM shrink that double-level metal even begins to be used in DRAM manufacturing. North American companies have held a traditionally strong market position in advanced CVD and PVD processing equipment, and thus have benefited from this shift in manufacturing strategy with increased market penetration in Japan.

Although an increase in North American company share gain in Japan in 1991 is certainly laudable, it must be noted that North American companies also lost almost 5 percentage points of share in their home market and more than 9 percentage points of share in Asia/Pacific. In both of these regions, North American company share was lost while Japanese company share continued to grow.

European Companies

European companies lost market share in every regional market in 1991. On a worldwide basis, European company revenue declined in every major category of wafer fab equipment with the exception of silicon epitaxy and track equipment. Dataquest believes that European companies, in particular, fell victim to the depressed equipment environment in their home market of Europe, which declined by 17 percent in 1991. Throughout the 1980s, the European market on average accounted for about 44 percent of total European equipment company revenue. However, in 1991, the home market represented only 33 percent of total European equipment company business as total European company revenue plunged 30 percent from its 1990 level.

Another important component in the loss of share for the European companies is the relatively small sales level of wafer fab equipment companies as compared with their North American and Japanese counterparts. According to Dataquest estimates, only the three largest European wafer fab equipment companies in 1991—ASM International, ASM Lithography, and E.T. Electrotech—achieved worldwide wafer fab equipment sales in excess of $20 million. It is very difficult for companies with a small revenue base to stave off the triple foes of a sluggish business environment, increased competition, and escalating R&D costs, while coping with an increasingly global and increasingly demanding customer base.

Dataquest Conclusions

Shifts in regional company market share grab both headlines and the attention of industry politicos. We believe that when evaluating the regional company share trends it is important to keep in mind that 1991 was a fairly sluggish year for the wafer fab equipment industry. Overall growth achieved only 3 percent, preceded by a 2 percent decline the year before. While we have noted some interesting changes in regional company market share for 1991, we caution that a single year does not necessarily define a trend. What is more important in establishing long-term market positioning and dominance is not just how companies fare when times are slow, but also the ability of companies to catch the tiger by the tail and ride out the next upswing in market growth.

Chapter 4
Lithography Market Trends

The material in this section focuses on lithography market trends.

The I-Line Lifeline: 1991 Stepper Market in Review
I-line steppers became the dominant tool choice for new system purchases in 1991. While total stepper shipments declined, revenue was buoyed by the higher average selling price of advanced i-line systems.

Track Triumvirate Prevails: 1991 Automatic Photoresist Processing Equipment Market in Review
The worldwide market for automatic photoresist processing equipment (track) was $369 million in 1991, up 13 percent from its 1990 level. This article highlights some of the key trends behind the healthy growth in last year's market and discusses the activities of the top three players that have continued their decade-long position of dominance in the worldwide track arena.

The I-Line Lifeline: 1991 Stepper Market in Review

I-line steppers became the dominant tool choice for new purchases in 1991. Total stepper unit shipments to semiconductor manufacturers were 679 units in 1991, down 12 percent from the 1990 level of 771. Buoyed by the higher average selling price of advanced i-line systems, worldwide stepper revenue was $1.03 billion in 1991, reflecting a decline of a mere 2 percentage points from its 1990 level of $1.05 billion. This section presents the significant trends and highlights of the 1991 stepper equipment market.

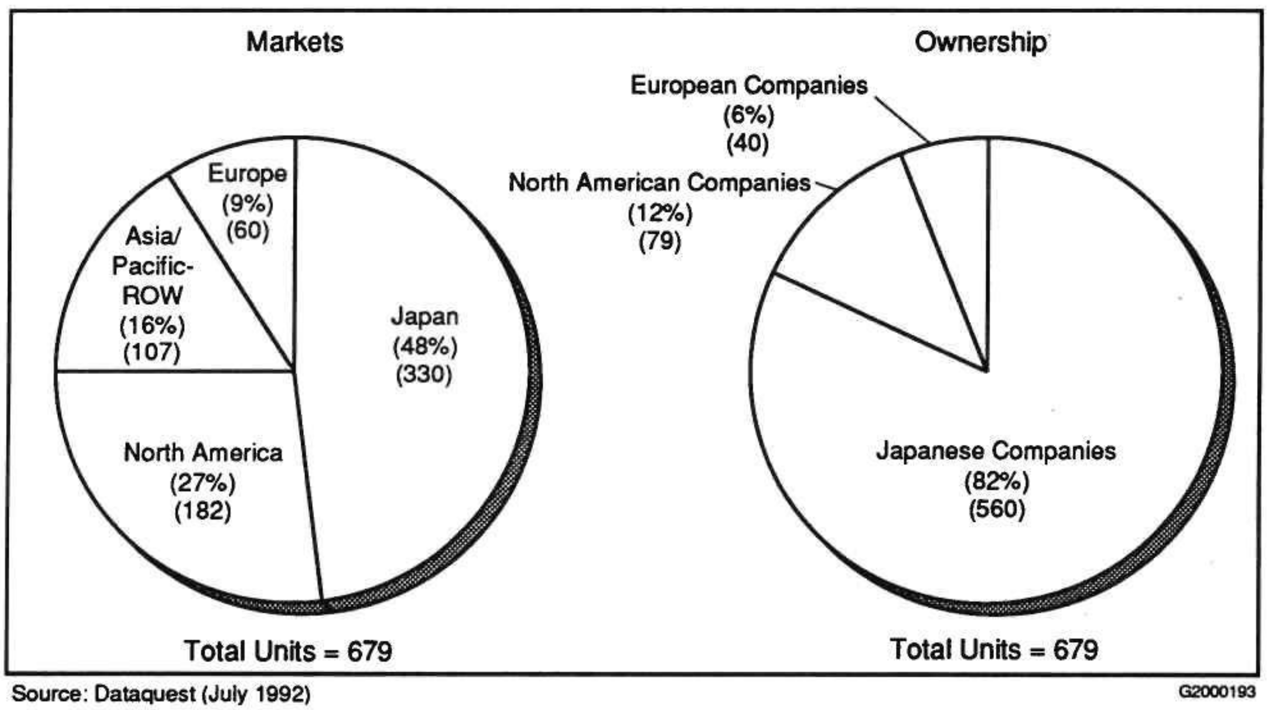
Regional Markets and Ownership

Figure 4-1 presents the worldwide 1991 stepper unit market segmented by region and ownership. As with other major categories of front-end processing equipment market, Japan continued its role as the largest regional market, accounting for almost half of 1991 stepper shipments. The Japanese stepper companies continued their dominance of the 1991 stepper market, accounting for more than 80 percent of worldwide shipments.

Stepper Market Highlights of 1991

Several key factors characterized the world of stepper lithography in 1991. I-line steppers continued to command a larger and larger portion of the stepper technology product mix. These tools constituted 21 percent of the stepper product mix in 1989 and

Figure 4-1
1991 Stepper Regional Markets and Ownership



Source: Dataquest (July 1992)

G2000193

36 percent in 1990, but by last year had increased their share to 60 percent of total system shipments. I-line steppers are the predominant lithography tool choice for products with line geometries in the sub-0.8 micron regime, including such devices as 4Mb and 16Mb DRAMs as well as advanced ASIC and logic chips. The development of semiconductor phase shift mask technology and recently announced advanced stepper illumination techniques, both of which are optimized for highly repetitive device patterns, holds promise for extending the capabilities of i-line lithography to the 0.35-micron regime.

The phase shift mask fever that took hold of the industry in 1990 continued into 1991. The challenges associated with phase shift mask inspection and repair still remained formidable, however. At the end of 1991, Nikon and Canon announced new i-line stepper illumination techniques, dubbed SHRINC and QUEST, respectively, that achieve the benefits of phase shifting on the wafer without having to use a mask as the source of the phase-shifting pattern. These new techniques, targeted at the 64Mb DRAM generation, provide some breathing room for development work to continue on phase shift mask inspection/repair technology for latter generations of DRAMs and other highly repetitive device product families. At the same time, Nikon and Canon benefit by being well-positioned with their new i-line techniques to offer an alternative lithographic approach to 64Mb DRAM device manufacturers.

Finally, 1991 can clearly be named the year of the wide-field lens. The industry saw a veritable explosion of wide-field lens product offerings. A total of 15 new wide-field i-line and excimer lenses were introduced by stepper manufacturers ASM Lithography, Canon, GCA, Hitachi, Nikon, and Ultratech. Wide-field lens capability to accommodate more die per exposure field, as well as the large die size associated with advanced device designs, is a key competitive feature of today's advanced stepper systems.

Company Rankings

Table 4-1 presents the worldwide company rankings for stepper unit shipments in 1991. In addition, Table 4-1 includes the percentage split by technology for each company's stepper shipment product mix in 1991.

Nikon

In 1991, Nikon continued to maintain its leadership position in the stepper market, a position it has held since 1984. Nikon's worldwide unit shipments totaled 350 units, down about 9 percent from its 1990 shipment level of 384. One key factor that began to affect Nikon's business activities toward the end of 1991 was the decision by many Japanese manufacturers to downsize or delay their capacity plans for 200mm fabs in Japan. The majority of these planned or existing 200mm fabs are slated for 4Mb and 16Mb DRAM devices. This slowdown in DRAM equipment purchases will have significant impact on Nikon, more so than any other stepper manufacturer, because of Nikon's traditionally strong position in supplying DRAM facilities.

Table 4-1
1991 Worldwide Stepper Company Ranking
(Unit Shipments)

			Percent Stepper Technology Mix			
Company	Units	Share (%)	g-line	i-line	Excimer/ deep-UV	1x
Nikon	350	51	31	66	3	0
Canon	145	21	50	41	9	0
Hitachi	65	10	0	100	0	0
ASM Lithography	40	6	8	87	5	0
Ultratech	40	6	0	0	0	100
GCA	31	5	19	58	23	0
SVG Lithography	8	1	0	0	100	0
Total	679	100	28	60	6	6

Source: Dataquest (July 1992)

Nikon experienced a decline of stepper shipments in all regions of the world with the exception of the United States, where there was particularly healthy growth. Dataquest estimates that Nikon's shipments reached 80 units in 1991, up from 56 units the year before. Of particular note for Nikon in 1991 was the shift in the company's product mix toward i-line stepper systems. Nikon shipped its first i-line tools in 1989, a year in which i-line constituted only 10 percent of the company's product mix. In just two years, i-line has grown to represent two-thirds of Nikon's worldwide stepper shipments. As mentioned earlier, an important event for Nikon in 1991 was its announcement of its new advanced illumination technique for i-line steppers that allows DRAM manufacturers to achieve some of the benefits of phase shift masks while eliminating the problems associated with mask inspection/repair technology.

Canon

Dataquest estimates that Canon's 1991 stepper unit shipments were 145 units, down about 3 percent from its 1990 level of 150 units. This decline for Canon is smaller than that experienced by Nikon because Canon's customer base includes a large number of ASIC and advanced logic manufacturers, and thus Canon has been somewhat more immune from the slowdown in DRAM fab activities. Last year marked the first year of significant shipments of Canon's first i-line product offering, the FPA-2000i. The success of that product offering allowed Canon to rapidly grow i-line steppers to about 40 percent of its product mix. As mentioned earlier, another significant event for Canon last year was its announcement of a new advanced illumination technique for i-line steppers that, like Nikon's technique, provides 64Mb DRAM manufacturers with a lithographic alternative to using phase shift masks.

Hitachi

Hitachi ranked third in worldwide stepper shipments in 1991 with 65 units, down from 84 units in 1990. Historically, Hitachi's shipments have been concentrated in Japan. However, Dataquest believes that the company shipped a substantial portion of its total 1991 stepper shipments to Goldstar in Korea. The Hitachi and Goldstar organizations have had long-standing relationships in the consumer electronics arena since the 1950s. As part of a semiconductor agreement in 1989, Goldstar acquired the rights to Hitachi's 1Mb and 4Mb DRAM technology in return for a variable portion of its DRAM output going to Hitachi. Hitachi uses this output from Goldstar to balance the capacity utilization of its Japanese DRAM lines against overall market demand. Some industry watchers speculate that Goldstar's purchase of Hitachi steppers is somehow tied to the DRAM technology agreement. However, Dataquest notes that this is not entirely supported by the facts, since Hitachi's own semiconductor operations do not exclusively rely on Hitachi steppers for use in their manufacturing facilities. Hitachi's stepper activity in Korea may mark the beginning of a significant shift in the company's marketing strategy to expand its customer base beyond a handful of Japanese device manufacturers and internal operations at some of the Hitachi semiconductor facilities.

ASM Lithography (ASML)

ASM Lithography shipped a total of 40 units in 1991, down from 58 the prior year. The U.S. market continued to be the largest regional market for ASML in 1991, representing about 58 percent of total system shipments. However, for the first time, shipments to Asia/Pacific moved ahead of ASML's stepper shipments to Europe. Dataquest believes that this decline for ASML in its home market was due to a severely depressed stepper market in Europe last year (total European stepper shipments of 60 units compared with 95 units the year before) coupled with ASML's aggressive marketing strategy to increase its penetration in the Asia/Pacific market, in particular, Taiwan. ASML has yet to ship any steppers to Japan. However, Dataquest believes that the company is actively laying the groundwork for future business activities in that region.

The major event for ASML in 1991 was the introduction of a major new product family of steppers at SEMICON/West in May. The PAS 5500 stepper family, which includes three wide-field i-line and one wide-field excimer stepper, has been designed in a modular fashion so that the steppers can be easily upgraded with new illumination systems, lenses, reticle transfer systems, wafer transport systems, and other elements as technology advances the definition of state-of-the-art lithography. Other system components such as the machine frame, lens platform and exposure stage, alignment system, internal clean room environment, and image sensor and calibration remain the same throughout the 5500 family. This modular design approach effectively addresses one of the hot issues among semiconductor manufacturers today: controlling the cost of ownership of today's wafer fab equipment.

Ultratech

Ultratech was the only stepper manufacturer to enjoy increased unit shipments in 1991. The company's shipments totaled 40 units, up from 34 units the year before. The company's 1991 unit shipments included 9 systems to Japan, representing the majority of the total of 12 units shipped by non-Japanese stepper companies to this region. After all of the uncertainty that plagued Ultratech in 1990, including possible consolidation with sister company GCA, a failed management buyout proposal, and dwindling employee morale, 1991 was definitely a turnaround year for the company. A new management team with solid experience in the wafer fab equipment industry was put in place, and a strong marketing campaign was launched to promote the company's "trailing edge" marketing strategy for 1x mix-and-match lithography. Outside the semiconductor arena, the company also began to aggressively promote its position as a leader in providing lithography solutions for the thin film head manufacturing environment.

GCA

GCA's stepper shipments totaled 31 units in 1991, down from 52 systems in 1990. The United States remains the largest regional market for the company, accounting for more than 80 percent of system shipments last year. GCA was the first vendor to begin i-line stepper shipments back in the mid-1980s, and today the company's product mix still largely reflects its participation in that market segment. However, it is important to note that GCA has placed significant emphasis on its excimer laser product offerings. As shown in Table 1, almost one-fourth of GCA's product mix is in the excimer area, the highest percentage of any vendor currently offering excimer laser steppers. Dataquest believes that the goal of the company's current emphasis on excimer lithography is to establish an early foothold in this advanced stepper segment and to use this product offering as part of the company's long-term strategy to regain its former market presence in the highly competitive stepper arena. GCA introduced its long-awaited XLS family of steppers at SEMICON/West in May 1991. This family of products, developed in conjunction with SEMATECH, includes three i-line and two excimer stepper product offerings.

SVG Lithography (SVGL)

SVG Lithography's shipments of its Micrascan 90 product totaled 8 units in 1991. Shipments in 1991 included two units to Europe and two units to Japan, one of which was the highly publicized shipment to Toshiba in early 1991. In 1991, IBM continued to be SVGL's major customer for the Micrascan. With the exception of the Toshiba shipment, Dataquest believes that all other units were sent to IBM facilities including Corbeil-Essonnes, France, and Yasu, Japan. Much of SVGL's activities in 1991 were taken up with development of its new advanced Micrascan tool, which will be introduced at SEMICON/West in June 1992. The product acceptance of the new advanced Micrascan system by device manufacturers other than IBM is absolutely key to SVGL's long-term competitive position in the marketplace.

Dataquest Conclusions

The worldwide stepper market was 679 units in 1991, down almost 30 percent from the peak year of 1989 when 954 units were shipped to the world's semiconductor manufacturers. The revenue decline (down 13 percent) was not nearly as precipitous because of the ever-escalating average selling price (ASP) of advanced stepper systems. Factors driving increasing stepper prices include new sources, new wide-field lens capability, and new alignment systems. Stepper ASP grew at a staggering compound annual growth rate (CAGR) of 16.8 percent between 1985 and 1990, and Dataquest anticipates that it will continue to increase at a rate of 12 to 13 percent CAGR between 1990 and 1995. Technology has always been king in lithography, but the 1990s will see cost of ownership emerge as technology's consort sharing the throne as an equal partner in future lithography buying decisions.

Track Triumvirate Prevails: 1991 Automatic Photoresist Processing Equipment Market in Review

The worldwide market for automatic photoresist processing equipment (track) was $369 million in 1991, up 13 percent from its 1990 level of $326 million. This healthy growth rate is of significance in light of the fact that the track equipment market is closely tied to purchases of lithography equipment, whose market declined 5 percent last year. This section highlights some of the key trends behind the healthy growth in last year's market and discusses the activities of the top three players, who have continued their decade-long position of dominance in the worldwide track arena.

Dataquest attributes the healthy growth rate in the 1991 track market to several factors. First, we believe that the average selling price (ASP) associated with a given track system increased at an accelerated pace last year. From a market research perspective, reliable information on track unit shipments is difficult to gather—the definition of what constitutes a unit of track equipment varies from vendor to vendor because of the modular and custom nature of a given customer's requirement. However, it is clear that track manufacturers are including more and more advanced modules and subsystems on their leading-edge product offerings, including vertical hot plates, random-access robotics, environmentally controlled chambers, and improved chemical dispense nozzles with sophisticated fluid volume controllers. In addition, continued emphasis is being placed on achieving tighter particle control throughout the entire track system. All of these elements are essential in order to achieve the same physical, chemical, and temporal environment for every wafer being processed. These factors all directly contribute to a higher ASP for track equipment.

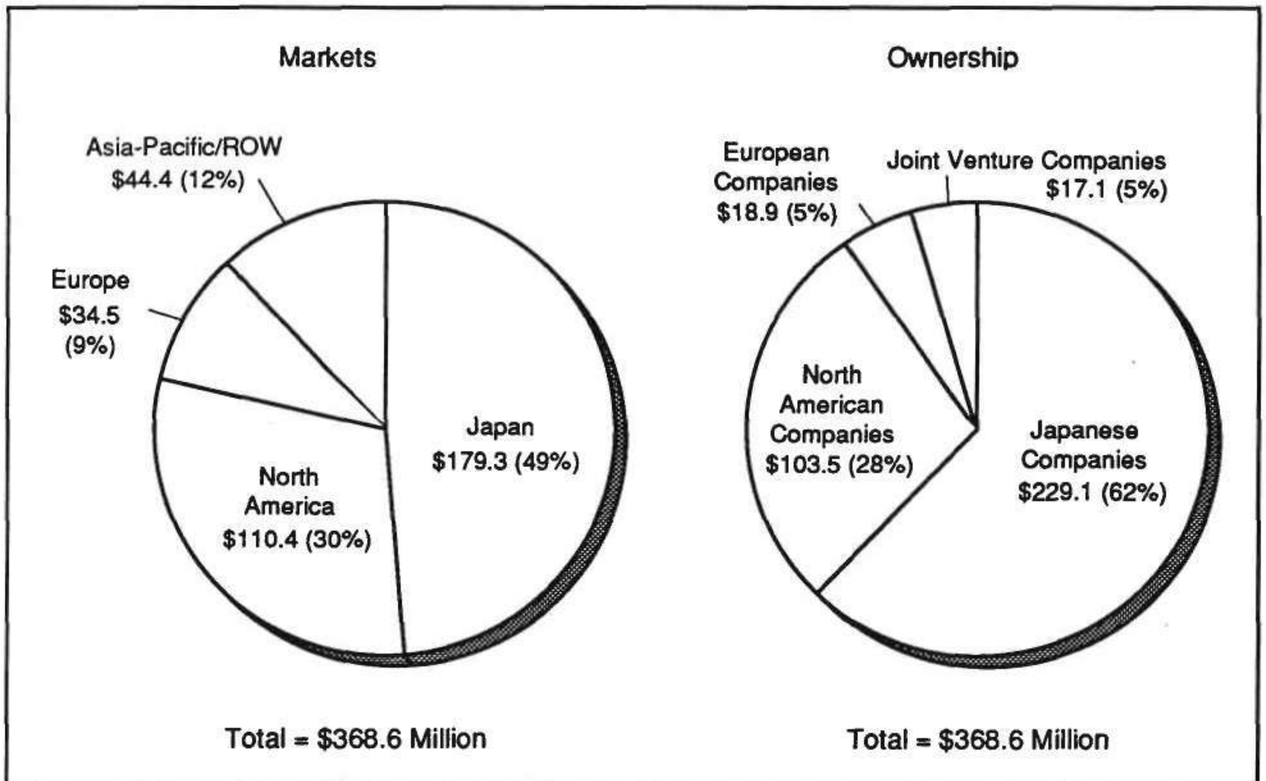
In addition, Dataquest believes that a significant level of replacement systems was purchased for volume production lines and advanced R&D facilities last year. This is because the newer advanced track tools available in just the last few years have undergone substantial improvements relative to many tools currently in the installed base. These older tools at volume production lines and R&D facilities are not particularly well-suited for the advanced processing requirements of devices such as 16Mb DRAMs. Not only do the newer track systems provide improved process performance but random-access systems can typically save from 25 to 30 percent on floor space. This reduction in footprint directly impacts cost of ownership and has contributed to an acceleration in the replacement activity in track.

Finally, the sluggish DRAM market has led many manufacturers to shift their product strategy from DRAMs to ASICs and other advanced logic products. As a result, we speculate that the market opportunity for standalone track systems last year expanded at a faster pace than might have otherwise been expected if DRAM activity had not been so slow. Standalone track systems provide an additional level of process flexibility that is well-suited for ASIC manufacturing. That flexibility typically is not required for high-volume DRAM manufacturing where the track system is directly interfaced to the lithography tool.

Regional Markets and Ownership

Figure 4-2 presents the worldwide 1991 track market segmented by region and ownership. As with other major categories of front-end processing equipment market, Japan represented the largest regional market for track equipment, accounting for 49 percent of world demand in 1991. Japanese companies continued to hold a particularly strong position in the track market with 62 percent share last year. This dominant share position in the world market in large part is attributed to the fact that the Japanese track companies have "owned" their home market of Japan, accounting for more than 98 percent share of the market every year since 1985. In 1991, only one non-Japanese track vendor had sales in Japan and that was Machine Technology (MTI). Dataquest believes that MTI's business activity in this region was directly related to the shipment of two SVG Lithography Micrascan step-and-scan tools to customers in Japan. (To date MTI has been the primary supplier of track systems interfaced to Micrascan tools worldwide.) In addition to dominating the largest regional market for track equipment, Japanese companies have also been focused on expanding export activities over the last several years, either by going direct, through representatives and distributors, or through joint-venture activity.

Figure 4-2
1991 Regional Automatic Photoresist Processing Equipment Markets and Ownership



Source: Dataquest (July 1992)

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Company Rankings

Table 4-2 presents the worldwide company rankings for the track equipment market in 1991. In order to better illustrate the influence and market positioning of companies providing the same track product offerings, we have combined the revenue of Tokyo Electron Ltd. (TEL) with its joint venture partner, Varian/TEL. This joint venture, established in 1989, is specifically focused on providing track, diffusion, and etch products from TEL in Japan to semiconductor manufacturers in the United States and Europe. The Varian/TEL joint venture is supported by the sales, marketing, and service organization of Varian.

Please note that Dataquest's estimates of the track equipment market include only those systems used in semiconductor device fabrication. Many of these same track companies supply systems that are used in other applications, such as compact disk coating and flat panel display manufacturing. We have excluded any such revenue associated with these nonsemiconductor manufacturing activities.

TEL and Varian/TEL

TEL and Varian/TEL claimed the No. 1 ranking in the track equipment market in 1991 with $143 million in revenue and 39 percent share of the world market. The combined activities of TEL and Varian/TEL have maintained this ranking since 1987. TEL was the first company to introduce a random-access track system, the Mark II, back in 1987. The company has continued to capitalize on that

Table 4-2
1991 Automatic Photoresist Processing Equipment Company Ranking (Revenue in Millions of Dollars)

Company	Revenue	Share (%)
TEL and Varian/TEL	143.3	38.9
Dainippon Screen	69.5	18.9
Silicon Valley Group	48.9	13.3
Machine Technology	26.6	7.2
Convac	18.9	5.1
Tazmo	15.2	4.1
Semiconductor Systems Inc.	14.0	3.8
Canon	12.3	3.3
Yuasa	5.9	1.6
Solitec	4.9	1.3
FSI International	4.8	1.3
Eaton	4.3	1.2
Worldwide Market Total	368.6	100.0

Note: No revenue associated with spares and service is included.
Source: Dataquest (July 1992)

early lead in advanced track systems. Its leading-edge product offering today is the Mark V.

The TEL and Varian/TEL operations have established a significant presence in all regions of the world. Dataquest estimates that TEL's 1991 share of the Japanese market was 55 percent and that the company accounted for 64 percent of the Asia/Pacific market last year. Varian/TEL, which has only been shipping track systems since 1989, garnered 23 percent share of the European market in 1991. Varian/TEL's share of the North American market last year was only 8 percent, but this relatively small position in the United States is not unreasonable considering that there exist a number of North American suppliers with well-entrenched positions in their home market.

Dainippon Screen (DNS)

Dainippon Screen ranked second in the 1991 track equipment market with sales of $70 million and 19 percent share of the world market. The company has continued to emphasize its export activities, and in 1991 track revenue from customers outside of Japan accounted for about one-fourth of total sales. DNS was delayed in introducing a random-access track system and as a consequence suffered a loss in worldwide market share in 1990. However, in 1991, the company regained a percentage point of share as sales of its random-access D-SPIN 60A system became a larger portion of the company's total product mix. In addition, Dataquest believes that DNS' gain in market share was in part attributed to the company's new developer solution nozzle (dubbed "soft impact nozzle") that can reduce dispense volumes of developer chemicals from 100cc to 35cc for 200mm wafer processing. The new nozzle also provides improved process uniformity.

Silicon Valley Group (SVG)

SVG ranked third in the 1991 track market with $49 million in sales. The company has suffered a decline in market share over the years because it has been unsuccessful in breaking into the world's largest regional market, Japan, and has had to face increasing levels of competition from Japanese competitors in the other parts of the world, including its home market of the United States. In 1987, SVG accounted for 20 percent of the worldwide track market. Five years later (1991), this market share position had eroded to 13 percent.

SVG still holds its No. 1 ranking in North America and garnered 34 percent share in its home market last year. An important component of SVG's 1991 North American revenue came from shipments to Motorola's MOS-11 facility. SVG's major advanced product offering is its 90 Series, a random-access track system introduced at SEMICON/West in May 1990. Dataquest estimates that the 90 Series product line accounted for about half of SVG's total track revenue in 1991.

Dataquest Conclusions

The top three players in the track market—TEL (including Varian/TEL), Dainippon Screen, and Silicon Valley Group—have dominated the track market throughout the 1980s. In 1982, they accounted for a combined share of 52 percent, which by last year had increased to a combined share of 72 percent. Ten other companies split the remaining 18 percent of the 1991 market. Clearly, the combination of advanced technology and random-access product offerings coupled with sufficient critical mass to support a global customer base have been key to the success of these larger players.

The midsize track players such as Machine Technology and Convac have advanced product offerings but will need to expand their global presence if they ever hope to gain membership to the upper echelons of the track market. The smaller track companies face a significant challenge in developing their long-term strategy for success in this marketplace. Some companies, such as FSI International with its TI-designed Polaris system, are aggressively marketing an advanced product offering designed to go head-to-head with the big guys. Other smaller players, however, may well be relegated to pursue noncompetitive niche applications or remain content with a single-region marketing focus for their business activities. The three major players in this marketplace show no sign of abdicating their positions of leadership anytime soon.

Chapter 5
Etch and Clean Market Trends

The material in this section focuses on etch and clean market trends.

Wet Processing Sales Stall in 1991: 1991 Wet Process Equipment Market in Review

The total wet processing equipment market tracked with wafer fab equipment demand, which was basically flat in 1991, although there were individual segments of wet process equipment that bucked the trend.

Jockeying for Position in a Tight Race for Market Leadership: 1991 Dry Etch Equipment Market in Review

The worldwide dry etch market grew a modest 2 percent in 1991 to reach a size of $705 million. The dry etch competitive arena appears to be a wide-open race for market leadership as the key contenders narrow the difference between their market share positions.

Wet Processing Sales Stall in 1991: 1991 Wet Process Equipment Market in Review

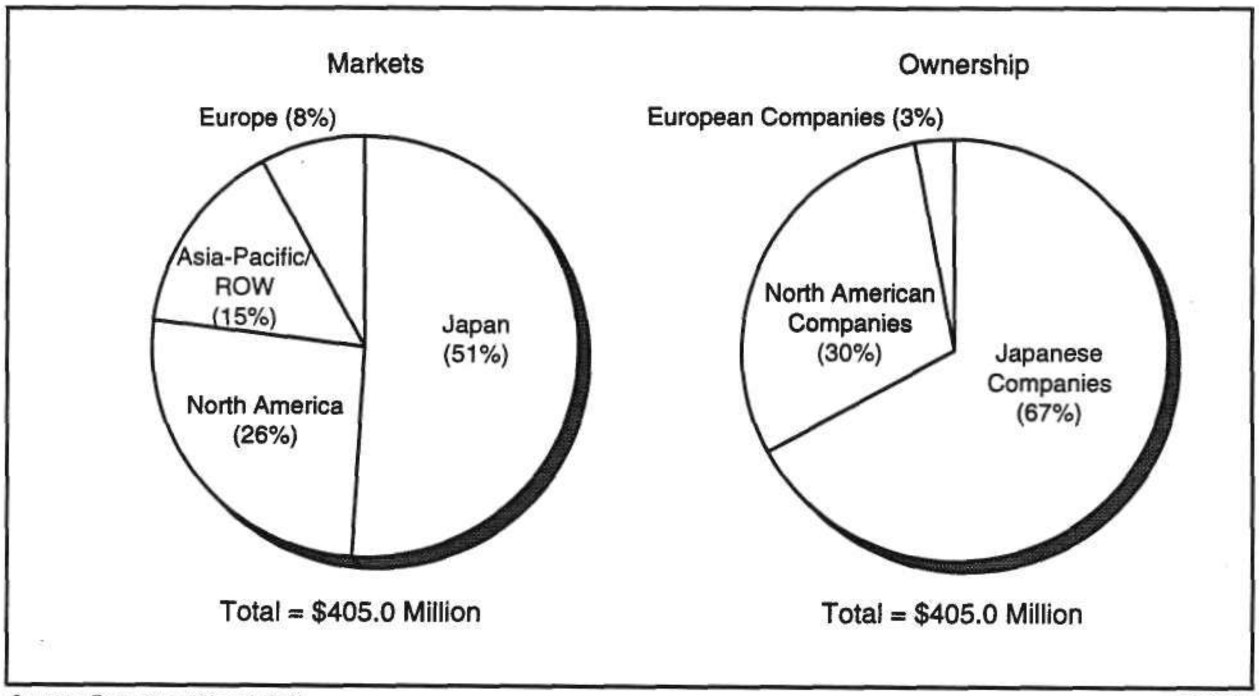
The worldwide wet process equipment market was $405 million in 1991, essentially flat with respect to its level the prior year. This section presents the significant highlights of the 1991 wet process equipment market with a focus on new technology trends and company activities.

Regional Markets and Ownership

Figure 5-1 shows the worldwide 1991 wet process equipment market segmented by region and ownership. Japan, with 51 percent ($205 million), continued to represent the largest wet process equipment market, though spending in Japan for wet process equipment last year declined sharply by 17 percent from its 1990 level of $246 million. The Japan wet process equipment market was active in the first half of 1991 because of a large backlog of orders from the prior year coupled with long lead times, on the order of six to eight months. However, a drastic reduction in shipments of wet process systems in the second half of the year led to the precipitous decline in wet process equipment sales in Japan for the year as a whole.

The North American market for wet process grew a record 41 percent from $75 million in 1990 to almost $106 million in 1991. The

Figure 5-1
1991 Wet Process Equipment Regional Markets and Ownership



Source: Dataquest (July 1992)

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tremendous growth in North American sales is largely attributable to increased spending on integrated wet systems. U.S. device makers are beginning to aggressively adopt the more expensive automated wet systems though automated systems still lag the degree of penetration achieved in Japan.

Company Rankings

Table 5-1 presents the worldwide company rankings for the wet process equipment market. Company revenue for wet process equipment is further segmented into the categories of integrated wet systems, manual wet benches, rinser/dryers, acid processors, and megasonic cleaners.

1991 Market Highlights

Carrierless Wet Stations

One significant trend in the wet processing equipment arena has been development of carrierless wet stations. A carrierless system removes the wafers from the cassette prior to processing. In 1991, 200mm carrierless wet stations for 16Mb DRAM applications were introduced by many equipment manufacturers: Dainippon Screen, Dan Science, Fuji Electric, Kuwano, Shimada, SubMicron Systems, and Sugai. One feature offered by all the carrierless systems is the elimination of chemical carryover and wafer contamination associated with the carrier. This makes these wet stations the most advanced cleaning systems available to satisfy the strict specifications that must be achieved in 16Mb DRAM processing.

The 200mm carrierless system has the same footprint as the corresponding 150mm wet station system with carriers, and thus achieves a very compact size even while processing the larger-diameter wafers. Another advantage of the carrierless systems is a significant reduction of chemical consumption. Table 5-2 summarizes several of the key features of 200mm carrierless wet stations compared with conventional 200mm systems. The price of carrierless wet stations in Japan ranges from ¥100 million to ¥200 million ($770,000 to $1.5 million). In addition to the companies identified, Sankyo Engineering is developing a carrierless system.

Tokyo Electron Enters the Wet Process Market

Historically, Tokyo Electron's (TEL) activity in the wet process market has been confined to the marketing of Semitool's acid processors and Sugai's wet stations. Strong growth in the wet processing equipment market (24.8 percent CAGR between 1987 and 1991), however, encouraged TEL to terminate its marketing agreement with Sugai and to build its own manufacturing facility. Wet processing equipment product offerings further establish TEL as one of the few players in the industry to provide one-stop shopping with a broad and diverse product mix of wafer fabrication equipment.

In addition to its desire to explore new market opportunities, there are several other key reasons for TEL entering the wet process equipment. Dataquest believes that TEL may have sensed

Table 5-1
1991 Worldwide Wet Process Equipment Company Ranking (Millions of Dollars)

Companies	Revenue	Share (%)	Integrated Wet Stations	Manual Wet Benches	Rinsers/ Dryers	Acid Processors	Mega-sonic Cleaners
Dainippon Screen	66.5	16.4	40.9	0	0	11.5	14.1
Kaijo	33.1	8.2	29.9	0	0.9	0	2.3
Sankyo Engineering	32.7	8.1	27.4	2.6	2.7	0	0
Sugai	32.6	8.0	31.4	1.2	0	0	0
FSI International	21.8	5.4	0	0	3.7	16.8	1.3
Santa Clara Plastics	20.2	5.0	19.5	0.7	0	0	0
Dan Science	19.8	4.9	14.9	4.4	0.5	0	0
Shimada	18.6	4.6	13.4	0	0	0	5.2
Maruwa	15.0	3.7	8.1	6.9	0	0	0
Verteq	14.9	3.7	1.7	0	6.0	0	7.2
Semitool	12.1	3.0	0	0	9.4	2.7	0
Submicron Systems Inc.	12.0	3.0	12.0	0	0	0	0
Enya	11.6	2.9	10.7	0.9	0	0	0
ETE	10.9	2.7	10.4	0.5	0	0	0
Universal Plastics	9.1	2.2	5.5	3.6	0	0	0
S&K Products	8.2	2.0	0	0	7.2	0	1.0
Pokorny	7.8	1.9	6.6	1.2	0	0	0
Toho Kasei	7.1	1.8	5.2	1.2	0.7	0	0
Kuwano Electric	7.1	1.8	7.1	0	0	0	0
Semifab	6.5	1.6	3.0	3.5	0	0	0
Tokyo Electron	5.6	1.4	5.6	0	0	0	0
Musashi	5.5	1.4	4.1	0.7	0	0.7	0
CFM Technology	5.3	1.3	5.3	0	0	0	0
SCI Manufacturing	4.8	1.2	4.8	0	0	0	0
Sapi Equipments	3.5	0.9	2.0	1.5	0	0	0
Advantage Production	3.4	0.8	0	0	0	3.4	0
Fuji Electric	2.1	0.5	2.1	0	0	0	0
Others	7.2	1.8	3.3	0.9	0.2	2.8	0
Total	405.0	100.0	274.9	29.8	31.3	37.9	31.1
Percentage of Total	100		68	7	8	9	8

Note: No revenue associated with spares and service included
Source: Dataquest (July 1992)

Table 5-2
Relative Comparison of Key Features for Conventional and Carrierless 200mm Wet Stations

	Conventional 200mm System	Carrierless 200mm System
Wafers per Batch	50	50
Footprint	1.00	0.70
Chemical Tank Capacity	1.00	0.53
QDR* Tank Capacity	1.00	0.68
Transportation Time between Baths	1.00	0.45

*QDR = Quick Dumper Rinse
Source: Dataquest (July 1992)

a technological limitation in Sugai's wet station capabilities for production of 16Mb and more advanced DRAMs. In addition, TEL has the second-largest share in the world vertical thermal reactor (VTR) market, and it is key that the company develop its own prediffusion clean system to be used in-line with its VTR products. The impact of TEL's decision to terminate its relationship with Sugai is already becoming apparent. With the loss of its major distributor, Sugai slipped from second place in the 1990 worldwide wet process equipment market to fourth position in 1991.

FSI Enters the Japanese Market

FSI International, a major supplier of wet processing equipment, recently entered the Japanese market through an alliance with Mitsui Corporation. The new entity formed from this alliance is named m·FSI. Under this arrangement, Mitsui's subsidiary, Chlorine Engineering, becomes one division of m·FSI and will continue to market ozone ashers for photoresist stripping applications. The joint venture also plans to manufacture and distribute FSI's surface conditioning products in Japan.

FSI is a leading manufacturer of hydrofluoric (HF) acid vapor phase cleaning systems. These systems are particularly effective in preventing organic as well as inorganic contaminants and particles from depositing on an activated silicon surface. The main application for vapor phase cleaning is the removal of native oxide. FSI's entry to the Japanese market, the major DRAM production base, is a key strategic move for the company because the removal of native oxide becomes critical as the oxide film becomes thinner in advanced DRAM fabrication. Dataquest believes that future vapor phase systems will be clustered with CVD equipment. However, current equipment is designed to carry out the rinsing/drying process under an atmosphere of nitrogen gas.

Megasonic Cleaner Market Experiences High Growth

As design rules enter into a submicron level, the allowance for the depth of focus has reduced, thus increasing the need for removing particles on both sides of silicon wafers by mechanical means. This has driven the megasonic cleaner market, especially scrubber systems, to grow at an accelerated pace the last five years from a $4 million level in 1987 to $31 million in 1991, reflecting compound annual growth exceeding 60 percent.

Facilities Expansions

Rapid growth of the wet process equipment market coupled with increasing system complexity has caused the production capability of wet process equipment suppliers to fall short of demand. Dataquest believes that many suppliers had to give up orders during 1989 and 1990 because of capacity shortages in their own facilities. As shown in Table 5-3, several manufacturers have rushed to build new facilities in order to attain sufficient capacity to meet the demands of semiconductor manufacturers.

Dataquest Conclusions

Although today's current carrierless wet processing systems are suited for the 0.5-micron process for 16Mb DRAM production, 64Mb DRAM production with line geometries of 0.3 microns will require the control of 0.03-micron particles. The control and cleaning of 0.3-micron particles is further complicated by the fact that the number of particles increases by geometrical progression inversely proportional to the particle size. Furthermore, the smaller the particle size, the stronger the particle's adherence to the wafer surface, thus making it more difficult to remove. Contact holes of 0.3-micron size have a high aspect ratio and thus will also require a more sophisticated cleaning process. As gate oxide and capacitor dielectric films become thinner (below 10nm), native oxide films will need to be removed completely. Because a limited number of existing wet process manufacturers provide such advanced cleaning technologies, Dataquest expects the wet processing equipment industry to rapidly migrate toward clearer product differentiation.

Table 5-3
New Planned Manufacturing Facilities for Wet Process Equipment Suppliers

Companies	New Plant Location	Completion Date	Land (sq. m)	Floor Space (sq. m)
Dainippon Screen	Shiga	Q4/92	26,200	19,900
Dan Science	Tokyo	Q3/92	3,518	4,196
Sankyo Engineering	Oita	Q2/91	8,440	2,877
Shimada	Shizuoka	Q3/92	7,410	NA
Tokyo Electron	Saga	Q3/92	104,482	13,100

NA = Not available
Source: Dataquest (July 1992)

Jockeying for Position in a Tight Race for Market Leadership: 1991 Dry Etch Equipment Market in Review

The worldwide 1991 dry etch equipment market grew a modest 2 percent to reach a size of $705 million. The growth in the dry etch market was roughly on par with the 1991 growth in the overall wafer fab equipment market. This section highlights the key trends in the 1991 dry etch equipment market.

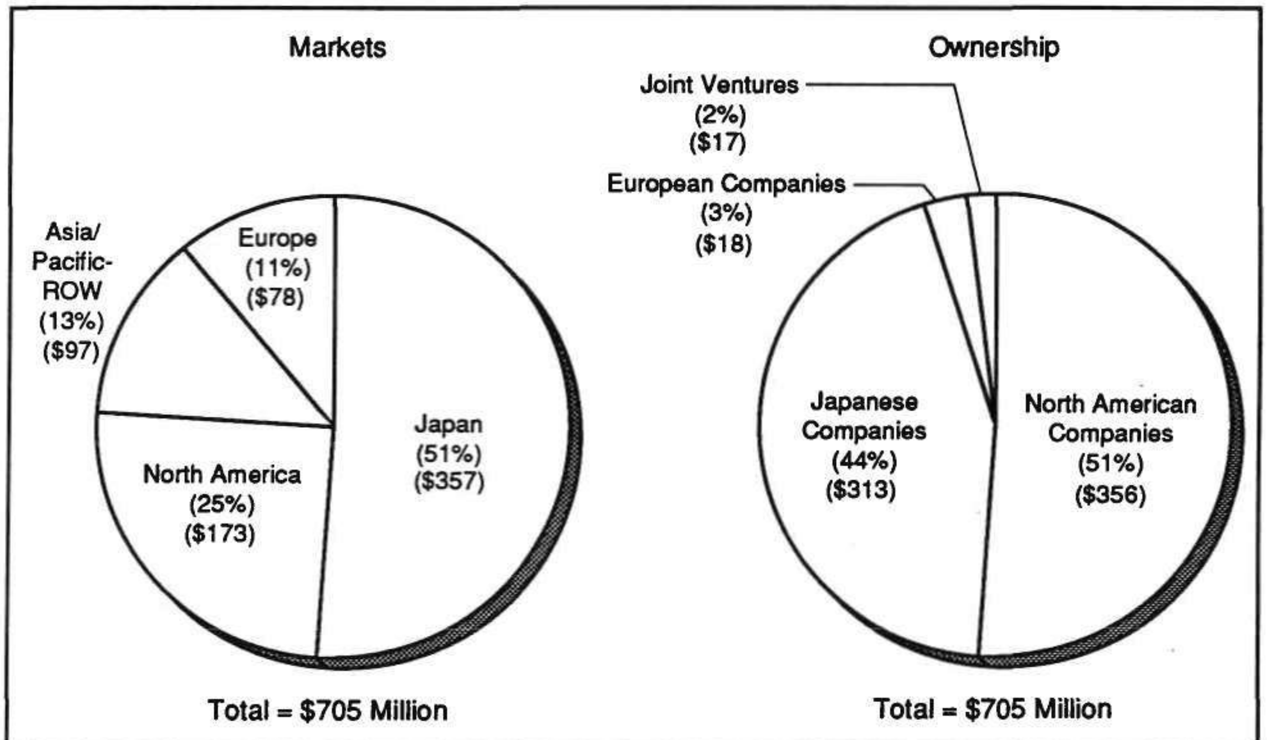
Regional Markets and Ownership

Figure 5-2 shows the worldwide 1991 dry etch market segmented by region and ownership. Japan, with 51 percent ($357 million), continued to represent the single largest dry etch equipment market. North American companies, with 51 percent share ($356 million), continued to cling on to a leadership position in the global dry etch business.

Company Rankings

Table 5-4 highlights the dry etch company rankings based on the worldwide 1991 market. The table also identifies the various dry etch market segment activities for each company.

Figure 5-2
1991 Dry Etch Regional Markets and Ownership



Source: Dataquest (July 1992)

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Table 5-4
1991 Worldwide Dry Etch Equipment Company Ranking (Revenue in Millions of Dollars)

Company	Revenue	Market Share (%)	Market Segment
Applied Materials	154.0	21.9	RIE, MERIE
LAM Research	127.1	18.0	RF plasma, RIE
TEL & Varian/TEL	120.9	17.2	RF plasma, RIE, MERIE
Hitachi	115.2	16.3	Microwave/ECR, RIE
Tegal	29.0	4.1	RF plasma, RIE, triode
Drytek	25.0	3.5	RIE, triode
Anelva	22.3	3.2	Microwave/ECR, RIE
Sumitomo Metals	15.4	2.2	Microwave/ECR
Tokyo Ohka Kogyo	15.3	2.2	Microwave/ECR, RF plasma
Shibaura Engineering Works	14.1	2.0	RIE
Plasma-Therm	13.8	2.0	RF plasma, RIE
E.T. Electrotech	12.0	1.7	RIE, triode
MRC (Sony)	9.6	1.4	MERIE
Oxford Plasma Technology	6.3	0.9	Microwave/ECR
Ulvac	6.2	0.9	RIE
Alcan Technology (Canon)	5.6	0.8	RF plasma, RIE
Gasonics	5.0	0.7	RF plasma
Others	7.9	1.0	
Worldwide Market Total	704.7	100.0	

Note: Spares and service are not included.
Source: Dataquest (July 1992)

Applied Materials

Applied Materials, with 21.9 percent ($154 million) of the market, managed to retain its leadership position. The company, however, lost market share on a worldwide basis by almost 4 percentage points between 1990 and 1991. Applied's late transition to single-wafer dry etch technology, together with the inability of the P5000 magnetically enhanced RIE technology to crack the all important single-wafer oxide etch market, were significant factors in the erosion of Applied's dry etch market share. Vigorous global competition from Hitachi, Lam Research, and Tokyo Electron Limited (TEL) further weakened Applied's dry etch market position.

On the positive side, Applied has recently begun to focus on executing on its strengths in the single-wafer P5000 metal etch, polycide etch, and silicon trench etch market. Applied's cash-cow 8000 Series hexode batch systems continue to be a market share and profit leader in 4-inch through 6-inch metal and dielectric etch applications. Continuous improvements to the hexode etch technology such as improved automation, molecular backside helium cooling, and enhanced process chemistry extended the range of applicability for the hexode system. Dataquest believes that Applied has new advanced plasma etch source technologies under development that will transition the company to single-wafer dry etch solutions for the crucial dielectric etch market.

The benefits of continuous improvement in the P5000 mainframe performance and reliability that evolved into the Mark-II version also have had a positive effect on Applied's recent dry etch market performance. The success of the P5000 CVD and dry etch family illustrates the economies of scale in performance improvement and cost reduction that can be gained by delinking process chamber development from mainframe development. Applied, which recently began signaling its intentions to migrate to a new mainframe for dry etch and CVD applications, will continue to adopt the same successful unified mainframe strategy for future thin film applications.

Lam Research

Lam Research, with 18 percent ($127 million) of the market, represented the most dramatic market success story of 1991. Lam picked up almost 5 percentage points of market share from 1990 to 1991. Lam's Rainbow platform continued to pick up multiple, large-volume orders at leading global device fabs. The strengths of the Rainbow system in the dielectric and polycide etch market, together with the system's proven reliability and simple architecture, enabled it to pick up incremental market share. Lam's growing participation in the Japanese market through Sumitomo Metals and its traditional strengths in the Asia/Pacific market allowed the company to outperform the overall 1991 dry etch market.

On the cautionary side, Lam will encounter increased competition from new advanced-source dry etch systems. Lam's future success depends upon successful execution in the Rainbow migration path for sub-0.5 micron applications together with the development of the new Alliance cluster tool platform and inductively coupled plasma source technology based on the IBM license. Lam has also positively benefited from the incredible Samsung-driven Asia/Pacific expansion in 1991. However, future Asia/Pacific business growth will depend upon the success of the Korean majors in the 4Mb/16Mb DRAM business. Lam needs to rapidly build up its applications and joint-development customer capabilities in Japan in order to gather firsthand information on the all-important Japanese dry etch market. Lam will need to weave a synergistic strategy that uses Sumitomo Metals' network in Japan while allowing Lam direct access to development efforts in Japan.

TEL and Varian/TEL

The TEL and Varian/TEL dry etch products accounted for 17.2 percent ($121 million) of the 1991 market. TEL continues to excel in delivering incrementally improved, cost-effective dry etch solutions that address the dielectric and polycide market segments. TEL is also successfully developing a market for its advanced magnetron etcher for sub-0.5 micron applications. TEL's extensive customer support network capability in Japan and Asia/Pacific, together with its U.S./European market presence through Varian/TEL, positions the company well in retaining its lead in the dry etch market. However, we caution that TEL's large dependence on the domestic Japanese market could be a negative factor given the current recessionary woes and capital spending freeze in Japan.

Hitachi

Hitachi, with 16.3 percent ($115 million) gained significant market share in 1991. Hitachi continued to excel in the metal etch market using its landmark microwave/ECR technology. The company's unique approach combining single-wafer dry etch, dry strip, and wet clean into the same platform has proven to be very successful in the Japanese metal etch and polysilicon gate etch market. Hitachi has effectively filled the void left in the market by the absence of a cost-effective single-wafer metal etch process. Dataquest believes that Hitachi will continue to expand its product portfolio to address the important dielectric etch market segment. Hitachi also appears to be focused on globalizing its capital equipment business in order to stay close to its increasingly globalized customers.

Dataquest Conclusions

The worldwide dry etch equipment market showed modest growth in 1991 to reach $705 million in size. The dry etch competitive arena appears to be a wide-open race for market leadership as the key contenders narrow the difference between their market share positions. A plethora of plasma source technologies are being pursued in the quest for sub-0.5 micron dry etch dominance. Focused, new source companies such as Plasma Materials Technology could reshape the dry etch technology landscape by offering value-added building block solutions. Future dry etch equipment companies may become value-added process integrators that provide enabling, global solutions to their semiconductor customers.

Technical Innovation Continues to Drive Market Growth: 1991 CVD Equipment Market in Review

The worldwide CVD equipment market grew 4 percent in 1991 and represented a $747 million market. This article presents the significant highlights of the 1991 CVD equipment market.

Regional CVD Equipment Market and Ownership

Figure 6-1 shows the worldwide 1991 CVD equipment market segmented by region and ownership. Japan, with 50 percent of the worldwide CVD market, continued its role as the largest regional market. However, North American companies continued their dominance of the 1991 CVD market, capturing 56 percent of the worldwide $747 million total.

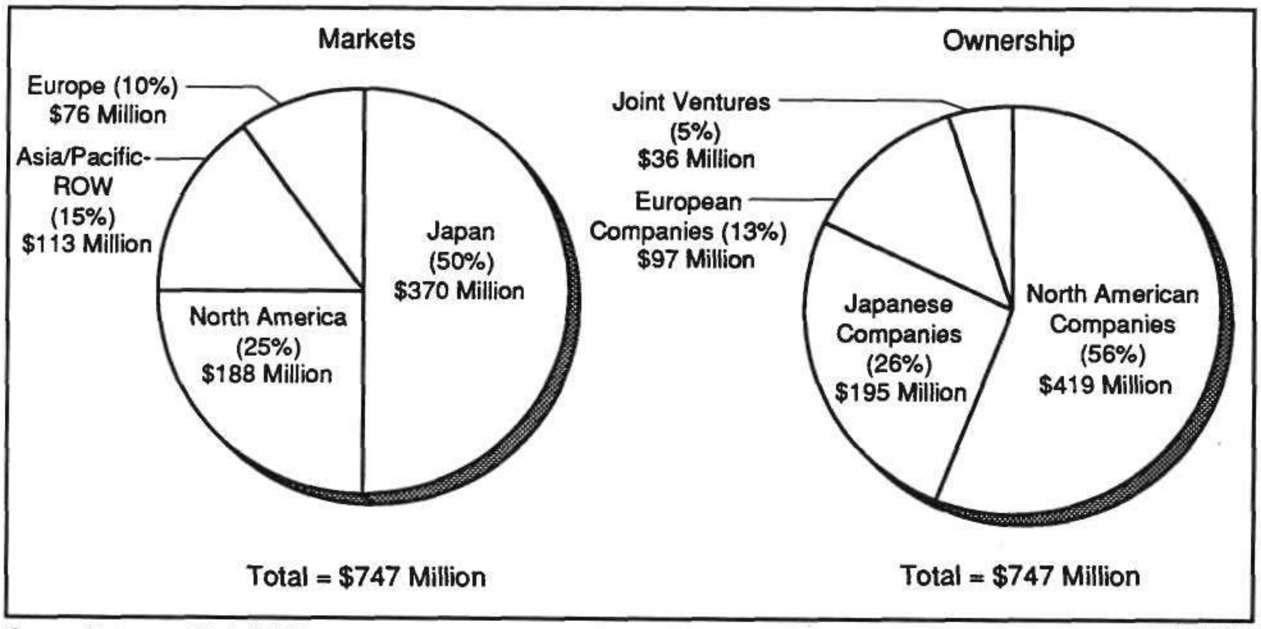
CVD Equipment Company Rankings

Table 6-1 lists the worldwide 1991 CVD equipment company market ranking, together with the market segment activities.

Applied Materials

Applied Materials, with 29.2 percent of the 1991 market, retained its position as the market leader. Applied's dielectric PECVD reactor business continued its strong thrust into intermetal dielectric and passivation applications. Applied has focused on designing its low-temperature TEOS-based oxide process into multiple applications within multilevel interconnect processes at leading device company fabs. The move toward double-level interconnect 16Mb DRAM

Figure 6-1
1991 CVD Regional Markets and Ownership



Source: Dataquest (July 1992)

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Table 6-1
1991 Worldwide CVD Equipment Company Ranking (Revenue in Millions of Dollars)

Company	Revenue	CVD Market % Share	Horizontal LPCVD Tube	Vertical LPCVD Tube	Horizontal PECVD	Reactor APCVD	Reactor LPCVD	Reactor PECVD	Reactor ECR CVD
Applied Materials	218.4	29.2	0	0	0	0	32	186.4	0
ASM International	70.5	9.4	7.9	22.6	40	0	0	0	0
Novellus Systems Inc.	69.7	9.3	0	0	0	0	5.7	64	0
Kokusai Electric	63.6	8.5	1.6	62	0	0	0	0	0
Tokyo Electron Ltd.	62.8	8.4	7.1	53	0	0	2.7	0	0
Watkins Johnson	48.5	6.5	0	0	0	48.5	0	0	0
Genus	34.8	4.7	0	0	0	0	34.8	0	0
Alcan Technology (Canon)	26.8	3.6	0	0	0	26.8	0	0	0
Silicon Valley Group	25.8	3.5	9.3	16.5	0	0	0	0	0
B.T. Electrotech	20	2.7	0	0	0	0	0	20	0
Ulvac	18.3	2.4	5.3	5	0	0	8	0	0
Amaya	12.3	1.6	0	0	0	12.3	0	0	0
BTU International	10.5	1.4	6	4.5	0	0	0	0	0
Varian/TEL	9.6	1.3	1.9	7.7	0	0	0	0	0
Others	55.8	7.5	4.8	20.3	1	4.3	6.7	11.4	7.3
Worldwide Market Total	747.4	100.0	43.9	191.6	41	91.9	89.9	281.8	7.3

Note: Spares and service are not included.
Source: Dataquest (July 1992)

has allowed Applied to address a progressively larger total available market. Applied's metal CVD business, which addresses the tungsten and tungsten silicide interconnect market, also showed healthy growth in 1991.

Dataquest believes that Applied's CVD marketing strategy is currently focused on lowering cost of ownership across the board in its huge installed base of P5000 CVD systems. The combination of Applied's traditional strengths in process development, together with its stronger focus on user economics issues, positions the company well for growth in the CVD market.

ASM International

ASM International, with $70.5 million in 1991 CVD revenue, captured 9.4 percent of the market. Although ASM International's traditional horizontal PECVD tube business has shown signs of decline in the last two years, the company is attempting to reposition itself as a leading supplier of vertical LPCVD tubes, vertical LPCVD tube-based cluster tools, and PECVD single-wafer reactors. ASM International has been particularly successful in Japan with its 6- and 8-inch horizontal PECVD tube and its new vertical LPCVD tube for poly and thermal nitride applications.

ASM International faces its biggest challenges in the next few years as it attempts to crack the high-growth reactor CVD market and the vertical LPCVD tube market against entrenched rivals that forged into the market earlier. The company is betting that its small-batch and large-batch vertical tube loadlocked cluster tools will find market acceptance in emerging integrated applications such as integrated gate-stack formation and preclean/oxidation/diffusion applications.

Novellus

Novellus, with $69.7 million in 1991 CVD systems revenue, captured 9.3 percent of the market. Novellus continues to penetrate the low-temperature silane-based and TEOS-based oxide market using its elegant Concept-One system architecture. Novellus' marketing strategy, which emphasizes low cost of ownership coupled with advanced film qualities, has been very successful in winning large-volume, multiple orders from several global device manufacturers. Novellus was also very effective in continuing its penetration of the crucial Japanese market.

Dataquest believes that Novellus has elected to pursue a long-term policy of direct participation in the Japanese market through the establishment of a comprehensive customer support, applications, and development facility in Japan. Novellus continued its efforts toward penetrating the metal CVD market with the Concept-One-W system. The success of Novellus in the metal CVD market will play a crucial determining role in the company's efforts toward penetrating the integrated interconnect applications market on the new CVD/PVD Concept-Two hybrid platform.

Dataquest also notes that dry etch technology is conspicuous by its absence in the Novellus product portfolio. We predict that Novellus will speedily acquire dry etch technology capability either through an acquisition, alliance, or internal development efforts. In the era of integrated thin films applications, the lines between deposition and etch technologies are rapidly blurring. Only companies that offer a complete, global, best-of-breed solution can sustain growth and profitability. Novellus has recently been putting a new management team in place that will transition it from a single-product, regionally focused company into a multiproduct, global capital equipment company.

Kokusai Electric and TEL

Kokusai Electric and Tokyo Electron Ltd. (TEL) continue their dominance of the vertical LPCVD tube business. Both companies have been extremely successful in delivering high-performance, production-worthy platforms for poly, thermal nitride, and undoped high-temperature oxide applications in 4Mb/16Mb DRAM applications. Both companies recently introduced loadlocked 8-inch vertical thermal reactors (VTRs) targeted at integrated thermal processes such as gate-stack formation, capacitor formation, and preclean/diffusion/oxidation.

Because of significant value-added automation, process-control, and defect-reduction features, both companies have been able to obtain premium market prices for their VTRs, which can range in price from $300,000 to $600,000 per tube. TEL is aggressively marketing its VTRs globally through the Varian/TEL joint venture in the United States and Europe, and by itself in Asia/Pacific. Kokusai Electric recently bought a majority stake in BTU International's Bruce Systems division and hopes to gain from BTU International's installed base, customer support/service, and process-control software expertise.

Watkins-Johnson

Watkins-Johnson, with 6.5 percent of the worldwide CVD market, continued its dominant position in the APCVD market. The company is attempting to diversify beyond its traditional silane-based BPSG premetal dielectric business. By offering TEOS/ozone low-temperature conformal dielectric solutions, the company hopes to parlay its core APCVD technology into the larger, potentially more lucrative intermetal dielectric market.

Dataquest believes that Watkins-Johnson will vigorously attempt to carry over its production worthiness, APCVD simplicity, and low cost of ownership advantages into the intermetal dielectric market.

Genus

Genus, with 4.7 percent of the 1991 CVD market, retained its position as the market leader in the LPCVD-based tungsten silicide market. However, Genus experienced significant competition from companies such as Applied Materials and Novellus in the blanket tungsten CVD segment.

Dataquest believes that Genus will continue to focus on developing advanced films such as high-temperature dichlorosilane silicide (DCS silicide) and CVD titanium nitride. Genus continues its strong links with key customers such as IBM in the blanket tungsten CVD market. Genus faces the challenge of fending off larger, better-capitalized competitors such as Applied and Novellus in the high-volume blanket tungsten and tungsten silicide market. The company must simultaneously channel its limited resources wisely toward the development of leapfrog films such as CVD titanium nitride, CVD copper, and DCS tungsten silicide.

Alcan Technology (Canon)

Alcan Technology (Canon), with almost $27 million in 1991 revenue, nearly doubled its CVD product revenue based on its pioneering TEOS/ozone APCVD technology. Its low temperature APCVD technology represents a significant challenge to the hitherto unchallenged PECVD technology dominance of the lucrative intermetal CVD film market.

Dataquest believes that other leading CVD companies will focus on development of TEOS/ozone APCVD intermetal dielectric solutions that will compete with Alcan in the CVD market.

Silicon Valley Group

Silicon Valley Group, with almost $26 million (3.5 percent) of the market, continues its focus on the vertical LPCVD tube business. The company won several significant 8-inch VTR orders in 1991. With BTU International's diminished position within the wafer fabrication equipment business, SVG remains as the last U.S. participant of significant size in the VTR business.

Dataquest believes that SVG is poised to continue its quest for market share gain in the LPCVD VTR market through development of the advanced vertical processor (AVP) family of clusterlike loadlocked tube products.

Dataquest Conclusions

The $747 million 1991 CVD equipment market represented one of the few growth spots in an otherwise lackluster wafer fabrication equipment market. Technology-driven market segments such as metal CVD, LPCVD VTR tubes, and TEOS/ozone APCVD continued to influence the growth of the CVD market. New CVD market players in areas such as APCVD and LPCVD VTR products may challenge the traditional dominance of the PECVD dielectric reactor companies. PECVD reactor companies, in turn, are scrambling to diversify their process applications into high-growth segments such as metal CVD, polysilicon LPCVD, and TEOS/ozone APCVD films. We expect the technology displacements to continue driving significant shifts in the quest for global CVD equipment market share.

Multilevel Metal Mania: 1991 Sputter Equipment Market in Review

The 1991 physical vapor deposition (PVD) market represented a bright spot in an otherwise lackluster wafer fab equipment market. The PVD market grew by 16 percent from $408 million in 1990 to $474 million in 1991. The sputtering equipment segment, which constitutes 93 percent of the 1991 PVD market, grew dramatically by 22 percent from $359 million in 1990 to $438 million in 1991.

Steep increases in sputtering equipment average selling prices (ASPs), together with enhanced unit demand for multilevel interconnect applications in advanced 4Mb DRAMs and microprocessor/ASIC devices, were responsible for robust growth in the 1991 sputtering equipment market. In contrast, the mature evaporation equipment market, which represents only 7 percent of the 1991 PVD market, actually declined 24 percent in 1991.

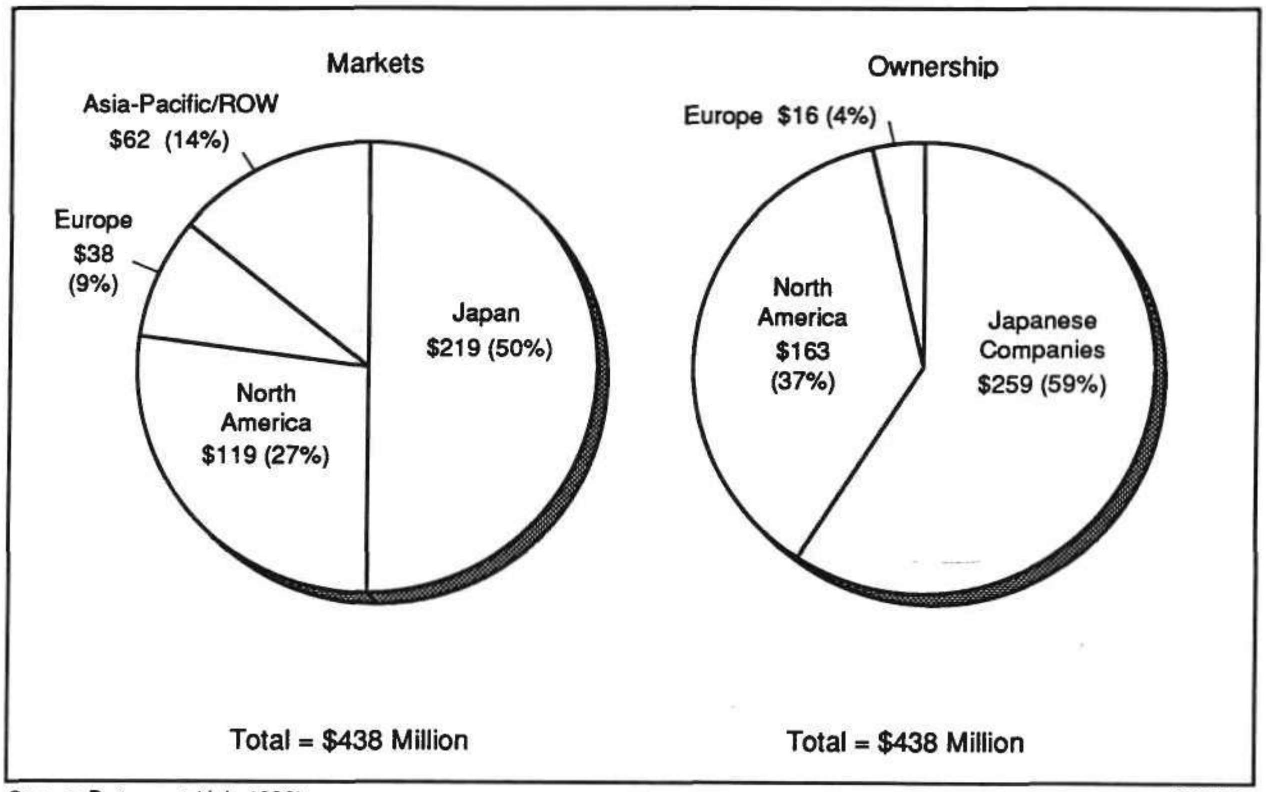
Regional Markets and Ownership

Figure 6-2 shows the worldwide 1991 sputtering equipment market segmented by region and ownership. Japan, with 50 percent ($219 million) of the 1991 sputtering market, represented the largest regional market. In 1991, semiconductor capital investment in Japan was focused on 150mm and 200mm advanced 4Mb DRAM shrink production and 16Mb DRAM pilot line production. Japan-based semiconductor manufacturers attempted to leapfrog competitive advances from lower-cost Korean DRAM producers such as Samsung by rapidly migrating to high-speed, premium DRAM products that were implemented in double-level metal. Japan-based fabs also focused on more flexibility and ASIC/microprocessor/memory multiproduct capability. The new focus on interconnect technology-driven products stimulated the expansion of the high-end flexible, cluster-tool sputtering equipment market in Japan.

The vigorous expansion of 4Mb DRAM and advanced logic fabs in Korea and Taiwan also stimulated the growth of the Asia/Pacific sputtering equipment market. Companies such as Samsung migrated to double-level metal versions of their shrink 4Mb DRAM production. In general, the migration from single- to double-level metal in the Japanese and Asia/Pacific markets stimulated the growth of the worldwide sputtering equipment market. Companies such as Digital Equipment Corporation, IBM, Intel, Motorola, and Texas Instruments migrated to triple-level metal for their advanced microprocessor and VLSI logic devices, thus sustaining the demand for advanced cluster-tool-based sputtering equipment in the North American market. The lack of major interconnect-intensive device production in Europe, coupled with overall anemic demand for wafer fab equipment, resulted in a generally weak European sputtering equipment market in 1991.

Japanese companies, with 59 percent ($259 million) of the worldwide market, retained their leadership position in the sputtering equipment market. North American companies, with 37 percent

Figure 6-2
1991 Regional Sputtering Equipment Markets and Ownership



Source: Dataquest (July 1992)

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($163 million) of the market, gained market share in 1991 at the expense of European equipment companies. Applied Materials, a newcomer to the market, augmented the North American company group performance because of its strong showing in the 1991 sputtering equipment market. The transfer of the Europe-based Balzers PVD business to the Japan-based MRC/Sony business favorably impacted the 1991 Japanese sputter company group performance.

Company Rankings

Table 6-2 ranks the 1991 worldwide sputtering equipment companies.

Anelva

Anelva, with 26.2 percent of the market, retained its leadership position. Anelva's strong position in the large Japanese market, together with its experience in isolated-chamber Ti/TiN/aluminum alloy sputtering applications on its popular Series 1051 cluster tool, has enabled the company to remain the top player in sputter systems. Dataquest believes, however, that Anelva will need to globalize its operations at an accelerated pace in order to overcome its excessive dependence on the Japanese market.

Table 6-2
1991 Worldwide Sputtering Equipment Company Ranking (Revenue in Millions of Dollars)

Company	Revenue	Market Share (%)
Anelva	114.5	26.2
Varian	90.9	20.8
MRC (Sony)	84.5	19.3
Applied Materials	55	12.6
Ulvac	54.5	12.5
E.T. Electrotech	12	2.7
CVC Products	7	1.6
Leybold-Heraeus	4.4	1.0
Shibaura Engineering Works	4	0.9
CPA	2	0.5
Novellus Systems, Inc.	1.8	0.4
Denton Vacuum	1.8	0.4
Sputtered Films	1.5	0.3
Others	3.8	0.9
Worldwide Market Total	437.7	100.0

Note: Spares and service are not included.
Source: Dataquest (July 1992)

Varian

Varian, with 20.8 percent, retained its No. 2 position in the market. Varian continued to aggressively penetrate the market with its advanced M2000 cluster-tool system for submicron device applications. Varian's strong presence in Asia/Pacific allowed it to capitalize on the 1991 boom in that region. The step-coverage enhancement provided by the Quantum source, together with Varian's pioneering efforts in collimation-based step-coverage enhancements, allowed the company to secure design wins at several major 4Mb DRAM production/16Mb DRAM pilot lines. Varian also continues to benefit from its cash-cow Series 3000 multichamber tool that cost-effectively addresses more mature device fab applications and capacity expansion programs.

Materials Research Corporation (MRC)/Sony

MRC/Sony, with 19.3 percent of the market, ranked third in the worldwide sputtering equipment market in 1991. MRC/Sony continued to proliferate applications for its successful Eclipse systems with enhancements such as improved throughputs, enhanced step-coverage, low-damage soft precleans, loadlock options, and particle-reduction kits. MRC/Sony's acquisition of the Balzers Clusterline sputtering family and its integration into the new Galaxy open-architecture cluster tool will allow MRC/Sony to address future needs of sub-0.5-micron devices. MRC/Sony's prior acquisition of the BCT/Spectrum metal CVD business also positions the company well in offering integrated PVD/CVD interconnect solutions on its Galaxy cluster tool.

Applied Materials

Applied Materials, a newcomer to the sputtering equipment market, demonstrated meteoric success in rapidly gaining 12.6 percent of the 1991 market. The company's flagship Endura cluster tool was very successful in capturing several key design wins at leading 200mm submicron device fabs. Dataquest attributes the phenomenal success of the Endura system to Applied's emphasis on exceptional reliability, low-particle performance, global customer support, process support, and migration path to integrated metal CVD/PVD solutions. Dataquest expects Applied to face intense competition in subsequent PVD market battles as competitive flexible cluster tools that offer staged, high-vacuum capability for 200mm submicron applications hit the market.

Ulvac

Ulvac accounted for 12.5 percent of the 1991 sputtering equipment market. Ulvac continued to market its flagship MLX-3000 cluster-tool sputtering system for isolated chamber sputtering applications. Ulvac is also bringing new cluster tools to market that address the integrated metal CVD/PVD/dry etch applications market. Ulvac will attempt to integrate its pioneering selective tungsten CVD and soft plasma preclean technologies with its sputtering film capabilities in order to offer a complete interconnect solution to its customers. Ulvac is also aggressively globalizing its operations in order to minimize its overdependence on key DRAM-driven Japanese customers such as Toshiba.

Dataquest Conclusions

The worldwide sputtering equipment market represented a bright spot in the 1991 wafer fab equipment market, posting aggressive growth of 22 percent. The market was driven by the accelerated conversion to double-level metal 4Mb DRAM shrink products and the continuing trend in microprocessor/VLSI logic devices toward triple- and quadruple-level metal. New entrants to the sputtering equipment market such as Novellus, together with the growing dominance of newly established players such as Applied Materials, may completely recast the balance of power in the sputtering equipment market. Incumbent market leaders such as Anelva, MRC/Sony, Ulvac, and Varian will fiercely defend their entrenched positions. A shakeout may be coming in the crowded sputtering equipment market.

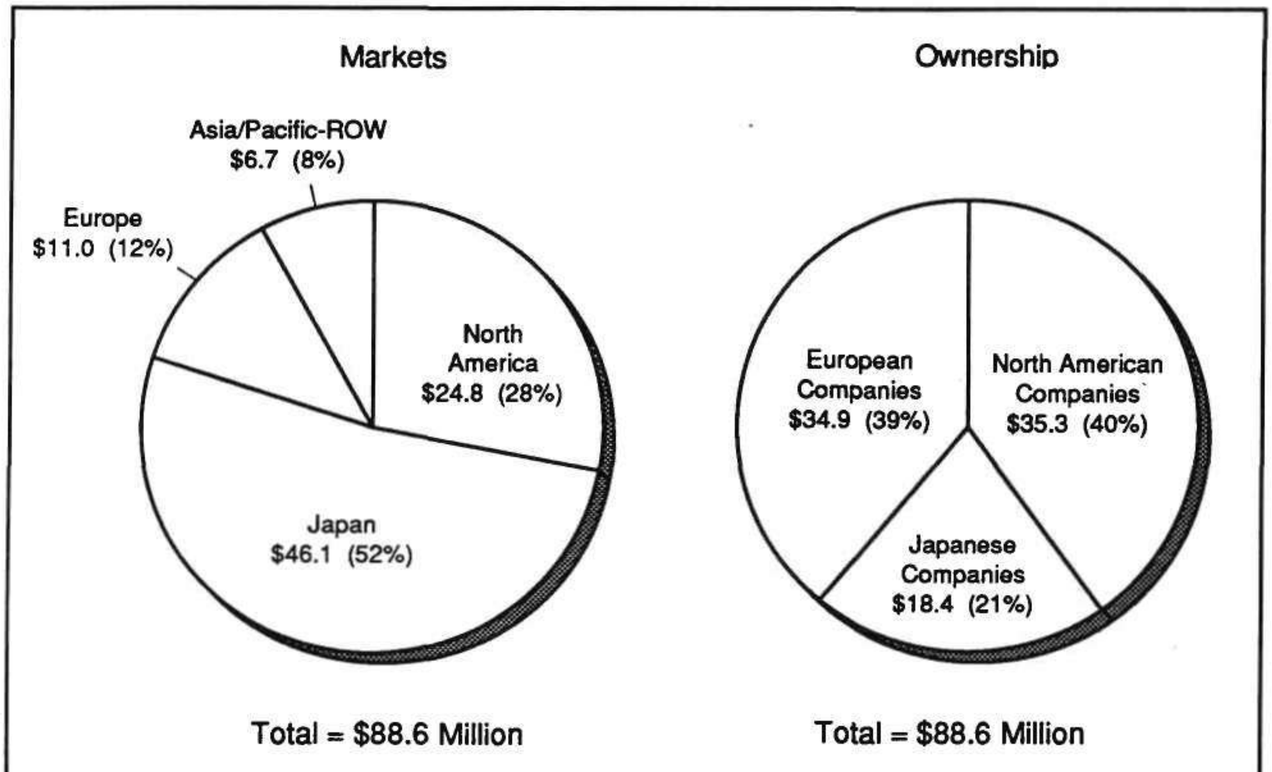
Japan Saves the Epi Equipment Market: 1991 Silicon Epitaxy Equipment Market in Review

The worldwide silicon epitaxial reactor market was $89 million in 1991, up 30 percent from its 1990 level of $68 million. The sales of epi equipment pushed ahead in 1991 because of strong sales in Japan and to a lesser extent Asia/Pacific. The traditionally strong North American market declined precipitously and the European market struggled to keep its head above water.

Regional Markets and Ownership

Figure 6-3 presents the worldwide 1991 silicon epitaxial equipment market segmented by region and company ownership. Surprisingly strong demand in Japan buoyed worldwide epitaxial equipment sales in what was a lackluster year in most regions of the world. Resilient epi equipment sales in Japan last year totaled $46.1 million, up from $18 million in 1990. The Asia/Pacific market was $6.7 and also saw strong growth albeit on a very small base. The North American market achieved a level of $24.8 million last year, which represented a significant decline of 30 percent relative to its 1990 level, while the European market was essentially flat at

Figure 6-3
1991 Silicon Epitaxy Equipment Regional Markets and Ownership



Source: Dataquest (July 1992)

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$11 million. North American and European epi companies, with almost equal share, dominate the market.

In Japan, several of the large merchant silicon companies put new capacity in place. Major projects included the construction of a Chitose line by Mitsubishi Metal and capacity increases by Toshiba Ceramics and Shin-Etsu Handotai at the Tokuyama Ceramics (subsidiary) and Isobe plants, respectively. Other capacity increases in Japan were at Osaka Titanium's Saga plant and Komatsu Electronic Metals' Nagasaki plant. The only significant epi capacity addition outside of Japan was for Wacker Chemitronic's Wasserburg plant in Germany.

Epi Wafer Applications

Discrete and bipolar devices are the major application in the Japanese market. On the other hand, merchant epitaxial wafers are largely used for CMOS devices in the United States. Intel and Motorola use them for microprocessors, IBM for DRAMs, and Texas Instruments (TI) for MOS devices.

The relatively small demand for CMOS epi wafers in the Japanese market is because Japanese companies have designed around epi films. Unlike IBM, which produces DRAMs for captive use, Japanese DRAM makers face intensive price competition and cannot afford to use epitaxial wafers, which cost two to three times the cost of silicon substrate.

Epi wafers, however, are required for bipolar devices. Epi films are used to form buried/diffused layers for the purpose of decreasing collector resistance. In MOS processing, the improved crystal structure of epi films prevents latchup and soft errors caused by alpha rays. In CCD applications, epi films provide improved gettering and uniformity, and in discrete applications, epi films are used solely for achieving film uniformity.

Japanese Drivers

The healthy growth of the Japanese epi equipment market last year can be attributed to several factors. The fastest growing application for epi films in Japan is the power IC market. The trend toward high-voltage and large-current IC designs is being driven by the increased performance and size reductions in consumer, information, and communications equipment.

The other major applications for epi films are insulated gate bipolar transistors (IGBTs), switching devices, and inverters, which control the speed of AC motors by varying the current frequency. From the equipment vendors' point of view, IGBT devices may be the largest application in terms of the number or reactors required because these devices require very thick epi films in the range of 100 to 150 microns. A relatively large amount of equipment is needed because of low throughput caused by the longer processing time required to grow a thick film.

On the CMOS side, Dataquest does not expect Japanese DRAM manufacturers to migrate to epi films until at least the 256Mb DRAM generation. As mentioned earlier, the cost remains prohibitively high for merchant DRAM applications. Japanese device companies have emphasized that they could only justify the use of epi wafers in current DRAM generations at a price 30 percent above that of prime wafer prices.

Another factor delaying the use of epitaxial wafers in DRAM applications is the use of high-energy ion implantation technology. Mitsubishi Electric has pioneered this application. The process is designed to improve latchup characteristics and soft error resistance by forming retrograde wells by ion implantation. Although the same effect can be achieved by using epitaxial wafers, ion implantation has the added benefit of reducing wafer processing by two mask steps. Of course, there is the additional expense of purchasing the implanter, which costs on the order of $3 million.

Company Rankings

As shown in Table 6-3, two companies—Applied Materials and ASM Epitaxy—dominate the worldwide epi equipment market. Both companies showed strong growth in year-to-year sales last year, and the combined sales of the two companies accounted for 70 percent of the worldwide epi equipment sales.

Applied Materials' strength in epi equipment goes back to the beginning of the company. Epi equipment was the first process equipment offered by Applied Materials. The workhorses of their product line today are the 7800 and 7700 series reactors. Both systems are barrel reactors. Applied is also working on a multichamber single-wafer system.

ASM Epitaxy quickly rose to prominence with the introduction of its Epsilon I system in the late 1980s. The Epsilon I was the first single-wafer epi reactor offered in the market. The company has

Table 6-3
1991 Worldwide Silicon Epitaxy Equipment Company Ranking (Millions of Dollars)

Company	Revenue	% Share
Applied Materials	32.0	36.1
ASM Epitaxy	29.9	33.8
Toshiba Machine	12.5	14.1
Kokusai Electric	5.9	6.7
LPE	5.0	5.6
Moore	3.3	3.7
Total	88.6	100.0

Note: Spares and service not included
Source: Dataquest (July 1992)

since introduced another version of the reactor Epsilon as well as a poly reactor called Paragon. The fast ramp of ASM Epitaxy's sales is a barometer of the demand for single-wafer reactors in the CMOS and BiCMOS epi markets, which require very thin epi films.

Toshiba Machine and Kokusai are the next largest vendors of epi equipment. Toshiba's $12.5 million sales in 1991 are largely captive; the company is the major supplier to Toshiba Ceramics, a sister company involved in the production of silicon and epi wafers. Kokusai, also a Japanese vendor, offers a pancake-type epi reactor. Kokusai's technology is older but ironically it may prove to be better suited for the high-growth market segment of thick film epi applications.

Dataquest Conclusions

The epi equipment market is relatively mature. Its fortunes are tied very closely to existing applications and epi wafer capacity expansions. Because of the high cost of epi wafers, device makers are very reluctant to adopt epi films in any designs other than those that absolutely require it. This trend is preventing the market from growing much beyond the $100 million level.

Chapter 7
Diffusion and Ion Implantation Market Trends

The material in this section focuses on diffusion and ion implantation market trends.

Vertical Turf Wars: 1991 Diffusion Equipment Market in Review

The worldwide diffusion equipment market grew modestly by 3 percent to $335 million in 1991. The market is now dominated by vertical thermal reactor (VTR) technology with vertical tube systems accounting for 60 percent of 1991 diffusion market revenue. The top three players in VTR technology already claim more than a 70 percent share in this briskly growing market segment.

Riding the Roller Coaster: 1991 Ion Implantation Market in Review

The worldwide market for ion implantation equipment declined 7 percent in 1991 to a level of $343 million. This was the most significant revenue decline for any major category of wafer fab equipment, excluding those mature segments currently being phased out in favor of newer technologies. Clearly, the roller coaster ride that traditionally has characterized ion implantation equipment market dynamics still appeared to be holding true last year.

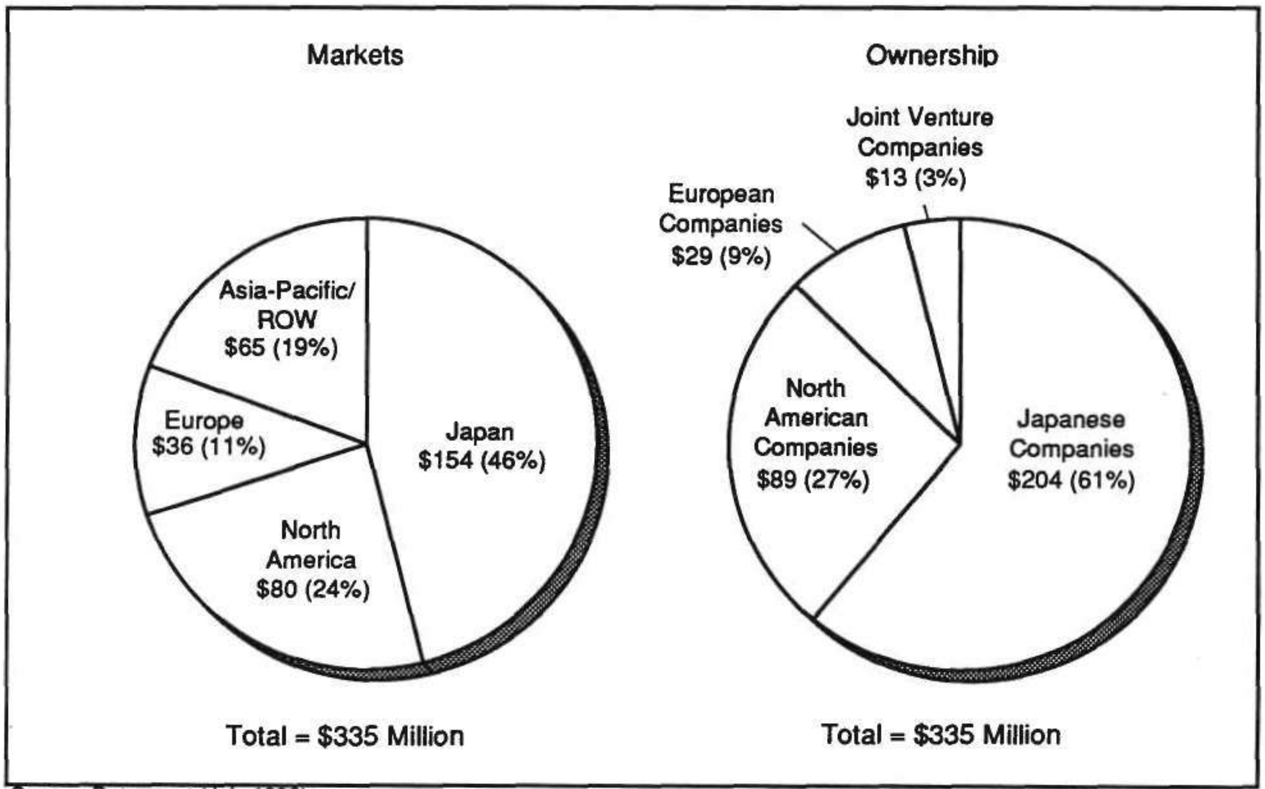
Vertical Turf Wars: 1991 Diffusion Equipment Market in Review

The worldwide diffusion equipment market grew modestly by 3 percent to $335 million in 1991. Steep increases in diffusion tube average selling prices (ASPs) were the main contributing factor for the slight market growth. Dataquest includes diffusion, wet/dry oxidation, anneal, implant drive-in, and BPSG reflow processes within the diffusion equipment market applications. The categories of low-pressure tube CVD and horizontal plasma-enhanced tube CVD market are not included within the diffusion market, but rather are included in Dataquest's estimates of the CVD equipment market. This section highlights the growth dynamics of the vertical- and horizontal-tube diffusion market.

Regional Markets and Ownership

Figure 7-1 shows the worldwide diffusion equipment market, segmented by region and ownership. Japan, with 46 percent ($154 million) in 1991, has represented the largest regional diffusion equipment market over the last few years. The Asia/Pacific market grew rapidly in 1991 to 19 percent ($65 million) of worldwide demand.

Figure 7-1
1991 Regional Diffusion Markets and Ownership



Source: Dataquest (July 1992)

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Japanese equipment companies also dominate ownership of the diffusion market: In 1991, they accounted for 61 percent share ($204 million) of the worldwide market. Japanese diffusion equipment companies are significant exporters of advanced diffusion tube equipment, especially in the category of vertical thermal reactor (VTR) tube products. North American companies captured 27 percent ($89 million) of the 1991 worldwide diffusion market.

Company Rankings

Table 7-1 presents the worldwide company rankings for the horizontal and vertical diffusion equipment market. Dataquest notes that sales of vertical diffusion equipment have grown rapidly and now comprise 60 percent ($200 million) of the 1991 worldwide diffusion market of $335 million. The horizontal diffusion equipment market is in a state of rapid decline. These systems are being implemented only in mature fab expansions and noncritical applications. Vertical diffusion furnaces have the advantages of easier

Table 7-1
1991 Worldwide Diffusion Equipment Company Ranking (Revenue in Millions of Dollars)

Company	Revenue	Market Share (%)	Horizontal Diffusion	Vertical Diffusion
Tokyo Electron Ltd.	92.7	27.7	37.0	55.7
Kokusai Electric	68.1	20.3	5.6	62.5
Silicon Valley Group	54.0	16.1	28.0	26.0
ASM International	21.7	6.5	11.7	10.0
BTU International	19.0	5.7	13.0	6.0
Varian/TEL	13.8	4.1	5.7	8.1
Ulvac	13.0	3.9	10.4	2.6
Koyo Lindberg	12.6	3.8	5.9	6.7
Disco	10.0	3.0	0	10.0
Gasonics	8.7	2.6	8.7	0
Shinko Electric	7.4	2.2	0	7.4
Centrotherm	6.7	2.0	6.7	0
Semitherm	3.0	0.9	0	3.0
General Signal Thin-film	3.0	0.9	1.0	2.0
Wellman Furnaces	0.5	0.1	0.5	0
Tystar	0.5	0.1	0.5	0
Pacific Western	0.4	0.1	0.4	0
Worldwide Market Total	335.1	100.0	135.1	200.0

Note: Spares and service are not included.
Source: Dataquest (July 1992)

automation, improved uniformity across 200mm wafers, tighter process control, and lower defect levels compared with horizontal diffusion furnaces. The downside to vertical furnace products is their higher ASP, which reflects more value-added automation and process control features.

Tokyo Electron (TEL)

TEL, with 27.7 percent of the 1991 market, retained its leadership position. TEL's vertical diffusion tube shipments comprised 60 percent of the company's total diffusion revenue. TEL also has a mature cash-cow portfolio of horizontal diffusion furnace products that account for the remaining 40 percent of its diffusion business. TEL continues to offer evolutionary improvements to its diffusion product line, such as enhanced automation, loadlocks, clustered VTR products, and in situ pre-cleans. Dataquest believes that TEL's strategy of offering value-added process features will enable it to continue its premium pricing policy as competition intensifies in the VTR business.

Kokusai Electric

Kokusai Electric, with 20.3 percent, captured the No. 2 position in the diffusion equipment market in 1991. Kokusai Electric's diffusion shipments are much more heavily skewed toward vertical furnaces: more than 90 percent of the company's diffusion revenue was obtained from vertical furnaces. Kokusai Electric's recent majority investment position within the Bruce Technologies front-end furnace division of BTU International is aimed at globalizing Kokusai's technology and obtaining rapid access to the installed base of BTU International's furnaces in North America and Europe. Kokusai Electric will also benefit from Bruce Technologies' expertise in process control and automation software. Dataquest believes that Kokusai Electric and TEL are caught up in a fierce battle for market supremacy within the large, technologically demanding Japanese diffusion market.

Silicon Valley Group (SVG)

SVG, with 16.1 percent of the 1991 market, is the third-largest supplier of diffusion equipment in the world. SVG is in the midst of a major product transition from its horizontal furnace product line to its newer VTR product family. The company has been quite successful in ramping up its VTR shipments. SVG's VTR diffusion business is now almost at the same level as its older horizontal furnace business. Dataquest believes that SVG is also in the final stages of development for its advanced vertical processor family for sub-0.5 micron diffusion applications. With BTU International's exit from the diffusion equipment business, SVG is the last major U.S. diffusion equipment company.

Dataquest Conclusions

The worldwide diffusion equipment market grew modestly to $335 million in 1991. Japanese diffusion equipment companies, which pioneered the adoption of VTR technology, own a major portion (61 percent) of the market. The diffusion equipment market is now dominated by VTR technology with VTR tube systems, which account for 60 percent of 1991 diffusion market revenue. Horizontal diffusion furnace companies that were caught off guard by the rapid shift to VTR technology are undergoing painful restructuring in order to stay in the diffusion business. The standardization of diffusion VTR product features may make it difficult for new companies to recoup their investment in development of advanced VTR products as commodity product pricing and margin erosion practices invade the hitherto lucrative VTR turf.

Riding the Roller Coaster: 1991 Ion Implantation Market in Review

The dynamics of the ion implantation equipment market can be compared to an amusement park roller coaster ride complete with thrilling heights and gut-wrenching depths. Plagued by an overall sluggish capital spending environment, the worldwide implant equipment market last year was $343 million, down 7 percent from its 1990 level of $370 million. Clearly, this percentage change was relatively modest when compared with the peak year of 1988 when the market grew 103 percent. Nor was last year's decline as severe as 1986 when ion implantation equipment revenue plummeted 60 percent. Fundamentally, the implant market is driven by capacity demands rather than technological innovation and this has contributed to a market environment characterized by sharp surges and subsequent drop-offs in activity.

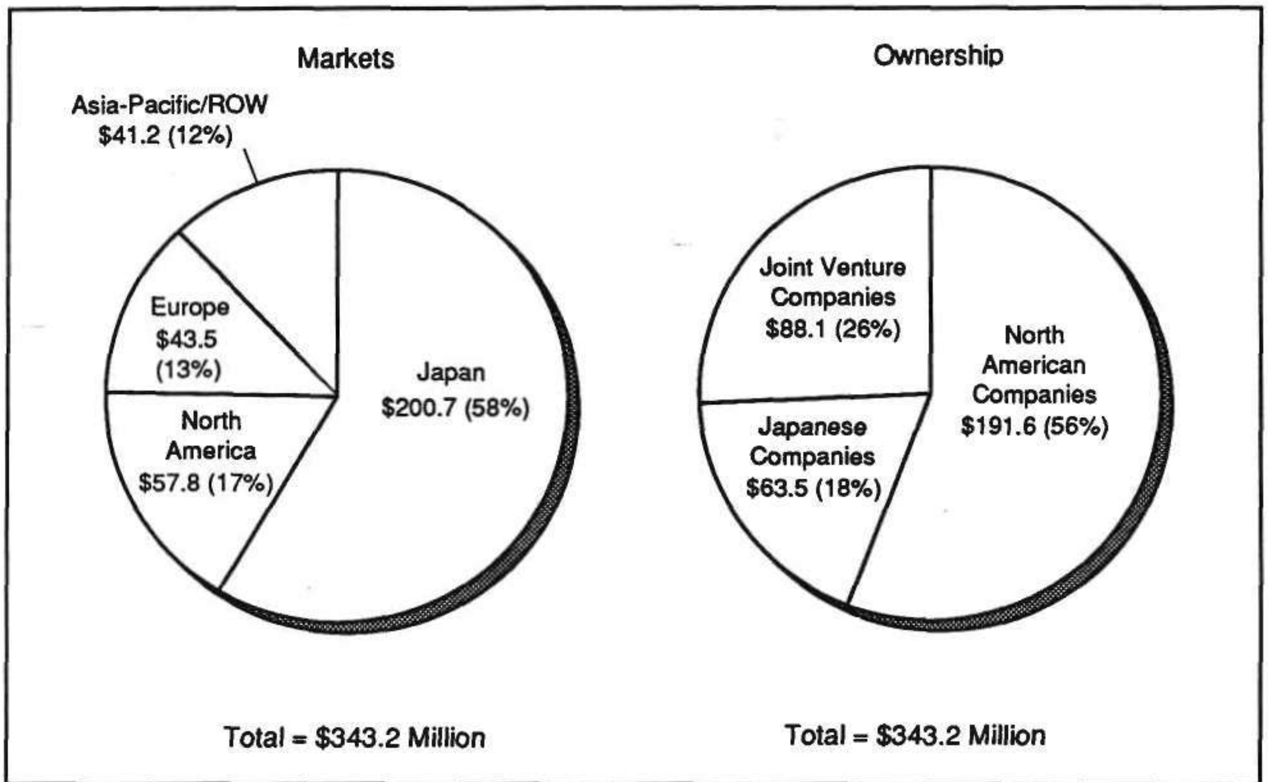
Both medium- and high-current tools suffered a decline in shipment levels and revenue in 1991. Unit shipments for medium- and high-current implanters tumbled 19 percent and 18 percent, respectively. The corresponding decline in medium- and high-current implant market revenue was minimized by increasing average selling prices (ASPs) as newer advanced systems became a larger portion of the total product mix. The medium-current implant market was about $108 million in 1991, down 5 percent from the previous year's level of $114 million, while the high-current implant market dropped to $218 million, a decline of 13 percent from its 1990 level of $250 million.

The high-voltage implant market experienced a significant increase in revenue last year, growing from about $7 million in 1990 to almost $18 million in 1991. However, one must keep in mind that this category of equipment represents only a small, niche segment. Unit shipments last year totaled only six systems as compared with three the year prior. A hefty increase in average selling price from $2.3 million to $2.9 million accounted for a significant portion of the revenue increase for high-voltage implanters in 1991.

Regional Markets and Ownership

Figure 7-2 presents the worldwide 1991 ion implantation equipment market segmented by region and ownership. Japan, with 58 percent share of the world market, continues its dominant position in the marketplace, driven by its need to equip advanced high-volume manufacturing facilities. North American companies, however, continue to hold their dominant position in all three segments of the implant market and together command 56 percent worldwide market share. Further influence of U.S. company technology in the implant market is also evident in the success of the two U.S./Japanese joint venture companies, TEL/Varian and Sumitomo/Eaton Nova, much of whose technology historically has flowed from their U.S. partner companies. In 1991, these joint venture companies represented 26 percent share of the worldwide implant market. The implant market is unlike most other segments of the wafer fab equipment industry because Japanese companies hold a relatively small minority position with only 18 percent share. This market share level has held essentially constant for the last three years.

Figure 7-2
1991 Regional Ion Implantation Equipment Markets and Ownership



Source: Dataquest (July 1992)

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Company Rankings

Table 7-2 presents the worldwide company rankings for the ion implantation equipment market in 1991, along with worldwide company revenue by segment of the implant market. In order to better illustrate the influence and market positioning of companies providing the same ion implant product offerings, we have combined the revenue of Varian with its joint venture company, TEL/Varian. Similarly, we present the combined implant revenue of Eaton and Sumitomo/Eaton Nova.

Please note that all revenue reported in Table 7-2 is end-user revenue. This distinction is of particular importance in understanding Dataquest's revenue estimates for the implant joint venture companies. The revenue associated with implant kits sent from one company (say Varian or Eaton) to be fabricated and assembled by its joint venture partner (TEL/Varian or Sumitomo/Eaton Nova) is valued at the full system shipment price to the semiconductor manufacturer, rather than at the value of the kit. Dataquest attributes the end-user revenue from assembled kits to the appropriate joint venture company.

Table 7-2
1991 Worldwide Ion Implantation Equipment Company Ranking (Revenue in Millions of Dollars)

Company	Revenue	Share (%)	Medium Current	High Current	High Voltage
Varian and TEL/Varian	132.3	38.5	55.8	76.5	0
Eaton and Sumitomo Eaton/Nova	102.2	29.8	12.6	86.3	3.3
Nissin Electric	42.2	12.3	28.0	11.2	3.0
Applied Materials	33.9	9.9	0	33.9	0
Genus	11.3	3.3	0	0	11.3
Ulvac	11.1	3.2	11.1	0	0
Hitachi	10.2	3.0	0	10.2	0
Worldwide Market Total	343.2	100.0	107.5	218.1	17.6

Note: No revenue associated with spares and service is included.
Source: Dataquest (July 1992)

Varian and TEL/Varian

Varian and TEL/Varian continue their leadership position in the ion implantation equipment market with combined revenue of $132 million (39 percent share). At SEMICON/Japan in December 1991, Varian formally introduced its new medium-current implanter, the E-500, to complement its core product offerings for 200mm processing (the E-220, single-wafer medium-current implanter, and the E-1000 and 180XP high-current, batch-processing systems). The E-500, like the E-220, is a parallel-beam scanning system. In addition to medium-current applications, the E-500 is also suited for certain high-energy applications that have more moderate energy requirements than traditional high-voltage implants. Such applications include charge-coupled devices and programmable ROMs.

Eaton and Sumitomo/Eaton Nova (SEN)

The combined activities of Eaton and Sumitomo/Eaton Nova (SEN) ranked second in the 1991 implant equipment market with revenue of $102 million and share of 30 percent. Eaton and SEN, together, rank first in the high-current implant market with 40 percent share. High-current implant has been the traditional strength of the Eaton and SEN organizations. This particularly strong market position in 1991 was fueled in large part by the success of the NV-GSD high-current system. Contrary to the historical practice of shipping kits from the United States to Japan, this tool was developed jointly in Japan by Sumitomo/Eaton Nova and Eaton. The technology for the NV-GSD has been transferred back to Eaton's facility in the United States, and the system now can be manufactured in either region of the world.

Nissin Electric

Nissin Electric ranked third in the worldwide ion implantation equipment market in 1991 with revenue of $42 million (12 percent share). Nissin continues to expand its export activities in the implant market segment with almost one-fourth of its 1991 revenue coming from customers outside of Japan. In contrast, fellow Japanese implant suppliers Hitachi and Ulvac only ship systems in their home market of Japan. Nissin introduced several new models of implant equipment in 1991, including its medium-current NH-20SP system, its high-current Exceed-8000, and an MeV implanter, NT-1000P. Nissin traditionally has held a strong position in medium-current implant but is currently a relatively small player in the high-current arena. With its new high-current product offering, the Exceed-8000, Nissin has focused on the features of low charge-up, low particulate contamination, less shadowing effect, higher throughput, and longer source lifetime.

Applied Materials

Applied Materials had ion implantation equipment sales of about $34 million in 1991, which provided the company with a share of 10 percent of the total implant market. Applied only participates in the high-current implant segment of the market, of which Dataquest estimates the company had 16 percent share. At SEMICON/West in May 1991, Applied introduced an enhanced version of its high-current product offering, the Precision Implant 9200XJ. This tool provides improved system performance and process capability and a new ion source. New beamline components and wafer-handling materials have also helped reduce particulate contamination, while new filtering techniques have helped to reduce BF_2 contamination. Dataquest believes that contamination problems with Applied's earlier high-current implanter (Precision Implant 9200) contributed to some erosion of Applied's market position in high current from 18 percent in 1990 to 16 percent in 1991.

Genus

While Genus claims only 3.3 percent share of the worldwide implant market, the company remains the dominant player in the high-voltage implant equipment segment with sales of $11 million. One of the most significant events in this implant segment last year was Mitsubishi Electric's adoption of high-voltage implant for volume production of 16Mb DRAMs. Dataquest believes that Genus was the vendor to supply Mitsubishi Electric with its high-voltage implant system. High-voltage implant is used to form retrograde wells and channel stoppers under LOCOS structures, as well as to avoid latch-up. Although high-voltage tools carry an impressive ASP of $2.9 million, the use of such systems can eliminate two mask layers from a 16Mb DRAM process and thus reduce the need for additional steppers, track systems, and strippers. One additional advantage of high-voltage implant is an improvement of soft error reduction by a factor of 20.

Ulvac

Dataquest estimates that Ulvac had implant sales of $11 million in 1991, all of which were medium-current systems shipped to customers in Japan. The company introduced a new medium-current tool last year, the IPZ-9000, which is the next-generation tool design of Ulvac's IPX family of products. Dataquest understands that this system adopts a unique multielectrostatic scanning method and creates a parallel beam that covers 150mm and 200mm wafers with a high degree of accuracy. The beam angle can be varied from 0 to 60 degrees, and the wafer can be rotated up to 80 revolutions per minute, which improves device symmetry while reducing shadowing effects. Recently, Ulvac's new system was adopted for GaAs applications in addition to traditional silicon wafer processing.

Hitachi

In 1991, Hitachi had implant sales of $10 million, representing 3 percent share of the world market. Hitachi only participates in the high-current segment of the market, and to date has only shipped systems to customers in its home market of Japan. The company's major advanced product offering, the IP-2500, was introduced at SEMICON/Japan in December 1990.

Dataquest Conclusions

The worldwide market for ion implantation equipment declined 7 percent last year. This was the most significant revenue decline for any major category of wafer fab equipment excluding those mature segments currently being phased out in favor of newer technologies. Total unit shipments of ion implanters of all three types declined 17 percent from 249 units in 1990 to 206 units in 1991. This 1991 shipment level is comparable to the 201 units shipped back in 1982!

Clearly, the roller coaster ride that traditionally characterizes ion implantation equipment market dynamics still appeared to be holding true last year. The reason behind the stunning highs and significant lows in implant unit shipments over the years is that the implant market fundamentally has been driven by capacity demands more so than technological innovations in the equipment. The question is whether ion implant equipment companies can expect their roller coaster market dynamics to evolve into a much more stable pattern as the semiconductor industry itself moderates its own binge/bust cycle of capital spending.

Chapter 8
Process Control Market Trends

The material in this section focuses on process control market trends.

CD Market Growth Bolstered by SEM Preference: 1991 Optical CD and CD SEM Equipment Markets in Review

CD SEM equipment continues to maintain its high-profile position in the critical dimension equipment market. At the same time, we are observing a growing presence of dedicated overlay tools in the optical CD product mix.

New Players, New Products in Advanced Defect Inspection: 1991 Wafer Inspection Equipment Market in Review

Advanced defect inspection systems continue to dominate the market and technology issues associated with wafer inspection equipment. Recent market activities in this segment include a new competitor entering the arena, the acquisition of an established player, and a host of new product offerings.

CD Market Growth Bolstered by SEM Preference: 1991 Optical CD and CD SEM Equipment Markets in Review

The worldwide critical dimension (CD) measurement equipment market was $154 million in 1991, up 5 percent from its 1990 level of $147 million. The CD SEM equipment segment of the market continued to outpace optical CD system demand. The CD SEM market represented $94 million of the $153.6 million total, and grew 8 percent in 1991 over its 1990 level of $88 million. The CD SEM equipment market has been on a steady growth path since this market segment first emerged in the mid-1980s. The continued market growth of this equipment segment reflects that CD SEM tools have become the established tool choice for CD measurement technology in submicron applications, particularly in the sub-0.8-micron regime.

In contrast to market growth in the CD SEM equipment segment, the optical CD equipment market was essentially flat in 1991 at a level of $59 million, after suffering declines of 12 percent in 1989 and 15 percent in 1990. The new emerging market for dedicated overlay tools was a key factor in preventing further erosion in the size of the total optical CD equipment market since the demand for optical CD tools with joint linewidth/overlay measurement capability continued down a path of decline last year.

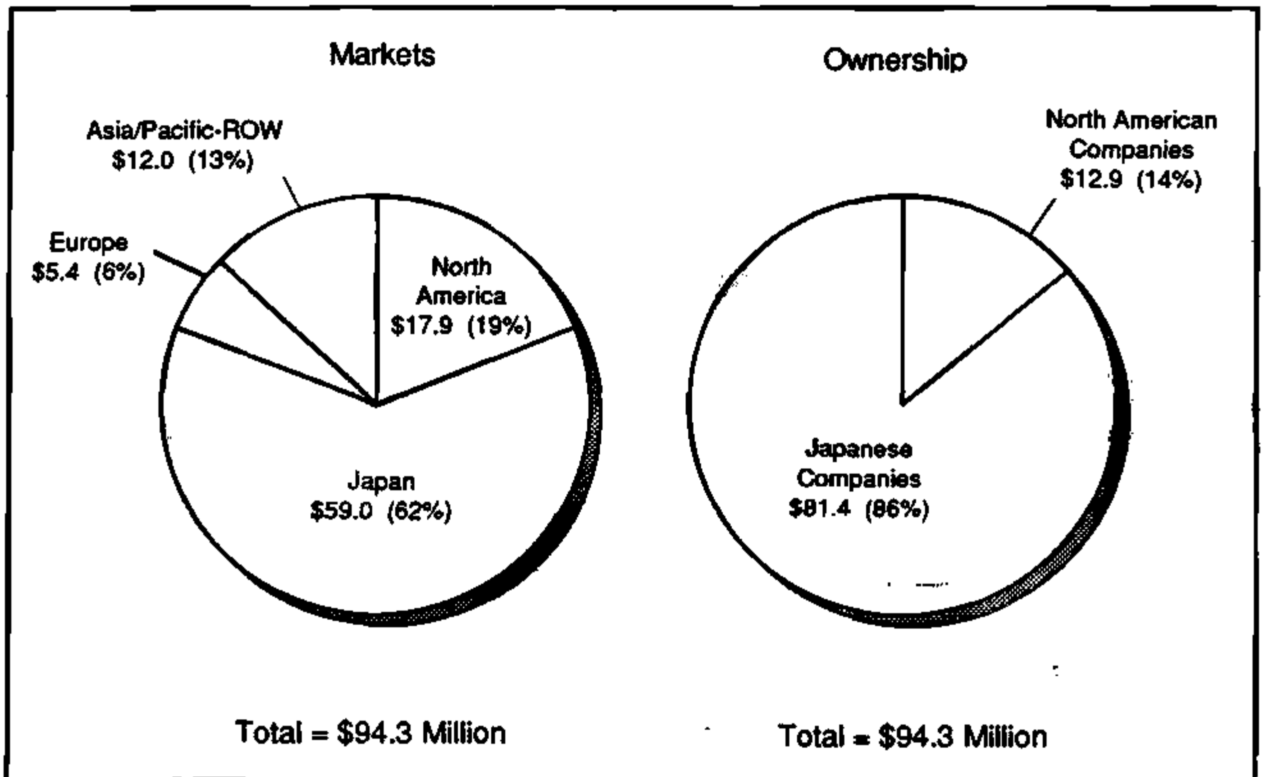
Regional Markets and Ownership

Figures 8-1 and 8-2 present the worldwide 1991 CD SEM and optical CD equipment markets segmented by region and ownership. As these figures clearly illustrate, Japan continues to strongly dominate the CD SEM arena, accounting for 62 percent of worldwide demand last year. This bias toward CD SEM equipment in large part is because of the prevalence of DRAM manufacturing in Japan, which is the technology driver for processing smaller and smaller feature sizes. At the same time that Japan represented the largest regional demand for CD SEM systems, Japanese equipment suppliers maintained their strong position of dominance with 86 percent share of the market. This dominance in large part is because of the commanding presence of Hitachi, which accounted for 74 percent share of the worldwide CD SEM equipment market.

In contrast to the strong bias toward CD SEM, Japan accounted for only one-third, or $19 million, of the worldwide optical CD equipment demand in 1991. Dataquest estimates that dedicated overlay tools represented more than 60 percent of that amount of optical CD tools purchased in Japan last year. This strong preference for dedicated optical overlay systems is because CD SEM measurement systems are not particularly well-suited for overlay measurements. The physics of the CD SEM measurement procedure restrict it to the measurement of surface features. An optical tool, however, can "see" through a transparent film to the alignment marks on an underlying layer.

North America represented 33 percent of the optical CD equipment market in 1991, while CD SEM system purchases in North America

Figure 8-1
1991 CD SEM Equipment Regional Markets and Ownership



Source: Dataquest (July 1992)

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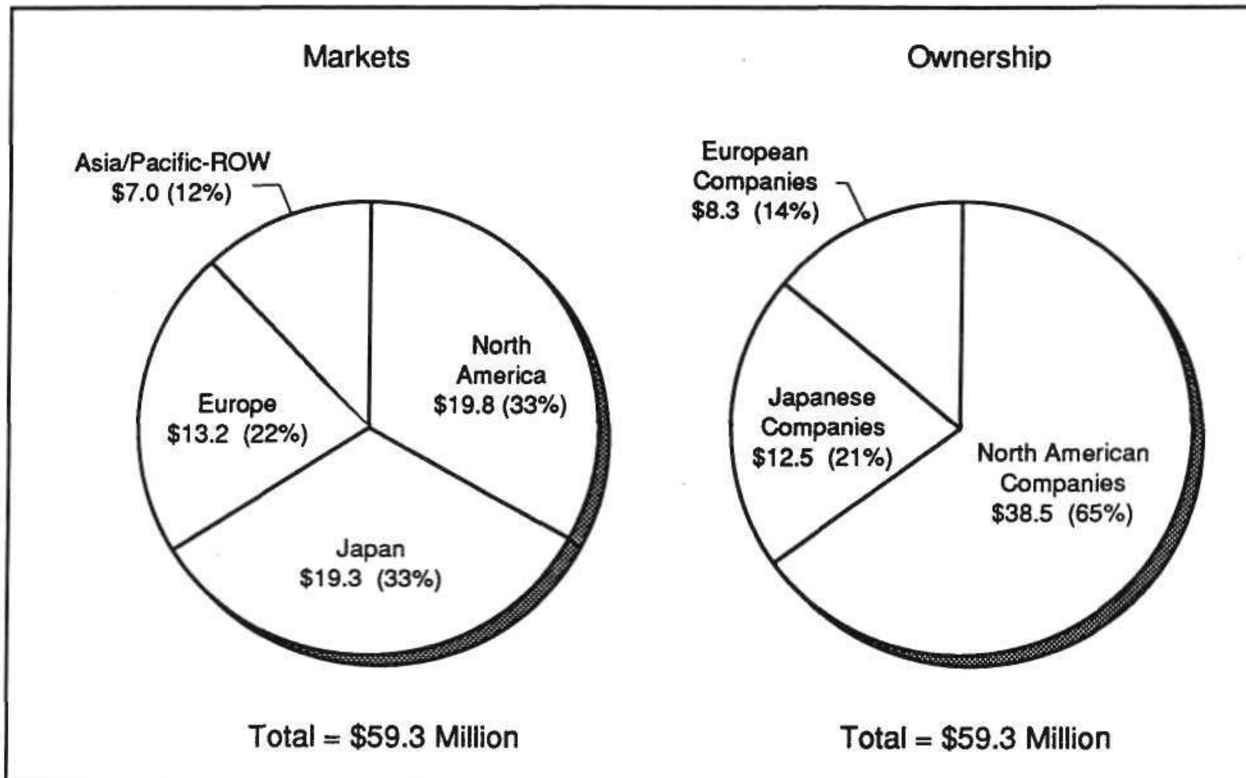
represented only 19 percent of worldwide demand. It is not surprising that device manufacturers in North America demonstrate a purchase preference for optical CD systems, as they have a strong domestic base of equipment suppliers to support their needs. North American companies dominate the optical CD arena, accounting for 65 percent of the worldwide market.

Like their counterparts in North America, semiconductor device manufacturers in Europe favor optical CD tools more strongly than CD SEM systems. Europe represented 22 percent of the optical CD equipment market and a mere 6 percent of the CD SEM market. Semiconductor manufacturers in Asia/Pacific-ROW purchased a fairly even balance of optical CD and CD SEM systems last year, and accounted for 12 percent and 13 percent, respectively, of worldwide equipment demand of these two categories of equipment.

It is interesting to note that the distribution of revenue on a regional basis for the combined optical CD and CD SEM equipment markets closely mirrors the regional distribution of the total wafer fabrication equipment market. So while there are regional preferences for a given measurement technology, overall CD equipment expenditure follows a well-behaved pattern of wafer fabrication spending.

Figure 8-2
1991 Optical CD Equipment Regional Markets and Ownership



Source: Dataquest (July 1992)

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Company Rankings

Table 8-1 presents the worldwide company rankings for the CD equipment market based on combined revenue of optical CD and CD SEM equipment. Company revenue for optical CD systems is further segmented into tools with joint linewidth/overlay measurement capability and dedicated overlay measurement systems. The following sections discuss several key observations to note when evaluating the company revenue and ranking estimates presented in Table 8-1.

Relatively Few Companies Offer both Optical CD and CD SEM Equipment

The CD equipment market has remained relatively fragmented over the years. In 1991, only 2 companies of the 15-plus suppliers offered both CD SEM and optical CD product offerings. These two companies—Hitachi and Biorad—ranked No. 1 and No. 2, respectively, in the 1991 total CD equipment market. Hitachi's total CD revenue of $74 million is strongly dominated by CD SEM equipment. This is a market where Hitachi has dominated the market since it emerged in the mid-1980s. It has enjoyed an enviable position of more than 70 percent worldwide market share for the last three years. Hitachi's optical CD revenue is derived from its LAMU system, a dedicated overlay tool that complements the company's strategy and focus on CD SEM equipment.

Table 8-1
1991 Worldwide CD Equipment Company Ranking (Millions of Dollars)

Companies	Total	% Share	Total CD SEM	Total Optical CD	Optical CD: Joint CD/ Overlay	Optical CD: Dedicated Overlay
Hitachi	73.8	48.0	69.6	4.2	0	4.2
BioRad	14.8	9.6	4.9	9.9	9.9	0
KLA Instruments	9.3	6.1	0	9.3	4.9	4.4
Holon	8.0	5.2	8.0	0	0	0
IVS, Inc.	7.6	4.9	0	7.6	7.6	0
Nano-Master	6.0	3.9	0	6.0	6.0	0
Nikon	5.9	3.8	0	5.9	3.3	2.6
Optical Specialties	5.7	3.7	0	5.7	0.7	5.0
Amray	3.4	2.2	3.4	0	0	0
Nanometrics	2.4	1.6	0	2.4	2.4	0
Opal	2.4	1.6	2.4	0	0	0
Angstrom	2.2	1.4	2.2	0	0	0
SiScan Systems	2.2	1.4	0	2.2	2.2	0
Topcon (formerly ABT)	2.1	1.4	2.1	0	0	0
Leica	1.8	1.2	0	1.8	1.8	0
JEOL	1.7	1.1	1.7	0	0	0
Ryokosha	0.7	0.5	0	0.7	0.7	0
Other Companies	3.6	2.3	0	3.6	3.6	0
Total	153.6	100.0	94.3	59.3	43.1	16.2

Note: Spares and service not included.
Source: Dataquest (July 1992)

Biorad ranked No. 1 in the optical CD equipment market with revenue of $10 million. Its CD SEM equipment revenue of $5 million last year placed it third in the CD SEM equipment market ranking. Biorad's optical CD and CD SEM equipment revenue historically has been focused on the North American and European markets. The company has yet to establish much of a presence with semiconductor manufacturers in Japan and Asia. Dataquest believes that it is essential for Biorad to expand its regional focus to the Far East because these two regions represent more than 60 percent of the worldwide demand for CD measurement equipment.

At the beginning of 1992, IVS, a key player in the optical CD arena, announced that it would acquire Angstrom Measurements, a start-up CD SEM equipment supplier. IVS has been an important player in the optical CD equipment market by virtue of having a relatively strong position in each of the regional markets, with the exception of Japan. IVS has yet to ship any equipment into this region. With the Angstrom CD SEM product, IVS is now well-positioned to continue to maintain its ranking as a top player in the various regional markets. Although fierce competition from domestic suppliers will always make Japan a difficult market to penetrate, the high-throughput capability of Angstrom's advanced CD SEM should garner IVS much attention from the Japanese semiconductor device manufacturers. Finally, Angstrom Measurements will provide IVS with some incremental amount of critical mass, which is vital to the survival of any small semiconductor equipment company. We note that the combined CD revenue of IVS and Angstrom would have ranked third, ahead of KLA Instruments, in the overall CD equipment market last year.

Dataquest believes that this balanced approach to CD product mix adopted by Hitachi, Biorad, and IVS is a distinct benefit because it allows the equipment supplier to offer a migration path of measurement technologies as well as a broader scope of measurement solutions to the device manufacturer.

The Growing Presence of Dedicated Overlay Tools in the Optical CD Product Mix

Traditionally, optical CD tools have been used to perform both linewidth and overlay measurement. However, as CD SEM equipment has become a larger portion of the overall CD product mix, a number of companies have designed systems that are specifically optimized for overlay measurement. Table 1 includes Dataquest's estimates for the 1991 dedicated overlay revenue of four companies: Hitachi, KLA Instruments, Nikon, and Optical Specialties (OSI). We believe that the dedicated overlay equipment revenue of these four companies was $16 million, or more than one-fourth of the total optical CD equipment market last year.

Hitachi has been a longtime supplier of a dedicated overlay system with its LAMU measurement system. Although Hitachi enjoys a strong market presence in every region with its CD SEM product offerings, it has not been able to effectively expand the sales of its overlay measurement system beyond customers in Japan.

KLA's current dedicated overlay product offering, the 5010, emerged from the KLA 5000 product family, which utilizes a patented KLA measurement technique known as coherence probe imaging. The KLA 5000 with joint CD/overlay capability was introduced in 1988; the company began shipments of a dedicated overlay system based on this same technology in 1990.

Nikon is a relatively newcomer in the dedicated overlay arena. The company's Instrument Group introduced its new dedicated overlay tool, the NRM-1, at SEMICON/West in May 1991. It is interesting to note that this tool was developed by the Instrument Group of Nikon, a different division than that which manufactures and markets Nikon's LAMPAS line of laser-based optical CD measurement systems.

OSI has been providing its Metra family of products to the marketplace since 1990. In particular, a focused strategy toward dedicated overlay equipment has benefited OSI, which has been a relatively small player in the market. Dataquest believes that OSI garnered the No. 1 position in this new emerging market segment last year with an estimated $5.0 million in dedicated overlay system revenue. The company has benefited from a close working relationship with its representative and distributor, Innotech of Japan. Last year, almost 70 percent of OSI's optical CD equipment revenue came from Japan. In May of this year, OSI announced that it will acquire Insystems, a manufacturer of advanced defect inspection tools. This acquisition will provide OSI with advanced process control equipment to complement its existing product offerings and will also benefit the company by adding much needed critical mass.

Make Note of a Newcomer to the CD SEM Arena

One company not shown in Table 8-1 is a new North American CD SEM start-up called Metrologix. This Silicon Valley-based company shipped its first CD SEM system, dubbed Metrostep TM 2001, in early 1992. This tool's measurement system incorporates a proprietary mixed-signal technique that mixes secondary electrons with other electrons to achieve excellent operation in a very linear regime. The company claims measurement capability in a production environment of 0.1μ with the potential to measure 0.05μ geometries. The system is reported to have a very impressive throughput level of 40 wafers per hour at five sites per wafer, substantially faster than the 12- to 15-wafer-per-hour rate reported by several vendors. With this level of tool performance, Metrologix has the capability to move to the head of the pack of that group of smaller CD SEM vendors (Angstrom, Biorad, and Opal) targeting high-throughput operation in a bid to wrest market share from Hitachi.

Dataquest Conclusions

The clear trend in CD measurement technology over the last several years has been toward CD SEM systems. With its sub-0.5-micron measurement capability and tool performance designed for the production environment, CD SEM equipment has become the preferred measurement technology for many semiconductor device manufacturers focused on advanced device fabrication. The two perceived disadvantages of CD SEM tools today, however, are their relatively low throughput and inability to measure overlay. Dataquest believes that within the next two years low throughput will no longer be considered a significant issue for CD SEM because of new high-throughput product offerings coming into the market.

The concern with CD SEM tools and overlay measurement is currently being addressed by optical CD tools. Several equipment companies have developed dedicated overlay measurement systems for the marketplace, while other optical CD vendors have refocused their marketing strategies to emphasize overlay measurement capability of their joint linewidth/overlay measurement tools. It has even been suggested that CD SEM tools also can be adapted to overlay measurement with proper process modifications that leave the area above alignment marks open. This approach is being investigated because it is believed that the transparent layers that prevent CD SEM tools from "seeing" alignment marks will also become a problem for optical-based overlay measurement tools in the 64Mb/256Mb DRAM processing regime. The transparent film is part of the total optical path, and at some point process-induced distortions in this transparent film will become so significant that an alternative method for overlay measurement will need to be established. If device manufacturers opt for the additional process steps to modify the area above alignment marks, CD SEM applications will expand beyond strictly linewidth measurements, which could well have a significant impact on future optical CD tool demand.

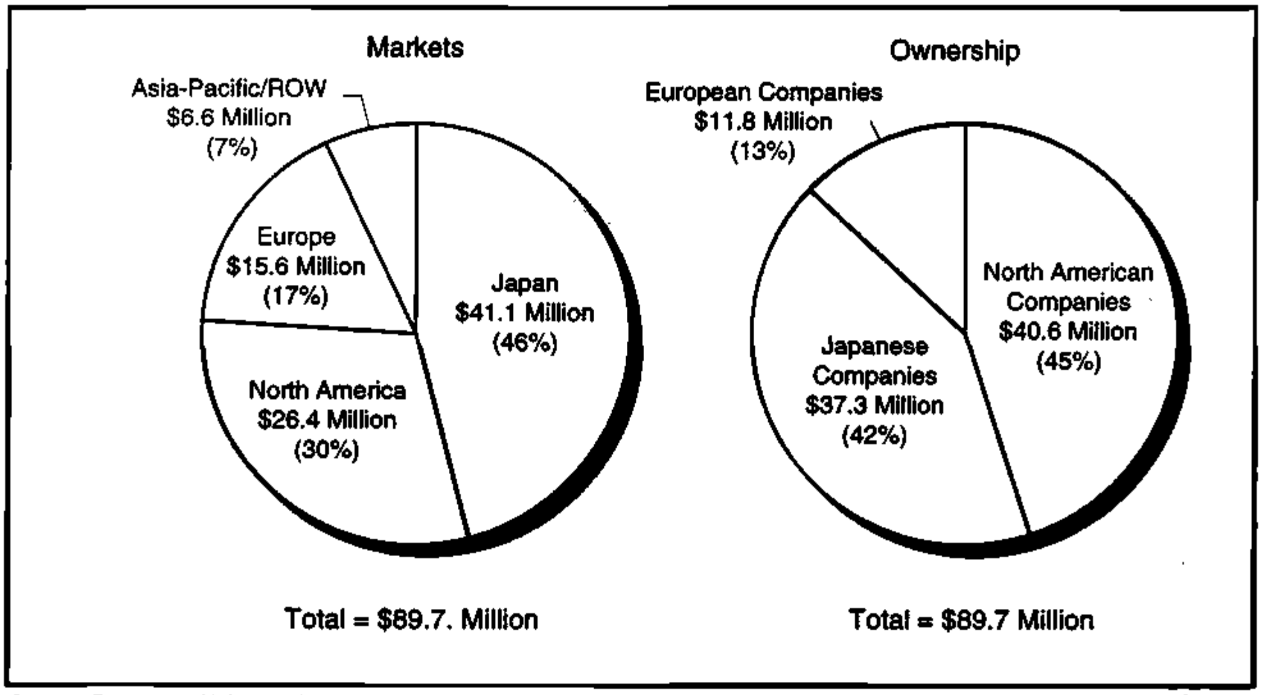
New Players, New Products in Advanced Defect Inspection: 1991 Wafer Inspection Equipment Market in Review

The wafer inspection equipment market was $90 million in 1991, essentially flat when compared with its 1990 level of $91 million. The two segments of the wafer inspection equipment market—microscope-based stations and automated defect inspection tools—experienced only moderately different market dynamics last year. Microscope-based station revenue grew a modest 4 percent to reach $33 million, while the market for advanced defect inspection stations declined 4 percent from its 1990 level to total about $56 million last year.

Regional Markets and Ownership

Figure 8-3 presents the worldwide 1991 wafer inspection equipment market segmented by region and ownership. As in other major categories of front-end wafer fab equipment, Japan dominated the market, accounting for 46 percent of worldwide demand. It is interesting to note, however, that semiconductor manufacturers in North America and Europe spent proportionately more on wafer inspection equipment as a percentage than is reflected by their total wafer fab equipment expenditure. For example, North America accounted for only 25 percent of the worldwide wafer fab equipment market but represented 30 percent of the wafer inspection

Figure 8-3
1991 Wafer Inspection Equipment Regional Markets and Ownership



Source: Dataquest (July 1992)
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equipment market. Similarly, the wafer fab equipment market in Europe represented only 11 percent of the world market, but semiconductor manufacturers in this region purchased 17 percent of the worldwide demand for wafer inspection equipment. One reason behind this seeming anomaly in spending patterns is that advanced defect inspection systems (which have a significantly higher average selling price than microscope stations) in both North America and Europe represent a substantially larger portion of the wafer inspection equipment product mix.

In 1991, we observed a significant gain in regional company share for one group of suppliers. Japanese companies accounted for 42 percent of the worldwide market last year, compared with only 25 percent in 1990. The increase in Japanese company share was mirrored by a decrease of similar magnitude for North America. European company share in 1991 was 13 percent, relatively constant as compared with the prior year. The gain in Japanese share mirrored by a drop in North American company share can be explained in large part by examining what happened in the advanced defect inspection arena. Hitachi, a new supplier of advanced defect inspection tools, entered the market with its new WI-870 system and shipped a number of units its first year. At the same time, North American suppliers of advanced defect inspection equipment—Insystems and KLA Instruments—were still experiencing the effects of overall sluggish market demand. These two companies spent much of their efforts in 1991 developing new tool technology or ramping up their manufacturing capability for new equipment product offerings.

Table 8-2
1991 Worldwide Wafer Inspection Equipment Company Ranking (Millions of Dollars)

Company	Revenue	% Share	Advanced Defect Inspection	Microscope-Based Stations
KLA Instruments	26.4	29.4	X	
Nikon	13.1	14.6		X
Insystems	13.0	14.5	X	
Hitachi	11.6	12.9	X	
Nidek	7.1	7.9		X
Nano-Master*	5.4	6.0	X	
Leica	4.9	5.5		X
Canon	4.4	4.9		X
Others	3.8	4.2		X
Total	89.7	100.0	56.4	33.3

*Formerly known as Micro-Controle
Note: No revenue associated with service and spares included
Source: Dataquest (July 1992)

Company Rankings

Table 8-2 presents the worldwide company rankings for the wafer inspection equipment market in 1991, together with the market segment activities.

KLA Instruments

KLA Instruments continued to maintain its No. 1 position in the wafer inspection equipment market last year through sales of advanced defect inspection systems totaling $26.4 million. The company's share of the market, however, has been steadily declining the last several years. In 1989, KLA commanded 49 percent share of the worldwide market, but by last year that position had eroded to only 29.4 percent share.

One major reason behind this erosion in market share has been the depressed market for advanced defect inspection systems. The drop in demand in advanced defect inspection systems began in the latter half of 1990 at the same time that the aggressive capital spending boom of the late 1980s began to fade. In October 1990, KLA introduced a new family of advanced defect inspection equipment, the 2100 series. Last year represented the first year of shipments for KLA's first product in the family, the 2110 advanced defect inspection system. This system offers 0.25-micron defect sensitivity and substantially improved throughput compared with the company's previous 20xx product line of inspection tools.

In June 1992, KLA introduced its newest product offerings in the 2100 family, the 2111 and the 2130 systems. The 2111 system specifications include a fivefold improvement in speed and a 20 percent increase in sensitivity relative to its predecessor, the 2110. The 2111, like the 2110, has been optimized for inspection of highly repetitive device patterns, such as memories. The 2130 system, also shown at SEMICON/West in June, has been designed as a high-speed inspection system to handle all device pattern types, both repetitive and random. Dataquest understands that a number of 2111 systems have already been shipped and that the 2130 has obtained customer acceptance.

In conjunction with these new advanced defect inspection product offerings, KLA also developed a new image and data analysis workstation, the 2550. The 2550's flexible, open architecture supports multiple KLA and non-KLA inspection tools, as well as optical and SEM defect review stations.

Nikon

Nikon's wafer inspection equipment revenue in 1991 was $13.1 million, which placed the company second in the worldwide ranking. It achieved this position by being the market leader in microscope-based wafer inspection stations. Nikon offers a variety of systems for wafer inspection through its Optistation family of products.

Insystems

Insystems ranked third in the wafer inspection equipment market with system revenue of $13 million. Insystems has suffered financial problems over the past several years as it has attempted to compete head-to-head with KLA in the advanced defect inspection equipment arena. Although Insystems has leading-edge technology, it has been burdened by having only a single product offering. In contrast, KLA has been better able to balance the effect of the industrywide slowdown by dispersing the impact on its business activities over a much wider mix of products.

The year 1991 was decidedly difficult for Insystems, as its cash flow position continued to deteriorate. Finally, in May 1992, it was announced that Optical Specialties Inc. (OSI) would acquire the assets of Insystems. The joint operation of the two companies will be consolidated under the OSI name. Dataquest understands that as part of the agreement all Insystems employees, products, and technology will be transferred to OSI. OSI, like Insystems, provides process control equipment to the semiconductor industry.

Insystems' latest family of products was announced at SEMICON/West in June 1992. The new IQ inspection systems represent the company's third generation of patterned wafer inspection equipment. The IQ inspection system family currently consists of two products, the IQ-155 and IQ-165. The IQ-155 offers high-speed inspection at 0.25-micron defect sensitivity, while sensitivity for the IQ-165 is specified at 0.1 microns. Both products can provide full wafer defect detection capability in less than five minutes. Several more product offerings in the IQ family are planned over the next 12 to 18 months. Dataquest understands that several IQ systems are in the field and that additional shipments are scheduled prior to the end of September.

Hitachi

Hitachi, a new entrant to the advanced defect inspection equipment market, achieved an impressive market position of nearly 13 percent share its first year with almost $12 million in system revenue. Its new automated defect detection tool, the WI-870, has 0.5-micron defect sensitivity and relies on a light intensity comparison technique to detect the presence of defects. Dataquest believes that a significant number of the company's first-year system shipments went to internal Hitachi semiconductor operations. Although Hitachi achieved impressive sales in its first year of system shipments, its long-term competitive position in this market will depend on its ability to penetrate accounts beyond Hitachi's semiconductor operations and Hitachi's semiconductor partners.

Dataquest Conclusions

Advanced defect inspection systems continue to dominate the market and technology issues associated with wafer inspection equipment. Although growth in this segment of the market has been relatively stagnant the last two years, recent activities clearly indicate that companies have been busy. A new competitor entering the arena, the acquisition of an established player, and a host of new product offerings may well herald significant changes in company share and drive new market opportunities in the near future.

Appendix A
Introduction to the Wafer Fab Equipment Database

Introduction

This document contains detailed information on Dataquest's view of the semiconductor wafer fabrication equipment market for the years 1989 through 1991. This database is the result of an extensive research project conducted by SEMMS whereby we contact the world's wafer fab equipment manufacturers to obtain detailed regional and company market share data.

Market

Dataquest has organized the wafer fab equipment market into 10 major categories of front-end processing equipment. These categories, along with key subcategories, are shown in Table A-1.

This equipment is used to perform five key tasks in the semiconductor device fabrication process, as follows:

- Patterning of a thin film (lithography and automatic photoresist processing equipment)
- Etching and cleaning of thin films and/or substrate surfaces (wet process, dry strip, dry etch equipment)
- Depositing a thin film (chemical vapor deposition, physical vapor deposition, silicon epitaxy, metalorganic CVD, and molecular beam epitaxy equipment)
- Modify the properties of a thin film or substrate (diffusion and ion implantation)
- And finally, verify that all previous steps in the fabrication process have been performed correctly (process control equipment including optical critical dimension (CD) measurement, CD scanning electron microscopy (SEM), and wafer inspection)

Capital spending by the world's merchant and captive semiconductor manufacturers consists of three components: spending for front-end, or wafer fab equipment; spending for back-end, or assembly and test equipment; and spending for property and plant. The total world market for the 10 categories of wafer fab equipment as defined in this database is equal to the total capital spending for front-end equipment by the world's semiconductor manufacturers.

Table A-1
Wafer Fab Equipment Categories

1. Lithography
   - Contact/Proximity
   - Projection Aligners
   - Steppers
   - Direct-Write Lithography
   - Maskmaking Lithography
   - X-Ray
2. Automatic Photoresist Processing Equipment
3. Etch and Clean
   - Wet Process
   - Dry Strip
   - Dry Etch
   - Ion Milling
4. Deposition
   - Chemical Vapor Deposition
   - Physical Vapor Deposition
   - Silicon Epitaxy
   - Metalorganic CVD
   - Molecular Beam Epitaxy
5. Diffusion
6. Rapid Thermal Processing
7. Ion Implantation
   - Medium Current
   - High Current
   - High Voltage
8. Process Control
   - Optical CD
   - CD SEM
   - Wafer Inspection
   - Other Process Control
9. Factory Automation
10. Other Equipment

Source: Dataquest (July 1992)

Most of the equipment categories are self-explanatory; however, a few categories require further definition. The Other Process Control category represents a broad market that includes mask inspection and repair equipment, process monitoring equipment, surface analysis equipment, and analytical instrumentation. This is a highly fragmented market with dozens of companies selling into a multitude of noncompetitive market niches.

Factory Automation includes CIM software for shop floor control, factory host computer systems, cell controllers and interface hardware, and wafer transport systems including automatic guided vehicles, robotics, and rail transport systems.

Other Equipment is a general, catchall category that includes the other capital equipment used throughout the fab but not classified with the other nine major types of wafer processing equipment. Included in this segment are decontamination systems, wafer markers, gas analyzers, storage stations, and other types of equipment.

Conventions

The data in the tables represent end-user revenue for calendar year shipments, organized by company or by region. For companies with a different fiscal year, calendar year shipments have been estimated. Shipments do not include spare parts or service but do include retrofits and upgrades. In addition, our market estimates reflect only equipment used in the front-end wafer fabrication process. We do not include equipment used in other market applications such as flat panel display manufacturing, thin film head manufacturing, or multichip modules. Finally, as part of our convention to report end-user revenue, the revenue associated with equipment kits sent from one company to be fabricated and assembled by another company is valued at the full system shipment price to the semiconductor manufacturer, rather than at the value of the kit. Thus, for public companies, the sales reported here may be different from the sales reported in the annual reports.

Exchange Rates

Worldwide market share estimates combine data from many countries, each of which has different and fluctuating exchange rates. Estimates of non-U.S. market consumption or revenue are based upon the average exchange rate for the given year. As a rule, our estimates are calculated in local currencies, and then converted to U.S. dollars.

For example, Japanese-manufactured equipment sold in Japan is valued in dollars in the database tables at the average exchange rate for each year, as shown in the following:

Yen/Dollar Exchange Rate

1989	1990	1991
139	144	135

Equipment Companies

Table A-2 presents a list of the equipment companies found in the database tables by region of company ownership. (Please note that Table A-2 includes companies that are currently active in the wafer fab

Table A-2
Wafer Fab Equipment Companies

North American Companies		
Advantage Production Technology	Gemini	Poly-Flow Engineering
AG Associates	General Signal Thinfilm Company	Process Products
Alameda Instruments	Genus	Process Technology Ltd.
American Semiconductor Equip. Tech.	Hampshire Instruments	Pure Aire Corporation
Amray	High Temperature Engineering	Rapro
Angstrom Measurements	Innotec	Reichert-McBain
Anicon	Insystems	S&K Products International
Applied Materials	Integrated Air Systems	Santa Clara Plastics
Ateq	Ion Tech	SCI Manufacturing
Athens	IPEC	Semiconductor Systems Inc.
Biorad	IVS Inc.	Semifab
Bjorne Enterprises	KLA Instruments	Semitherm
Branson/IPC	Kurt J. Lesker	Semitool
BTU International	Lam Research	Silicon Valley Group
CFM Technology	LFE	SiScan Systems
CHA Industries	Machine Technology Inc.	Solitec
CPA	Materials Research Corp.	Spectrum CVD
Crystal Specialties	Matrix	Spire
CVC Products	Mattson Technologies	Sputtered Films
CVD Equipment	Metrologix	SubMicron Systems Inc.
Denton Vacuum	Micronix	Tegal
Dexon	Moore	Tempress
Drytek	MR Semicon	Thermco
Eaton	MRL Industries	Tylan
Emcore	Nanometrics	Ultratech
Epitaxy Inc.	Nanoquest	Universal Plastics
Estek	Nanosil	Varian

(Continued)

Table A-2 (Continued)
Wafer Fab Equipment Companies

Etec	National Electrostatics	Veeco
Focus Semiconductor	Novellus Systems Inc.	Verteq
FSI International	Optical Specialties Inc.	Watkins-Johnson
Fusion Semiconductor Systems	Peak Systems	
Gasonics	Perkin-Elmer	
GCA	Plasma-Therm	
	Japanese Companies	
ABT Corporation	Holon	Samco
Advanced Film Technology Inc.	Japan Production Engineering	Sankyo Engineering
Amaya	JEOL	Seiden Sha
Anelva	Kaijo Denki	Seiko
Canon	Kokusai Electric	Shibaura
Chemitronics	Koyo Lindberg	Shimada
Chlorine Engineering	Kuwano Electric	Shinko Electric
Dainippon Screen	Kyoritsu	Sugai
Daiwa Semiconductor	Maruwa	Sumitomo Metals
Dan Science Co. Ltd.	MRC (Sony)	Tazmo
Denko	Musashi	Tohokasei
Disco	Nidek	Tokuda
Eiko	Nikon	Tokyo Electron Ltd.
Elionix	Nippon EMC	Tokyo Ohka Kogyo
Enya	Nippon Sanso	Toshiba
Ergo Plasma Systems	Nissin Electric	Toyoko Chemical
ETE Company Ltd.	Plasma Systems	Ulvac
Fuji Electric	Ramco	Ushio
Hitachi	Ryokosha	Yuasa

(Continued)

Table A-2 (Continued)
Wafer Fab Equipment Companies

	European Companies	
AET	Helmut Seier	Sitesa
Addax Technologies	ISA Riber	Technics
Aixtron	Jipelec	Temescal
ASM International	Karl Suss	Thomas Schwonn
ASM Lithography	Leica	VG Instruments
Balzers	Leica Lasertechnik	Vickers Instruments
BCT Spectrum	Leybold-Heraeus	Wellman Furnaces
Cambridge Instruments	LPE	Wild Leitz
Centrotherm	Micro-Controle	Wild Leitz Instruments
Convac	Nano-Master	Zeiss
CVT	Plasma Technology	
E.T. Electrotech	Pokorny	
EEV	Sapi Equipments	
Heidelberg Instruments	Semco Engineering	
	Joint Venture Companies	
Alcan Technology	TEL/LAM	Ulvac/BTU
BTU/Ulvac	TEL/Varian	Varian/TEL
Sumitomo/Eaton Nova	M·FSI	

Source: Dataquest (July 1992)

equipment industry in addition to those companies that, for whatever reason, are no longer participants.) The database comprises a total of 96 U.S. equipment companies, 58 Japanese companies, 38 European companies, and 8 joint venture companies. These 200 companies account for virtually all of the world's wafer processing equipment for lithography, automatic photoresist processing, etch and clean, deposition, diffusion, rapid thermal processing, ion implantation, critical dimension and wafer inspection equipment.

Table A-3 presents a summary of recent mergers and acquisitions in the wafer fab equipment industry. Merger and acquisition activity is often accompanied by a change in company name. These changes have been incorporated in our market share tables. For example, Vickers Instruments was acquired by Biorad in early 1989. Thus, Vickers' sales of optical CD and CD SEM equipment in 1989 is found under the company's new name, Nanoquest; subsequently, estimates under the Vickers category drop to 0.

Notes on Market Share

In the process of conducting data collection and evaluating market statistics, Dataquest will sometimes consolidate or revise previously published market estimates. We revise one year of history only in those situations when an individual company's market position or the size of a given regional market for a segment of wafer fab equipment would be altered significantly.

Dataquest believes that the estimates presented within this document are the most accurate and meaningful statistics available.

Despite the care taken in gathering, analyzing, and catergorizing the data in a meaningful way, careful attention must be paid to the definitions and assumptions used herein when interpreting the estimates presented in this document. Variuos companies, government agencies, and trade associations may use slightly different definitions of product catergories and regional groupings, or they may include different companies in their summaries. These differences should be kept in mind when making comparisions between data and numbers provided by Dataquest and those provided by other suppliers.

Table A-3
Summary of Mergers and Acquisitions Incorporated in the Wafer Fab Equipment Database

Company	Action	Company	Now Identified As	First Year Change Noted In Database
Angstrom Measurement	acquired by	IVS, Inc.	IVS, Inc.	1992
BCT Spectrum	acquired by	MRC Sony	MRC Sony	1992
Ateq Corporation	merges with	Etec Systems Corporation	Etec Systems, Inc.	1992
Tokuda	acquired by	Shibaura	Shibaura	1991
Denko Systems	name change to	Shinko Electric	Shinko Electric	1991
Sitesa S.A.	acquired by	Addaz Technologies	Addax Technologies	1991
ABT Corporation	acquired by	Toshiba	Topcon	1991
BTU/Ulvac	acquired by	Ulvac	Ulvac	1991
Ulvac/BTU	acquired by	Ulvac	Ulvac	1991
Micro-Controle	name change to	Nano-Master	Nano-Master	1991
Spectrum CVD	acquired by	Balzers AG	BCT Spectrum	1991
Semiconductors Systems Inc.	management buyout from	General Signal	Semiconductor Systems Inc.	1991
Branson/PC	merged with	Gasonics	Gasonics	1991
ASM Lithography (e-beam lithography group)	acquired by	Cambridge Instruments	Leica	1990
Circuits Processing Apparatus (GSTC)	management buyout from	General Signal Thinfilm	CPA	1990
Materials Research Corp.	acquired by	Sony	Materials Research Corp.	1990
Nanoquest	name change to	-	Biorad Micro-measurements	1990
Perkin-Elmer (e-beam lithography group)	acquired by	industry consortium	Etec Systems, Inc.	1990

(Continued)

Table A-3 (Continued)
Summary of Mergers and Acquisitions Incorporated in the Wafer Fab Equipment Database

Company	Action	Company	Now Identified As	First Year Change Noted In Database
Perkin-Elmer (optical lithography group)	acquired by	Silicon Valley Group	SVG Lithography	1990
Wild Leitz	merged with	Cambridge Instruments	Leica	1990
Wild Leitz Instruments	name change to	-	Leica Lasertechnik	1990
ASM Lithography (50% of joint venture)	acquired by	Philips	ASM Lithography	1989
Cambridge Instruments (MOCVD group)	acquired by	MR Semicon	MR Semicon	1989
Estek (wet processing equipment group)	acquired by	Verteq	Verteq	1989
GCA Corporation	acquired by	General Signal	GCA Corporation	1989
Heidelberg Instruments	acquired by	Wild Leitz	Wild Leitz Instruments	1989
TEL/Thermco	acquired by	Tokyo Electron Ltd.	Tokyo Electron Ltd.	1989
Thermco	acquired by	Silicon Valley Group	Silicon Valley Group	1989
Tylan (diffusion and CVD group)	management buyout from	Tylan	Tystar	1989
Vickers Instruments	acquired by	Biorad	Nanoquest	1989
General Ionex	acquired by	Genus	Genus	1988
TEL/Lam	acquired by	Tokyo Electron Ltd.	Tokyo Electron Ltd.	1988
Tempress	merged with	Circuits Processing Apparatus	General Signal Thinfilm	1988
AET Addax (RTP group)	acquired by	Sitesa	Sitesa Addax	1987
Anicon	acquired by	Silicon Valley Group	Silicon Valley Group	1987
Gemini	acquired by	Lam Research	Lam Research	1987

Source: Dataquest (July 1992)

Appendix B
Wafer Fab Equipment—Summary Data by Category

This section of the equipment database consists of two summary tables for the worldwide fab equipment market. Both tables present sales by equipment category for the years 1989 to 1991. In Table B-1, the annual sales for each equipment category are organized by region of equipment sales; in Table B-2, annual sales for each equipment category are organized by equipment vendor nationality (United States, Japan, and Europe). Joint venture equipment companies have their own listing.

For example, the total worldwide sales for contact/proximity aligners of $22.6 million in 1989 is the same in both Table B-1 and Table B-2; however, whereas Table B-1 breaks the sales down by region, Table B-2 breaks the sales down by nationality of the companies supplying the aligners.

In Table B-2, the subtotal fab equipment line item designates that portion of the total worldwide fab equipment market for which detailed company data are available. For some of the categories in Table B-2 (Ion Milling, Other Process Control, Factory Automation, and Other Equipment), detailed company data are not complete. For these categories, top-down estimates have been made and included in Tables B-1 and B-2 so that world fab equipment sales are consistent across all tables. Detailed company data are available for approximately 86 percent of the total worldwide wafer fab equipment market for 1991.

Table B-1
Revenue from Shipments of Wafer Fab Equipment into Each Region
(End-User Revenue in Millions of U.S. Dollars)

	1989	1990	1991
Lithography			
Contact/Proximity			
North American Market	7.3	6.2	2.6
Japanese Market	5.7	8.6	7.9
European Market	6.0	5.3	7.0
Asia/Pacific-ROW Market	3.6	3.9	3.3
Total Contact/Prox.	22.6	24.0	20.8
Projection Aligners			
North American Market	22.4	24.8	14.8
Japanese Market	43.9	36.9	30.7
European Market	13.0	15.1	7.6
Asia/Pacific-ROW Market	15.0	16.6	15.3
Total Projection	94.3	93.4	68.4
Total Steppers			
North American Market	336.4	289.0	277.5
Japanese Market	532.4	535.5	502.1
European Market	110.6	131.8	94.1
Asia/Pacific-ROW Market	201.3	95.9	155.4
Total Projection	1,180.7	1,052.2	1,029.1
Direct-Write Lithography			
North American Market	10.0	15.9	7.3
Japanese Market	34.5	27.1	35.6
European Market	20.4	24.1	7.3
Asia/Pacific-ROW Market	5.2	9.1	5.1
Total Direct-Write	70.1	76.2	55.3
Maskmaking Lithography			
North American Market	15.4	14.7	9.5
Japanese Market	40.1	22.9	29.8
European Market	8.2	3.5	3.0
Asia/Pacific-ROW Market	5.5	6.0	3.5
Total Maskmaking	69.2	47.1	45.8
X-Ray			
North American Market	2.0	.0	2.4
Japanese Market	.0	.0	1.8
European Market	2.8	1.6	.0
Asia/Pacific-ROW Market	.0	.0	.0
Total X-Ray	4.8	1.6	4.2

(Continued)

Table B-1 (Continued)
Revenue from Shipments of Wafer Fab Equipment into Each Region
(End-User Revenue in Millions of U.S. Dollars)

	1989	1990	1991
Total Lithography			
North American Market	393.5	350.6	314.1
Japanese Market	656.6	631.0	607.9
European Market	161.0	181.4	119.0
Asia/Pacific-ROW Market	230.6	131.5	182.6
Total Lithography	1,441.7	1,294.5	1,223.6
Automatic Photoresist Processing Equipment			
North American Market	91.1	90.7	110.4
Japanese Market	156.2	171.4	179.3
European Market	38.6	35.5	34.5
Asia/Pacific-ROW Market	47.7	28.4	44.4
Total Track	333.6	326.0	368.6
Etch and Clean			
North American Market	87.8	74.9	105.6
Japanese Market	201.7	245.8	204.8
European Market	43.3	44.0	34.7
Asia/Pacific-ROW Market	44.0	35.3	59.9
Total Wet Process	376.8	400.0	405.0
Dry Strip			
North American Market	27.0	25.1	32.2
Japanese Market	75.9	75.5	62.1
European Market	6.9	9.3	9.2
Asia/Pacific-ROW Market	11.4	7.8	15.6
Total Dry Strip	121.2	117.7	119.1
Dry Etch			
North American Market	186.1	184.5	173.1
Japanese Market	329.9	365.9	356.6
European Market	74.5	95.6	77.8
Asia/Pacific-ROW Market	79.0	44.4	97.2
Total Dry Etch	669.5	690.4	704.7
Ion Milling			
North American Market	3.0	3.0	3.8
Japanese Market	5.0	5.0	7.0
European Market	3.0	3.0	2.1
Asia/Pacific-ROW Market	1.5	2.0	3.8
Total Ion Milling	12.5	13.0	16.7

(Continued)

Table B-1 (Continued)
Revenue from Shipments of Wafer Fab Equipment into Each Region
(End-User Revenue in Millions of U.S. Dollars)

	1989	1990	1991
Total Etch and Clean			
North American Market	303.9	287.5	314.7
Japanese Market	612.5	692.2	630.5
European Market	127.7	151.9	123.8
Asia/Pacific-ROW Market	135.9	89.5	176.5
Total Etch and Clean	1,180.0	1,221.1	1,245.5
Deposition			
CVD			
North American Market	193.3	224.4	188.6
Japanese Market	262.4	343.7	369.7
European Market	73.2	92.9	76.4
Asia/Pacific-ROW Market	82.3	55.5	112.7
Total CVD	611.2	716.5	747.4
PVD			
North American Market	111.8	132.2	133.0
Japanese Market	175.0	197.6	232.4
European Market	45.0	50.7	43.3
Asia/Pacific-ROW Market	36.6	28.0	65.3
Total PVD	368.4	408.5	474.0
Silicon Epitaxy			
North American Market	31.7	35.7	24.8
Japanese Market	20.7	18.2	46.1
European Market	16.5	11.9	11.0
Asia/Pacific-ROW Market	6.1	2.4	6.7
Total Silicon Epitaxy	75.0	68.2	88.6
Metalorganic CVD			
North American Market	14.9	12.2	13.9
Japanese Market	16.6	16.2	22.9
European Market	9.6	13.5	9.4
Asia/Pacific-ROW Market	3.5	2.4	5.2
Total MOCVD	44.6	44.3	51.4
Molecular Beam Epitaxy			
North American Market	20.8	9.3	10.5
Japanese Market	22.3	25.1	29.8
European Market	23.7	12.2	10.6
Asia/Pacific-ROW Market	7.2	11.4	8.0
Total MBE	74.0	58.0	58.9

(Continued)

Table B-1 (Continued)
Revenue from Shipments of Wafer Fab Equipment into Each Region
(End-User Revenue in Millions of U.S. Dollars)

	1989	1990	1991
Total Deposition			
North American Market	372.5	413.8	370.8
Japanese Market	497.0	600.8	700.9
European Market	168.0	181.2	150.7
Asia/Pacific-ROW Market	135.7	99.7	197.9
Total Deposition	1,173.2	1,295.5	1,420.3
Diffusion			
North American Market	87.8	77.1	79.9
Japanese Market	128.2	172.8	154.1
European Market	46.2	41.1	36.3
Asia/Pacific-ROW Market	68.4	33.0	64.8
Total Diffusion	330.6	324.0	335.1
Rapid Thermal Processing			
North American Market	10.4	14.6	18.4
Japanese Market	7.0	9.2	14.4
European Market	4.1	3.1	6.9
Asia/Pacific-ROW Market	3.6	2.8	2.1
Total RTP	25.1	29.7	41.8
Ion Implantation			
Medium Current			
North American Market	23.5	17.2	16.3
Japanese Market	76.8	69.7	59.6
European Market	8.7	7.9	13.7
Asia/Pacific-ROW Market	22.3	18.7	17.9
Total Medium Current	131.3	113.5	107.5
High Current			
North American Market	59.3	58.4	38.6
Japanese Market	164.7	136.1	129.7
European Market	26.3	27.1	26.5
Asia/Pacific-ROW Market	50.4	27.9	23.3
Total High Current	300.7	249.5	218.1
High Voltage			
North American Market	7.4	2.6	2.9
Japanese Market	15.5	4.2	11.4
European Market	.0	.0	3.3
Asia/Pacific-ROW Market	1.7	.0	.0
Total High Voltage	24.6	6.8	17.6

(Continued)

Table B-1 (Continued)
Revenue from Shipments of Wafer Fab Equipment into Each Region
(End-User Revenue in Millions of U.S. Dollars)

	1989	1990	1991
Total Implantation			
North American Market	90.2	78.2	57.8
Japanese Market	257.0	210.0	200.7
European Market	35.0	35.0	43.5
Asia/Pacific-ROW Market	74.4	46.6	41.2
Total Implantation	456.6	369.8	343.2
Optical CD*			
North American Market	25.4	22.9	19.8
Japanese Market	20.5	15.3	19.3
European Market	12.9	16.5	13.2
Asia/Pacific-ROW Market	10.8	4.2	7.0
Total Optical CD	69.6	58.9	59.3
CD SEM			
North American Market	26.2	23.2	17.9
Japanese Market	41.4	54.5	59.0
European Market	9.5	6.8	5.4
Asia/Pacific-ROW Market	3.5	3.1	12.0
Total CD SEM	80.6	87.6	94.3
Wafer Inspection			
North American Market	40.1	27.7	26.4
Japanese Market	42.9	40.2	41.1
European Market	23.4	18.3	15.6
Asia/Pacific-ROW Market	10.8	4.6	6.6
Total Wafer Inspection	117.2	90.8	89.7
Other Process Control			
North American Market	129.6	120.0	121.0
Japanese Market	176.8	171.0	181.0
European Market	48.8	45.0	42.0
Asia/Pacific-ROW Market	49.2	32.0	54.0
Total Other Process Control	404.4	368.0	398.0
Total Process Control			
North American Market	221.3	193.8	185.1
Japanese Market	281.6	281.0	300.4
European Market	94.6	86.6	76.2
Asia/Pacific-ROW Market	74.3	43.9	79.6
Total Process Control	671.8	605.3	641.3

(Continued)

Table B-1 (Continued)
Revenue from Shipments of Wafer Fab Equipment into Each Region
(End-User Revenue in Millions of U.S. Dollars)

	1989	1990	1991
Factory Automation			
North American Market	37.0	40.0	36.0
Japanese Market	112.0	121.0	132.0
European Market	25.0	27.0	23.0
Asia/Pacific-ROW Market	21.0	28.0	36.0
Total Automation	195.0	216.0	227.0
Other Equipment			
North American Market	58.2	50.8	49.1
Japanese Market	97.9	97.1	96.5
European Market	25.2	24.8	20.3
Asia/Pacific-ROW Market	28.5	16.7	27.2
Total Other Equipment	209.8	189.4	193.1
Total Wafer Fab Equipment			
North American Market	1,665.9	1,597.1	1,536.3
Japanese Market	2,806.0	2,986.5	3,016.7
European Market	725.4	767.6	634.2
Asia/Pacific-ROW Market	820.1	520.1	852.3
Total Fab Equipment	6,017.4	5,871.3	6,039.5

*The category of Optical CD includes dedicated overlay tools, in addition to joint linewidth/overlay measurement systems.

Ref: SUMMREG

Source: Dataquest (July 1992)

Table B-2
Each Regional Company Base's Revenue from Shipments of Wafer Fab Equipment to the World (End-User Revenue in Millions of U.S. Dollars)

	1989	1990	1991
World Fab Equipment Market	6,017.4	5,871.3	6,039.5
Lithography			
Contact/Proximity			
North American Companies	.0	.0	.0
Japanese Companies	6.3	10.5	7.9
European Companies	16.3	13.5	12.9
Joint Venture Companies	.0	.0	.0
Total Contact/Proximity	22.6	24.0	20.8
Projection Aligners			
North American Companies	44.9	37.0	21.2
Japanese Companies	49.4	56.4	47.2
European Companies	.0	.0	.0
Joint Venture Companies	.0	.0	.0
Total Projection	94.3	93.4	68.4
Steppers			
North American Companies	145.4	136.8	113.2
Japanese Companies	912.1	824.4	844.6
European Companies	123.2	91.0	71.3
Joint Venture Companies	.0	.0	.0
Total Steppers	1,180.7	1,052.2	1,029.1
Direct-Write Lithography			
North American Companies	9.9	10.5	.0
Japanese Companies	41.0	54.9	44.6
European Companies	19.2	10.8	10.7
Joint Venture Companies	.0	.0	.0
Total Direct-Write	70.1	76.2	55.3
Maskmaking Lithography			
North American Companies	34.7	28.0	25.5
Japanese Companies	29.6	16.6	17.8
European Companies	4.9	2.5	2.5
Joint Venture Companies	.0	.0	.0
Total Maskmaking	69.2	47.1	45.8
X-Ray			
North American Companies	2.0	.0	2.4
Japanese Companies	.0	.0	.0
European Companies	2.8	1.6	1.8
Joint Venture Companies	.0	.0	.0
Total X-Ray	4.8	1.6	4.2

(Continued)

Table B-2 (Continued)
Each Regional Company Base's Revenue from Shipments of Wafer Fab Equipment to the World
(End-User Revenue in Millions of U.S. Dollars)

	1989	1990	1991
Total Lithography			
North American Companies	236.9	212.3	162.3
Japanese Companies	1,038.4	962.8	962.1
European Companies	166.4	119.4	99.2
Joint Venture Companies	.0	.0	.0
Total Lithography	1,441.7	1,294.5	1,223.6
Automatic Photoresist Processing Equipment			
North American Companies	106.8	98.5	103.5
Japanese Companies	195.2	198.3	229.1
European Companies	12.2	15.4	18.9
Joint Venture Companies	19.4	13.8	17.1
Total Track	333.6	326.0	368.6
Wet Process			
North American Companies	114.5	96.2	122.7
Japanese Companies	248.6	291.6	271.0
European Companies	13.7	12.2	11.3
Joint Venture Companies	.0	.0	.0
Total Wet Process	376.8	400.0	405.0
Dry Strip			
North American Companies	39.8	37.8	38.8
Japanese Companies	68.3	68.2	59.4
European Companies	.0	.0	.0
Joint Venture Companies	13.1	11.7	20.9
Total Dry Strip	121.2	117.7	119.1
Dry Etch			
North American Companies	388.0	358.7	356.2
Japanese Companies	258.3	294.6	313.7
European Companies	17.0	23.0	18.3
Joint Venture Companies	6.2	14.1	16.5
Total Dry Etch	669.5	690.4	704.7
Deposition			
CVD			
North American Companies	372.3	416.4	418.5
Japanese Companies	143.6	170.6	195.4
European Companies	91.3	101.9	97.1
Joint Venture Companies	4.0	27.6	36.4
Total CVD	611.2	716.5	747.4

(Continued)

Table B-2 (Continued)
Each Regional Company Base's Revenue from Shipments of Wafer Fab Equipment to the World
(End-User Revenue in Millions of U.S. Dollars)

	1989	1990	1991
PVD			
North American Companies	157.7	123.0	173.5
Japanese Companies	161.1	236.1	271.3
European Companies	49.6	49.4	29.2
Joint Venture Companies	.0	.0	.0
Total PVD	368.4	408.5	474.0
Silicon Epitaxy			
North American Companies	46.9	36.8	35.3
Japanese Companies	12.2	6.7	18.4
European Companies	15.9	24.7	34.9
Joint Venture Companies	.0	.0	.0
Total Silicon Epitaxy	75.0	68.2	88.6
Metalorganic CVD			
North American Companies	15.7	17.0	18.5
Japanese Companies	14.5	11.2	16.9
European Companies	14.4	16.1	16.0
Joint Venture Companies	.0	.0	.0
Total MOCVD	44.6	44.3	51.4
Molecular Beam Epitaxy			
North American Companies	17.2	4.7	5.2
Japanese Companies	15.5	15.6	24.7
European Companies	41.3	37.7	29.0
Joint Venture Companies	.0	.0	.0
Total MBE	74.0	58.0	58.9
Total Deposition			
North American Companies	609.8	597.9	651.0
Japanese Companies	346.9	440.2	526.7
European Companies	212.5	229.8	206.2
Joint Venture Companies	4.0	27.6	36.4
Total Deposition	1,173.2	1,295.5	1,420.3
Diffusion			
North American Companies	117.2	100.3	88.6
Japanese Companies	159.5	167.9	203.8
European Companies	35.3	33.0	28.9
Joint Venture Companies	18.6	22.8	13.8
Total Diffusion	330.6	324.0	335.1

(Continued)

Table B-2 (Continued)
Each Regional Company Base's Revenue from Shipments of Wafer Fab Equipment to the World (End-User Revenue in Millions of U.S. Dollars)

	1989	1990	1991
Rapid Thermal Processing			
North American Companies	21.2	25.0	35.6
Japanese Companies	2.4	3.0	2.9
European Companies	1.5	1.7	3.3
Joint Venture Companies	.0	.0	.0
Total RTP	25.1	29.7	41.8
Ion Implantation			
North American Companies	223.7	199.7	191.6
Japanese Companies	82.9	64.8	63.5
European Companies	1.6	.0	.0
Joint Venture Companies	148.4	105.3	88.1
Total Ion Impantation	456.6	369.8	343.2
Optical CD[1]			
North American Companies	37.6	34.4	38.5
Japanese Companies	19.1	11.8	12.5
European Companies	12.9	12.7	8.3
Joint Venture Companies	.0	.0	.0
Total Optical CD	69.6	58.9	59.3
CD SEM			
North American Companies	16.0	11.5	12.9
Japanese Companies	64.6	76.1	81.4
European Companies	.0	.0	.0
Joint Venture Companies	.0	.0	.0
Total CD SEM	80.6	87.6	94.3
Wafer Inspection			
North American Companies	74.6	55.2	40.6
Japanese Companies	28.8	22.3	37.3
European Companies	13.8	13.3	11.8
Joint Venture Companies	.0	.0	.0
Total Wafer Insp.	117.2	90.8	89.7
Subtotal Fab Equipment[2]			
North American Companies	1,986.1	1,827.5	1,842.3
Japanese Companies	2,513.0	2,601.6	2,763.4
European Companies	486.9	460.5	406.2
Joint Venture Companies	209.7	195.3	192.8
Subtotal Fab Equipment	5,195.7	5,084.9	5,204.7

(Continued)

Table B-2 (Continued)
Each Regional Company Base's Revenue from Shipments of Wafer Fab Equipment to the World
(End-User Revenue in Millions of U.S. Dollars)

	1989	1990	1991
Ion Milling			
All Companies	12.5	13.0	16.7
Other Process Control			
All Companies	404.4	368.0	398.0
Factory Automation			
All Companies	195.0	216.0	227.0
Other Equipment			
All Companies	209.8	189.4	193.1
Total Fab Equip.	6,017.4	5,871.3	6,039.5

[1]The category of Optical CD includes dedicated overlay tools, in addition to joint linewidth/overlay measurement systems.

[2]Subtotal Fab Equipment does not include Ion Milling, Other Process Control, Factory Automation, and Other Equipment categories, as detailed company data are not complete for these categories. Aggregate data for these categories are added to provide a consistent total for the worldwide wafer fab equipment market.

Ref: SUMMSHR

Source: Dataquest (July 1992)

Appendix C
Wafer Fab Equipment—Company Shares by Category

This section of the equipment database contains detailed worldwide company market share data by region for the major front-end equipment categories for the years 1989, 1990, and 1991.

Table C-1
Each Company's Revenue from Shipments of Lithography Equipment to the World by Equipment Category (End-User Revenue in Millions of U.S. Dollars)

	1989	1990	1991
World Lithography Market	1,441.7	1,294.5	1,223.6
Contact/Proximity			
Canon	6.3	10.5	7.9
Karl Suss	16.3	13.5	12.9
Total Cont./Prox.	22.6	24.0	20.8
Projection Aligners			
Canon	49.4	56.4	47.2
Perkin-Elmer	44.9	.0	.0
SVG Lithography	.0	37.0	21.2
Total Projection	94.3	93.4	68.4
Steppers			
ASET	4.0	.0	.0
ASM Lithography	123.2	91.0	71.3
Canon	182.9	202.2	219.7
GCA	68.9	78.2	46.8
Hitachi	75.5	103.8	86.7
Nikon	653.7	518.4	538.2
Perkin-Elmer	10.2	.0	.0
SVG Lithography	.0	30.6	30.4
Ultratech	62.3	28.0	36.0
Total Steppers	1,180.7	1,052.2	1,029.1
Direct-Write Lithography			
ASM Lithography	7.2	.0	.0
Ateq	.0	.0	.0
Cambridge	12.0	.0	.0
Etec	.0	10.5	.0
Hitachi	9.4	19.5	17.8
JEOL	31.6	35.4	26.8
Leica	.0	10.8	10.7
Perkin-Elmer	9.9	.0	.0
Total Direct-Write	70.1	76.2	55.3

(Continued)

Table C-1 (Continued)
Each Company's Revenue from Shipments of Lithography Equipment to the World by Equipment Category (End-User Revenue in Millions of U.S. Dollars)

	1989	1990	1991
Maskmaking Lithography			
ASM Lithography	2.4	.0	.0
Ateq	13.7	14.0	15.0
Cambridge	2.5	.0	.0
Etec	.0	14.0	10.5
Hitachi	6.6	6.2	6.7
JEOL	15.8	10.4	11.1
Leica	.0	2.5	2.5
Perkin-Elmer	21.0	.0	.0
Toshiba	7.2	.0	.0
Total Maskmaking	69.2	47.1	45.8
X-Ray			
Hampshire Instruments	.0	.0	2.4
Perkin-Elmer	2.0	.0	.0
Karl Suss	2.8	1.6	1.8
Total X-Ray	4.8	1.6	4.2
Total Lithography	1,441.7	1,294.5	1,223.6

Ref: LITHSHR
NM = Not meaningful
Source: Dataquest (July 1992)

Table C-2
Each Company's Revenue from Shipments of Automatic Photoresist Processing Equipment (Track) to the World (End-User Revenue in Millions of U.S. Dollars)

	1989	1990	1991
Worldwide			
Canon	10.1	8.4	12.3
Convac	12.2	15.4	18.9
Dainippon Screen	67.7	59.2	69.5
Eaton	10.5	4.7	4.3
FSI International	.0	.0	4.8
GCA	.0	.0	.0
Machine Technology	11.3	21.0	26.6
Semiconductor Systems	22.0	23.0	14.0
Silicon Valley Group	54.0	44.0	48.9
Solitec	9.0	5.8	4.9
Tazmo	9.3	17.5	15.2
Tokyo Electron Ltd.	99.3	105.9	126.2
Varian/TEL	19.4	13.8	17.1
Yuasa	8.8	7.3	5.9
Total Worldwide	333.6	326.0	368.6

Ref: TRACKSHR
Source: Dataquest (July 1992)

Table C-3
Each Company's Revenue from Shipments of Wet Process Equipment to the World (End-User Revenue in Millions of U.S. Dollars)

	1989	1990	1991
World Wet Process Market	376.8	400.0	405.0
Integrated Wet Systems			
CFM Technology	.3	2.1	5.3
Dainippon Screen	41.8	43.4	40.9
Dalton Corporation	1.7	1.7	1.2
Dan Science Co., Ltd.	10.0	12.7	14.9
Dexon	4.4	.5	.0
ETE Company, Ltd.	2.9	7.6	10.4
Enya	6.5	7.0	10.7
Fuji Electric	10.7	2.0	2.1
Integrated Air Systems	.0	.0	.0
Kaijo Denki	22.4	30.9	29.9
Kuwano Electric	9.4	9.6	7.1
Maruwa	4.0	5.9	8.1
Musashi	1.2	5.8	4.1
Pokorny	4.7	6.2	6.6
Poly-Flow Engineering	.0	.0	.0
Pure-Aire	2.6	1.1	1.2
Sankyo Engineering	29.7	33.6	27.4
Santa Clara Plastics	14.3	9.2	19.5
Sapi Equipements	2.5	3.0	2.0
SCI Manufacturing	1.1	.4	4.8
Semifab	6.2	3.5	3.0
Shimada	8.6	16.3	13.4
Submicron Systems, Inc.	2.0	10.0	12.0
Sugai	29.8	34.3	31.4
S&K Products International	7.7	3.0	.0
Tohokasei	2.0	8.0	5.2
Toyoko Chemical	1.7	3.8	.9
Tokyo Electron	.0	.0	5.6
Universal Plastics	5.5	4.5	5.5
Verteq	1.1	1.7	1.7
Other Companies	8.2	.0	.0
Total Integr. Systems	243.0	267.8	274.9

(Continued)

Table C-3 (Continued)
Each Company's Revenue from Shipments of Wet Process Equipment to the World
(End-User Revenue in Millions of U.S. Dollars)

	1989	1990	1991
Manual Wet Benches			
Dainippon Screen	2.3	.0	.0
Dan Science Co., Ltd.	2.2	5.2	4.4
Dexon	2.0	.5	.0
Dalton Corporation	.9	.9	.7
Enya	4.0	4.7	.9
ETE Company, Ltd.	1.1	2.1	.5
Integrated Air Systems	.0	.0	.0
Kaijo Denki	1.1	1.6	.0
Kyoritsu	2.5	3.1	.0
Maruwa	1.4	6.4	6.9
Musashi	.7	.9	.7
Pokorny	3.5	1.2	1.2
Pure-Aire	.4	.2	.2
Sankyo Engineering	3.0	3.4	2.6
Santa Clara Plastics	2.3	.9	.7
Sapi Equipements	3.0	1.8	1.5
SCI Manufacturing	1.3	.0	.0
Semifab	1.4	3.0	3.5
Shimada	.0	.0	.0
Sugai	1.1	1.4	1.2
Tohokasei	1.1	2.4	1.2
Toyoko Chemical	1.1	1.3	.0
Universal Plastics	3.9	3.5	3.6
Verteq	.0	.0	.0
Other Companies	4.5	.0	.0
Total Man. Benches	44.8	44.5	29.8
Rinsers/Dryers			
Dainippon Screen	.0	.0	.0
Dan Science Co., Ltd.	.5	.3	.5
Enya	.0	.0	.0
Estek	.0	.0	.0
FSI International	1.2	4.3	3.7
Kaijo Denki	1.6	2.5	.9
Kuwano	.0	.0	.0

(Continued)

Table C-3 (Continued)
Each Company's Revenue from Shipments of Wet Process Equipment to the World
(End-User Revenue in Millions of U.S. Dollars)

	1989	1990	1991
Poly-Flow Engineering	.3	.2	.2
Sankyo Engineering	2.4	2.1	2.7
Semitool	7.7	8.6	9.4
Shimada	.0	.0	.0
S&K Products International	3.9	5.0	7.2
Sugai	.0	.0	.0
Tohokasei	.4	.5	.7
Verteq	6.6	7.0	6.0
Other Companies	.5	.0	.0
Total Rinser/Dryers	25.1	30.5	31.3
Acid Processors			
Advantage Production Technology	.0	.0	3.4
Alameda Instruments	.0	1.2	1.6
Athens	2.0	4.2	1.2
Dainippon Screen	7.9	11.8	11.5
FSI International	22.5	12.7	16.8
Musashi	.0	.0	.7
Poly-Flow Engineering	4.1	.3	.0
Semitool	3.2	2.9	2.7
Total Acid Process.	39.7	33.1	37.9
Megasonic Cleaners			
Dainippon Screen	16.5	10.5	14.1
Enya	1.1	.0	.0
FSI International	1.5	.9	1.3
Kaijo Denki	.1	2.1	2.3
S&K Products	.0	.0	1.0
Shimada	.0	5.8	5.2
Verteq	5.0	4.8	7.2
Total Megasonics	24.2	24.1	31.1
Total W.W. Wet Process	376.8	400.0	405.0

Ref: WETSHR

Source: Dataquest (July 1992)

Table C-4
Each Company's Revenue from Shipments of Dry Strip Equipment to the World
(End-User Revenue in Millions of U.S. Dollars)

	1989	1990	1991
World Dry Strip Market	121.2	117.7	119.1
Worldwide			
Alcan Tech	13.1	11.7	19.2
Branson/IPC	16.0	14.5	.0
Chemitronics	.0	.0	.0
Chlorine Engineers	2.8	2.7	.0
Drytek	1.4	.0	.0
Fusion Semiconductor Systems	1.5	1.5	1.9
Gasonics	6.2	8.2	22.9
Hitachi	5.0	2.7	5.6
LFE	1.7	1.4	1.5
Lam Research	.0	.0	.0
m.FSI	.0	.0	1.7
Machine Technology	1.5	.2	.0
Matrix	7.0	9.0	7.5
Mattson Technologies	.0	.0	1.5
Plasma Systems	17.0	24.9	21.2
Plasma-Therm	1.0	.0	.0
Ramco	11.0	16.0	10.3
Samco	1.0	.9	1.1
Shinko Seiki	.0	.0	1.1
Sumitomo Metals	.0	.0	2.1
Tegal	3.5	3.0	3.5
Tokyo Ohka Kogyo	26.0	18.7	15.7
Ulvac	5.5	2.3	2.3
Total Worldwide	121.2	117.7	119.1

Source: Dataquest (July 1992)

Table C-5
Each Company's Revenue from Shipments of Dry Etch Equipment to the World (End-User Revenue in Millions of U.S. Dollars)

	1989	1990	1991
World Dry Etch Market	669.5	690.4	704.7
Worldwide			
Alcan Technology	.0	2.5	5.6
Anelva	48.5	29.4	22.3
Applied Materials	208.0	175.0	154.0
Branson/IPC	3.2	3.5	.0
Drytek	30.0	22.0	25.0
Elionix	.3	1.2	.7
E.T. Electrotech	15.0	17.5	12.0
GCA	.0	.0	.0
Gasonics	.0	.0	5.0
Hitachi	47.6	91.5	115.2
Kokusai	1.0	1.1	.0
Lam Research	83.2	109.2	127.1
Materials Research	7.4	.0	.0
Matrix	.0	.0	2.3
MRC (Sony)	.0	4.7	9.6
Plasma Systems	3.3	1.7	1.5
Plasma Technology	2.0	5.5	6.3
Plasma-Therm	15.2	18.0	13.8
Samco	2.2	2.8	3.4
Shibaura	.0	.0	14.1
Sumitomo Metals	12.0	15.7	15.4
Tegal	41.0	31.0	29.0
Tokyo Electron	80.6	99.2	110.0
Tokuda	32.4	24.1	.0
Tokyo Ohka	21.7	16.6	15.3
TEL/LAM	.0	.0	.0
Ulvac	8.7	6.6	6.2
Varian/TEL	6.2	11.6	10.9
Total Worldwide	669.5	690.4	704.7

Ref: DETCHSHR
Source: Dataquest (July 1992)

Table C-6
Each Company's Revenue from Shipments of Chemical Vapor Deposition Equipment to the World
(End-User Revenue in Millions of U.S. Dollars)

	1989	1990	1991
World CVD Market	611.2	716.5	747.4
Tube CVD			
Horizontal Tube LPCVD			
ASM International	15.0	10.0	7.9
BTU International	17.5	7.2	6.0
Centrotherm	4.5	4.8	3.1
Enya	1.7	.0	.0
General Signal Thinfilm	4.0	3.0	.0
Kokusai Electric	2.2	4.5	1.6
Koyo Lindberg	3.0	1.0	.0
Process Technology	2.5	3.0	1.4
Silicon Valley Group	10.0	10.0	9.3
Solitec	5.0	5.0	.0
TEL/Thermco	.0	.0	.0
Thermco	.0	.0	.0
Tokyo Electron Ltd.	14.7	6.9	7.1
Tylan	.0	.0	.0
Tystar	.8	.4	.3
Ulvac	.0	.0	5.3
Ulvac/BTU	4.0	6.2	.0
Varian/TEL	.0	2.1	1.9
Wellman	.3	.0	.0
Total Horizontal LPCVD	85.2	64.1	43.9
Vertical Tube LPCVD			
ASM International	3.0	17.5	22.6
BTU International	.0	5.0	4.5
Denko	3.5	3.8	.0
Disco	.0	.0	2.7
General Signal Thinfilm	2.0	4.0	3.0
Helmut Seier	.0	.0	.0
Koyo Lindberg	1.1	2.1	1.9
Kokusai Electric	44.9	55.1	62.0
Semitherm	1.0	1.5	1.5
Shinko Electric	.0	.0	6.2
Silicon Valley Group	4.0	11.2	16.5

(Continued)

Table C-6 (Continued)
Each Company's Revenue from Shipments of Chemical Vapor Deposition Equipment to the World
(End-User Revenue in Millions of U.S. Dollars)

	1989	1990	1991
Toyoko Chemical	5.8	5.9	5.0
Tokyo Electron Ltd.	15.9	34.0	53.0
Ulvac	.0	.0	5.0
Varian/TEL	.0	2.7	7.7
Total Vertical LPCVD	81.2	142.8	191.6
Horizontal Tube PECVD			
ASM International	51.0	49.6	40.0
Pacific Western	2.8	2.5	1.0
Total Horizontal Tube PECVD	53.8	52.1	41.0
Total Worldwide Tube CVD	220.2	259.0	276.5
Non-Tube CVD Reactors			
APCVD Reactors			
Alcan (Canon)	.0	15.0	26.8
Amaya	19.0	16.0	12.3
Applied Materials	9.0	5.0	.0
General Signal Thinfilm	.8	.8	.5
Hitachi	1.1	.0	.0
Kokusai Electric	.0	.0	.0
Koyo Lindberg	.6	.8	.6
Pacific Western	.0	.0	.0
Tempress	1.3	1.3	.0
Toshiba Machine	4.2	3.2	3.2
Watkins-Johnson	42.0	41.0	48.5
Total APCVD Reactors	78.0	83.1	91.9
LPCVD Reactors			
Anicon	2.0	1.3	.0
Anelva	1.1	1.4	2.8
Applied Materials	.0	26.0	32.0
BCT Spectrum	.0	.0	2.0
BTU/Ulvac	.0	1.6	.0
Enya	1.7	3.5	.0
Focus Semiconductor	.0	.0	.0
Genus	62.0	44.0	34.8
Kokusai Electric	.0	3.1	.0
LAM Research	.0	2.7	1.9

(Continued)

Table C-6 (Continued)
Each Company's Revenue from Shipments of Chemical Vapor Deposition Equipment to the World
(End-User Revenue in Millions of U.S. Dollars)

	1989	1990	1991
Novellus	.0	1.0	5.7
Silicon Valley Group	2.0	1.3	.0
Spectrum CVD	3.6	3.2	.0
Tokyo Electron, Ltd.	.0	4.9	2.7
Ulvac	4.2	4.5	8.0
Varian	5.0	.0	.0
Total LPCVD Reactors	81.6	98.5	89.9
PECVD Reactors			
Anelva	.4	.0	.0
Applied Materials	143.0	170.0	186.4
Enya	3.5	3.8	1.6
E.T. Electrotech	15.5	17.5	20.0
Japan Production	7.0	8.0	5.6
LAM Research	.0	.0	.0
Novellus	49.0	63.0	64.0
Plasma-Therm	3.0	3.0	1.2
Samco	1.0	2.3	3.0
Total PECVD Reactors	222.4	267.6	281.8
ECR CVD			
Anelva	1.0	.4	2.2
Fuji Electric	.0	.0	.9
Plasma Technology	2.0	2.5	1.5
Sumitomo Metals	6.0	5.4	2.7
Total ECR CVD Reactors	9.0	8.3	7.3
Total Worldwide Non-Tube CVD	391.0	457.5	470.9
Total Worldwide CVD	611.2	716.5	747.4

Ref: CVDSHR

Source: Dataquest (July 1992)

Table C-7
Each Company's Revenue from Shipments of Physical Vapor Deposition Equipment to the World (End-User Revenue in Millions of U.S. Dollars)

	1989	1990	1991
World PVD Market	368.4	408.5	474.0
Sputtering			
Advanced Film Tech.	.0	.7	.8
Anelva	80.9	90.8	114.5
Applied Materials	.0	15.0	55.0
Balzers	8.2	7.0	.0
CHA Industries	.1	.4	.7
Circuit Processing	.0	.0	.0
CPA	.0	1.0	2.0
CVC Products	12.0	7.5	7.0
E.T. Electrotech	14.1	13.5	12.0
GSTC	2.0	.0	.0
Innotec	.5	.8	.7
Ion Tech	.1	.1	.2
Kurt J. Lesker	.8	1.0	1.0
Leybold-Heraeus	8.8	7.8	4.4
Materials Research	54.0	.0	.0
MRC Sony	.0	62.6	84.5
Novellus	.0	.0	1.8
Perkin-Elmer	1.0	.0	.0
Shibaura	.0	.0	4.0
Shinko Seiki	.0	.0	.4
Sputtered Films	1.2	1.0	1.5
Temescal	.1	.1	.0
Tokuda	5.6	5.8	.0
Ulvac	55.7	58.6	54.5
Varian	73.0	84.0	90.9
Others	1.9	1.5	1.8
Total Sputtering	320.0	359.2	437.7

(Continued)

Table C-7 (Continued)
Each Company's Revenue from Shipments of Physical Vapor Deposition Equipment to the World
(End-User Revenue in Millions of U.S. Dollars)

	1989	1990	1991
Evaporation			
Anelva	4.3	4.1	4.1
Balzers	5.4	6.5	.0
CHA Industries	7.1	4.0	3.7
CVC Products	2.0	2.7	2.7
Innotec	.2	.4	.5
Kurt J. Lesker	.6	.6	.8
Leybold-Heraeus	1.8	1.5	2.0
Temescal	11.2	13.0	10.8
Ulvac	14.6	13.5	8.5
Others	1.2	3.0	3.2
Total Evaporation	48.4	49.3	36.3
Total Worldwide PVD	368.4	408.5	474.0

Ref: PVDSHR

Source: Dataquest (July 1992)

Table C-8
Each Company's Revenue from Shipments of Silicon Epitaxy Equipment to the World
(End-User Revenue in Millions of U.S. Dollars)

	1989	1990	1991
Worldwide			
Applied Materials	22.2	25.0	32.0
ASM Epitaxy	6.2	19.2	29.9
Kokusai Electric	5.7	2.2	5.9
Lam Research	22.2	7.9	.0
LPE	4.8	5.5	5.0
Moore	1.6	3.0	3.3
Rapro	.9	.9	.0
Sitesa	4.9	.0	.0
Toshiba Machine	6.5	4.5	12.5
Total Worldwide	75.0	68.2	88.6

Ref: EPISHR

Source: Dataquest (July 1992)

Table C-9
Each Company's Revenue from Shipments of Metalorganic CVD Equipment to the World (End-User Revenue in Millions of U.S. Dollars)

	1989	1990	1991
World MOCVD Market	44.6	44.3	51.4
Worldwide			
Aixtron	11.4	13.9	15.0
Cambridge Instruments	.0	.0	.0
Crystal Specialties	.0	.0	.0
CVD Equipment	1.3	.7	.7
CVT	2.0	2.2	1.0
Daiwa Semiconductor	.0	.0	.0
EEV	.0	.0	.0
Emcore	10.0	11.6	12.2
MR Semicon	2.0	3.0	4.6
Nippon EMC	2.2	1.7	2.2
Nippon Sanso	6.8	5.6	6.9
Nissin Electric	.0	.0	1.1
Samco	.6	.8	.9
Seiden	.0	.0	.0
Semco Engineering	1.0	.0	.0
Shimada Rika	.0	.0	.0
Spire	2.4	1.7	1.0
TEL	2.9	.0	.0
TEL/Thermco	.0	.0	.0
Thomas Schwonn	.0	.0	.0
Toyoko Chemical	.0	.0	.0
Ulvac	2.0	3.1	4.3
Yamoto	.0	.0	1.5
Total Worldwide	44.6	44.3	51.4

Ref: MOCVDSHR
Source: Dataquest (July 1992)

Table C-10
Each Company's Revenue from Shipments of Molecular Beam Epitaxy Equipment to the World
(End-User Revenue in Millions of U.S. Dollars)

	1989	1990	1991
Worldwide			
Anelva	6.8	6.2	8.7
Daido Sanso	.0	.0	1.8
Eiko	2.9	2.6	2.2
Emcore	.0	1.0	.0
Intevac	.0	.0	5.2
ISA Riber	22.3	20.3	14.0
Nissin Electric	.0	.0	.6
Perkin-Elmer	.0	.0	.0
Seiko	.0	.0	.0
Ulvac	4.0	4.9	5.9
Varian	17.2	3.7	.0
VG Instruments	19.0	17.4	15.0
Yamoto Semico	1.8	1.9	5.5
Total Worldwide	74.0	58.0	58.9

Ref: MBESHR

Source: Dataquest (July 1992)

Table C-11
Each Company's Revenue from Shipments of Diffusion Furnace Equipment to the World
(End-User Revenue in Millions of U.S. Dollars)

	1989	1990	1991
World Diffusion Market	330.6	324.0	335.1
Horizontal Tube			
ASM International	22.0	15.6	11.7
BTU International	41.0	18.0	13.0
Denko	.0	.0	.0
Gasonics	8.0	8.0	8.7
GSTC	5.0	4.0	1.0
Kokusai Electric	10.8	4.8	5.6
Koyo Lindberg	5.0	4.5	5.9
Pacific Western	.6	.6	.4
Process Technology	.0	.0	.0
Silicon Valley Group	52.0	38.0	28.0
Solitec	.0	.0	.0
TEL/Thermco	.0	.0	.0
Tempress	.0	.0	.0
Thermco	.0	.0	.0
Tokyo Electron Ltd.	73.0	44.2	37.0
Tylan	.0	.0	.0
Tystar	.6	.5	.5
Ulvac	.0	.0	10.4
Ulvac/BTU	10.0	13.2	.0
Varian/TEL	.7	4.2	5.7
Others	6.3	8.6	7.2
Total W.W. Horizontal	235.0	164.2	135.1

(Continued)

Table C-11 (Continued)
Each Company's Revenue from Shipments of Diffusion Furnace Equipment to the World
(End-User Revenue in Millions of U.S. Dollars)

	1989	1990	1991
Vertical Tube			
ASM International	7.0	8.8	10.0
BTU International	.0	6.0	6.0
Denko	4.0	6.9	.0
Disco	3.6	5.8	10.0
GSTC	3.0	5.0	2.0
Helmut Seier	.0	.0	.0
Koyo Lindberg	3.1	7.6	6.7
Kokusai Electric	43.1	46.1	62.5
Semitherm	2.0	4.0	3.0
Shinko Electric	.0	.0	7.4
Silicon Valley Group	5.0	16.2	26.0
TEL/Thermco	.0	.0	.0
Tokyo Electron Ltd.	16.9	48.0	55.7
Ulvac	.0	.0	2.6
Ulvac/BTU	2.3	3.3	.0
Varian/TEL	5.6	2.1	8.1
Total Worldwide Vertical	95.6	159.8	200.0
Total Worldwide	330.6	324.0	335.1

Ref: DIFF
Source: Dataquest (July 1992)

Table C-12
Each Company's Revenue from Shipments of Rapid Thermal Processing Equipment to the World (End-User Revenue in Millions of U.S. Dollars)

	1989	1990	1991
Worldwide			
Addax Technologies	.0	.0	2.3
AG Associates	11.0	14.6	24.4
Dainippon Screen	1.8	2.3	2.0
Eaton	.0	.0	.0
High Temperature Eng.	.0	.3	.8
Jipelec	.0	.7	1.0
Kokusai	.0	.0	.6
Koyo Lindberg	.6	.7	.3
Nanosil	.4	.5	.3
Peak Systems	8.5	8.4	8.6
Process Products	1.3	1.2	1.5
Sitesa Addax	1.5	1.0	.0
Varian	.0	.0	.0
Total Worldwide	25.1	29.7	41.8

Ref: RTPSHR

Source: Dataquest (July 1992)

Table C-13
Each Company's Revenue from Shipments of Ion Implantation Equipment to the World
(End-User Revenue in Millions of U.S. Dollars)

	1989	1990	1991
World Implanter Market	456.6	369.8	343.2
Medium Current			
Balzers	1.6	.0	.0
Eaton	23.0	17.5	12.6
Nissin	35.4	37.5	28.0
Sumitomo/Eaton Nova	.9	.0	.0
TEL/Varian	28.0	20.4	11.7
Ulvac	13.8	6.9	11.1
Varian	28.6	31.2	44.1
Total Medium Current	131.3	113.5	107.5
High Current			
Applied Materials	49.4	46.0	33.9
Eaton	56.0	50.1	40.6
Hitachi	14.4	11.2	10.2
Nissin	16.4	9.2	11.2
Sumitomo/Eaton Nova	47.5	51.6	45.7
TEL/Varian	72.0	33.3	30.7
Ulvac	.0	.0	.0
Varian	45.0	48.1	45.8
Total High Current	300.7	249.5	218.1
High Voltage			
Eaton	.0	.0	3.3
Genus	17.7	6.8	11.3
National Electrostatics	4.0	.0	.0
Nissin	2.9	.0	3.0
Sumitomo Eaton Nova	.0	.0	.0
Varian	.0	.0	.0
Total High Voltage	24.6	6.8	17.6
Total Worldwide	456.6	369.8	343.2

Ref: IMPLSHR

Source: Dataquest (July 1992)

Table C-14
Each Company's Revenue from Shipments of Optical CD and CD SEM Equipment to the World
(End-User Revenue in Millions of U.S. Dollars)

	1989	1990	1991
World Optical CD & CD SEM Market	150.2	146.5	153.6
Optical Critical Dimension			
Biorad	.0	10.1	9.9
Heidelberg Instruments	.0	.0	.0
Hitachi	6.6	5.4	4.2
IVS, Inc.	7.2	8.0	7.6
KLA Instruments	6.5	8.6	9.3
Leica	.0	6.5	1.8
Leica Lasertechnik	.0	1.0	.0
Micro-Controle	2.2	4.4	.0
Nano-Master	.0	.0	6.0
Nanometrics	.9	1.8	2.4
Nanoquest	9.0	.0	.0
Nidek	.3	.0	.0
Nikon	8.0	3.8	5.9
Optical Specialties	4.7	1.9	5.7
Perkin-Elmer	1.4	.0	.0
Reichert-McBain	.0	.0	.0
Ryokosha	1.4	1.0	.7
SiScan Systems	5.0	2.0	2.2
Vickers Instruments	.0	.0	.0
Wild Leitz	7.9	.0	.0
Wild Leitz Instruments	2.0	.0	.0
Other CD Companies	6.5	4.4	3.6
Total Optical CD	69.6	58.9	59.3

(Continued)

Table C-14 (Continued)
Each Company's Revenue from Shipments of Optical CD and CD SEM Equipment to the World
(End-User Revenue in Millions of U.S. Dollars)

	1989	1990	1991
CD SEM			
ABT Corporation	1.5	5.2	.0
Amray	2.1	1.7	3.4
Angstrom Measurements	.3	.0	2.2
Biorad	.0	6.9	4.9
Hitachi	57.0	62.0	69.6
Holon	6.1	8.9	8.0
JEOL	.0	.0	1.7
Metrologix	.0	.0	.0
Nanometrics	2.3	.5	.0
Nanoquest	8.5	.0	.0
Opal	2.8	2.4	2.4
Topcon	.0	.0	2.1
Vickers	.0	.0	.0
Total CD SEM	80.6	87.6	94.3
Total Worldwide CD & CD SEM	150.2	146.5	153.6

The category of Optical CD includes dedicated overlay tools, in addition to joint linewidth/overlay measurement systems.
Ref: CDSHR
Source: Dataquest (July 1992)

Table C-15
Each Company's Revenue from Shipments of Wafer Inspection Equipment to the World
(End-User Revenue in Millions of U.S. Dollars)

	1989	1990	1991
World Wafer Inspection Market	117.2	90.8	89.7
Wafer Inspection			
Canon	3.5	4.2	4.4
Estek	.0	.0	.0
Hitachi	.0	.0	11.6
Insystems	14.3	16.8	13.0
KLA Instruments	57.1	37.0	26.4
Leica	.0	6.8	4.9
Micro-Controle	3.1	5.0	5.4
Nidek	5.3	6.7	7.1
Nikon	19.1	10.7	13.1
Optical Specialties	2.0	.3	.1
Wild Leitz	8.8	.0	.0
Carl Zeiss	1.8	1.4	1.4
Other Companies	2.2	1.9	2.3
Total W.W. Wafer Inspection	117.2	90.8	89.7

Ref: INSPSHR

Source: Dataquest (July 1992)

Semiconductor Consumption and Shipment Forecast

June 29, 1992

Source: Dataquest

Market Statistics

Semiconductors *Worldwide*

SCWW-COR-MS-9201

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Semiconductor Consumption and Shipment Forecast

June 29, 1992

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Semiconductor Consumption and Shipment Forecast

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Note: All tables show estimated data.

Semiconductor Consumption and Shipment Forecast

Introduction

This document contains detailed information on Dataquest's view of the semiconductor device market. Included in this document are the following:

- 1987-1991 historical data
- 1992-1996 forecast data

Worldwide market revenue estimates combine data from many countries, each of which has a different and fluctuating exchange rate. Estimates of non-U.S. market revenue are based on the average exchange rate for the given year. Refer to the section entitled "Exchange Rates" for more information regarding these average rates. As a rule, Dataquest's estimates are calculated in local currencies and then converted to U.S. dollars.

The average exchange rate for a quarter is estimated as the simple arithmetic mean of the average monthly values for the three months of the quarter. Similarly, the average exchange rate for a year is estimated as the simple arithmetic mean of the average monthly values for the 12 months of the year.

Dataquest does not forecast exchange rates per se; however, we do forecast semiconductor markets in several regions of the world, and we use the U.S. dollar as a common currency for market comparisons. In the forecast period, Dataquest assumes that the most recent actual month's exchange rate will apply throughout all future months of the forecast. For example, the current semiconductor forecast uses actual exchange rates through June 1992, and assumes that the June rate applies throughout all future months. Then the quarterly and annual exchange rates are estimated as described in the previous paragraph.

More detailed data on this market may be requested through Dataquest's client inquiry service. Qualitative analysis of these data is provided in the *Dataquest Perspectives* located in the binder of the same name.

Segmentation

This section outlines the market segments specific to this document. Dataquest's objective is to provide data along lines of segmentation that are logical, appropriate to the industry in question, and immediately useful to clients.

For a detailed explanation of Dataquest's market segmentation, refer to the *Dataquest Research and Forecast Methodology* document located in the *Dataquest* binder. For a complete listing of all market segments tracked by Dataquest, please refer to the *Dataquest High-Technology Guide: Segmentation and Glossary.*

Dataquest defines the semiconductor industry as the group of competing companies primarily engaged in manufacturing semiconductors and related solid-state devices. Important products of the semiconductor industry include integrated circuits, discrete devices, and optoelectronic devices.

For forecasting purposes, Dataquest defines the semiconductor market according to the following functional segmentation scheme:

- Total Semiconductor
  - Total Integrated Circuit
    - Bipolar Digital
      - Bipolar Memory
      - Bipolar Logic
    - MOS Digital
      - MOS Memory
      - MOS Microcomponents
      - MOS Logic
    - Analog
  - Total Discrete
  - Total Optoelectronic

Definitions

This section lists the definitions used by Dataquest to present the data in this document. Complete definitions for all terms associated with Dataquest's segmentation of the high-technology marketplace can be found in the *Dataquest High-Technology Guide: Segmentation and Glossary.* Definitions for semiconductor devices can be found in the *Dataquest Semiconductor Market Share Survey Guide.*

Total Semiconductor (IC + Discrete + Optoelectronic). Defined as any active semiconductor product that contains semiconducting material (such as silicon, germanium, or gallium arsenide) and reacts dynamically to an input signal, either by modifying its shape or adding energy to it. This definition excludes standalone passive components such as capacitors, resistors, inductors, oscillators, crystals, transformers, and relays.

Total Integrated Circuit (Digital Monolithic Bipolar IC + Digital Monolithic MOS IC + Analog Monolithic IC). An IC is defined as a large number of passive and/or active discrete semiconductor circuits integrated into a single package. In a monolithic IC, discrete circuits are integrated onto a small number of dice.

Bipolar Digital (Bipolar Digital Memory IC + Bipolar Digital Logic IC). A bipolar digital IC is defined as a monolithic semiconductor product in which 100 percent of the die area performs digital functions, and concurrently, 100 percent of the die area is manufactured using bipolar semiconductor technology. A digital function is one in which data carrying signals vary in discrete values.

Bipolar Memory. Defined as a bipolar digital semiconductor product in which binary data are stored and electronically retrieved. Includes ECL random-access memory (RAM), read-only memory (ROM), programmable ROM (PROM), and first-in/first-out (FIFO) memory.

Bipolar Logic (Bipolar Application-Specific IC + Other Bipolar Logic IC + Bipolar Digital Microcomponent). Defined as a bipolar digital semiconductor product in which more than 50 percent of the die area performs logic functions. Includes bipolar digital microcomponent ICs.

MOS Digital (MOS Digital Memory IC + MOS Digital Microcomponent IC + MOS Digital Logic IC). Defined as a monolithic semiconductor product in which 100 percent of the die area performs digital functions, and concurrently, any portion of the die area is manufactured using metal oxide semiconductor (MOS) technology. A digital function is one in which data carrying signals vary in discrete values. Includes mixed technology manufacturing, such as BiMOS and BiCMOS, where some MOS technology is employed.

MOS Memory (DRAM + SRAM + EPROM + Other Nonvolatile MOS Digital Memory + Other MOS Digital Memory). Defined as an MOS digital IC in which binary data are stored and electronically retrieved.

MOS Microcomponents (MOS Digital Microprocessor + MOS Digital Microcontroller + MOS Digital Microperipheral). Defined as an MOS digital IC that contains a data processing unit or serves as an interface to such a unit. Includes both CISC and RISC.

MOS Digital Logic (MOS Digital Application-Specific IC + Other MOS Logic IC). Defined as an MOS digital semiconductor product in which more than 50 percent of the die area performs logic functions. Excludes MOS digital microcomponent ICs.

Analog IC. Defined as monolithic analog ICs plus hybrid ICs. (A monolithic analog IC is a semiconductor product that deals in the realm of electrical signal processing, power control, or electrical drive capability. It is one in which some of the inputs or outputs can be defined in terms of continuously or linearly variable voltages, currents, or frequencies. Includes all monolithic analog ICs manufactured using bipolar, MOS, or BiCMOS technologies. A monolithic IC is a single die contained in a single package. A hybrid IC is a semiconductor product that consists of more than one die contained in a single package. A hybrid IC may perform 100 percent linear, 100 percent digital, or mixed-signal (both linear and digital) functions. Note that hybrid digital ICs are reported in this category, and not under the earlier category of monolithic digital ICs. Includes all hybrid ICs manufactured using bipolar, MOS, or BiCMOS technologies.)

Total Discrete (Transistor + Diode + Thyristor + Other Discrete). A discrete semiconductor is defined as a unit building block performing a fundamental semiconductor function.

Total Optoelectronic (LED Lamp/Display + Optocoupler + CCD + Laser Diode +

Photosensor + Solar Cell). Defined as a semiconductor product in which photons induce the flow of electrons, or vice versa. Other functions may also be integrated onto the product. This category does not include LCD, incandescent displays, fluorescent displays, cathode ray tubes (CRTs), or plasma displays.

Regional Definitions

North America: Includes United States and Canada

United States: Includes 48 contiguous states, Washington, D.C., Alaska, Hawaii, and Puerto Rico

Canada: Canada

Europe: Western Europe includes Benelux (Belgium, Netherlands, and Luxembourg), France, Italy, Scandinavia (Denmark, Finland, Norway, Sweden, and Iceland), United Kingdom and Eire (England, Wales, Scotland, Northern Ireland, and Ireland), Germany (including former East Germany), and Rest of Europe (Austria, Gibraltar, Greece, Liechtenstein, Malta, Monaco, Portugal, San Marino, Spain, Switzerland, Turkey, Andorra, and Vatican City)

Japan: Japan

Asia/Pacific: Includes East Asia (People's Republic of China, Hong Kong, Macau, North and South Korea, and Republic of China), South Asia (Bangladesh, Myanmar, India, Nepal, Maldives, Pakistan, Sri Lanka, and Bhutan), Southeast Asia (Brunei, Timor, Indonesia, Kampuchea, Laos, Malaysia, Philippines, Singapore, Thailand, Vietnam, Borneo, Sumatra, Sulawesi, and Java)

Rest of World: All other countries

Line Item Definitions

Factory revenue is defined as the money value received by a semiconductor manufacturer for its goods. Dataquest includes all revenue, both merchant and captive, for semiconductor suppliers selling to the marchant market. The data exclude completely captive suppliers where devices are manufacturered solely for the company's own use. A product that is used internally is valued at the market price rather than at the transfer or factory price.

Revenue estimates for 1989 and 1990 have been restated from previous publication to reflect minor modifications to the market share and market size methodology.

Forecast Methodology and Assumptions

Dataquest publishes five-year revenue forecasts for the semiconductor market during the second and fourth quarters of each year. In doing so, Dataquest uses a variety of forecasting techniques (both qualitative and quantitative) that vary by technology area. An overview of Dataquest forecasting techniques can be found in the *Dataquest Research and Forecast Methodology Guide*.

Dataquest's semiconductor forecast methodology leverages the resources of its parent, The Dun & Bradstreet Corporation, as well as the considerable internal resources of Dataquest.

Dun & Bradstreet Corporation information is used to develop the macroeconomic forecasts for the world's major economies. This forecast identifies trends in the economic health of the world's leading consumers and producers of electronic equipment. Using this forecast in conjunction with input from Dataquest's regional offices, Dataquest identifies the likelihood of whether a particular region or country will increase or decrease its consumption of electronic equipment.

Dataquest follows a four-step process to forecast the semiconductor market. First, Dataquest's Semiconductor Applications Market group, along with Dataquest's various electronics systems groups, provides a long-range outlook for the overall growth of the electronic equipment market. Semiconductor content ratios are developed by region to reflect the growing penetration of semiconductors into electronic equipment. This establishes a five-year trend growth path for total semiconductors for a five-year period from a demand-side perspective.

Second, Dataquest uses a decomposition time series model to generate forecasts of regional total semiconductor sales. The model assumes that sales are affected by factors such as long-run trends, short-run aggregate economic and industry-specific conditions, and seasonality. The forecast is made by using statistical methods to analyze each of the components separately, then combining them into a single aggregate. The model is especially useful for assessing market fluctuations about the trend growth path.

Third, Dataquest's worldwide semiconductor service and its Semiconductor Equipment, Materials, and Manufacturing service, in conjunction with its various regional offices, collaborate to formulate expectations of semiconductor market short-range fluctuations around the long-range trend. Tactical market issues and anticipated semiconductor materials demand significantly impact the short-range forecast out to 12 months. Semiconductor equipment purchases and semiconductor device trends drive the forecast in the 12- to 24-month time frame. Semiconductor fab facilities and long-term semiconductor device trends have the greatest impact on the forecast period covering two to five years.

The final step in the forecast process is to reconcile expected fluctuations in the electronics market and trends in the semiconductor industry so that the fluctuations do not inexplicably diverge from semiconductor industry trends. Dataquest anticipates that, in the absence of shocks to the market, market fluctuations converge toward the long-term trend.

Semiconductor Industry Assumptions

The North American semiconductor market continues to strengthen. Dataquest expects the North American market to grow 15.1 percent in 1992, up from a meager 2.7 percent in 1991. The market is clearly on target midway through the year. According to the latest WSTS statistics, total semiconductor bookings (three-month moving average) growth for the three months ended in June was 18.0 percent above year-earlier bookings, compared with 11.9 percent in May. Total semiconductor billings growth for the same period was 14.8 percent above year-earlier billings, compared with 13.3 percent in May.

Strength in the North American market can be attributed largely to the recovery of the U.S. economy and the relaxation of household and business budget constraints for durable goods and capital equipment. In particular, however, chip demand stems from strong orders of portable PCs, client/server computers, and network hardware.

Dataquest expects the Japanese market to decline 9.4 percent (dollar-based) in 1992, the first yearly decline since 1985. The latest market statistics support this outlook. The dollar value of total semiconductor billings for the three months ended in May was 14.5 percent below year-earlier billings. The bookings picture is even more bleak. Total semiconductor bookings for the same period were 17.7 percent below year-earlier levels.

Japan's situation is due to more than just weakness in its European export market. Other factors include a heightened level of international competition in chips and systems, a glut of worldwide DRAM fab capacity, rising costs of capital in Japan, and a dearth of new, high-volume consumer electronic systems. Dataquest does not expect an improvement in Japan's export market to alleviate these structural problems in 1992.

Dataquest forecasts the European market to grow 7.2 percent in 1992, up from 5.8 percent in 1991. Total semiconductor billings for the three months ended in June was 9.0 percent above year-earlier billings. Total semiconductor bookings for the same period were 7.1 percent above year-earlier levels. We believe that the European market will show more growth in the second half of 1992 than usual, as recovery in the U.S. market starts to pull through demand in Europe later in the year.

Recovery of the U.K. and French economies will help offset decelerating growth in Germany. PC manufacture in Ireland is strong, and much of the growth in the United Kingdom is related to multinational companies increasing their data processing and consumer equipment production. Investment in telecommunications infrastructure and the introduction of GSM mobile cellular phones also provide growth stimulus.

Dataquest forecasts the Asia/Pacific-Rest of World market to grow 21.6 percent in 1992.

Again, the latest statistics support this outlook. Total semiconductor bookings growth for the three months ended in May was 15.8 percent above year-earlier bookings. Total semiconductor billings growth for the same period was 25.5 percent above year-earlier billings. Expansion continues to be driven by foreign investment and improvement in Western export markets.

Forecast Economic Assumptions

The worldwide economy is expected to show mixed results in 1992. The Dun & Bradstreet Corporation forecast the following outlook for the Group of Seven (G7) Countries:

- The U.S., Canada, and U.K. economies are expected to recover from recession in 1992. Real gross domestic product (GDP) is expected to expand 2.1, 1.6, and 0.5 percent, respectively, in 1992. (These economies contracted at rates of 0.7, 1.5, and 2.4 percent, respectively, in 1991.) Though modest in comparison to historical rates of expansion during recovery periods, the benefit is that inflationary pressures will likely be held in check, sustaining the expansion's duration. Expansion should accelerate to 2.5 percent, 4.0 percent, and 2.2 percent, respectively, in 1993.
- Real GDP growth is expected to accelerate in France and Italy during 1992, from 0.9 percent in 1991 to 2.1 percent and from 1.4 percent percent in 1991 to 1.5 percent, respectively. The pace of growth should pick up in 1993 to 2.7 percent and 2.2 percent, respectively.
- Real GDP growth is expected to decelerate in Germany and Japan during 1992, from 3.2 percent in 1991 to 1.1 percent and from 4.4 percent in 1991 to 2.0 percent, respectively. Moderating these countries' short-term growth prospects are the cost burden of Germany's reunification, the rise in Japan's cost of capital, and the recent bout of asset deflation. The respective economies are expected to reaccelerate to 2.8 percent and 3.3 percent growth in 1993.

Exchange Rates

Dataquest uses an average annual exchange rate in converting revenue to U.S. dollar values. The following outlines these rates for 1991:

Japan (Yen/U.S.$)	136.00
Europe (Ecu/U.S.$)	0.81
France (Franc/U.S.$)	5.64
Germany (Deutsche Mark/U.S.$)	1.66
United Kingdom (U.S.$/Pound Sterling)	1.77

Table 1
Revenue from All Semiconductors Shipped to the World for Use in All Applications, 1987-1991
(Millions of U.S. Dollars)

	1987	1988	1989	1990	1991
Total Semiconductor	38,250	50,859	54,339	54,545	59,694
Total IC	29,886	41,068	44,613	44,459	48,855
Bipolar Digital	4,760	5,200	4,314	4,173	3,628
Bipolar Memory	621	689	460	431	356
Bipolar Logic	4,139	4,511	3,854	3,742	3,272
MOS Digital	17,473	26,988	31,140	30,152	34,315
MOS Memory	6,056	11,692	15,405	12,128	12,841
MOS Microcomponent	5,108	7,144	7,808	9,584	11,774
MOS Logic	6,309	8,152	7,927	8,440	9,700
Analog	7,654	8,880	9,159	10,134	10,912
Total Discrete	6,655	7,612	7,320	7,674	8,035
Total Optoelectronic	1,709	2,179	2,406	2,412	2,804

Source: Dataquest (June 1992)

Table 2
Revenue from All Semiconductors Shipped to the World for Use in All Applications, 1992-1996 (Millions of U.S. Dollars)

	1992	1993	1994	1995	1996
Total Semiconductor	62,925	72,668	82,627	88,122	94,991
Total IC	52,074	60,902	70,002	74,609	80,720
Bipolar Digital	3,271	2,989	2,733	2,498	2,252
Bipolar Memory	339	274	209	185	176
Bipolar Logic	2,932	2,715	2,524	2,313	2,076
MOS Digital	37,287	45,007	53,063	56,540	61,713
MOS Memory	14,683	18,927	22,888	21,978	23,661
MOS Microcomponent	12,985	14,804	17,258	20,016	21,920
MOS Logic	9,619	11,276	12,917	14,545	16,132
Analog	11,516	12,907	14,206	15,571	16,754
Total Discrete	8,126	8,730	9,290	9,868	10,403
Total Optoelectronic	2,725	3,036	3,335	3,645	3,868

Source: Dataquest (June 1992)

Table 3
Revenue Growth from All Semiconductors Shipped to the World for Use in All Applications, 1987-1991 (Percent Change)

	1987	1988	1989	1990	1991
Total Semiconductor	24.1	33.0	6.8	.4	9.4
Total IC	26.5	37.4	8.6	-.3	9.9
Bipolar Digital	10.1	9.2	-17.0	-3.3	-13.1
Bipolar Memory	2.5	10.9	-33.2	-6.3	-17.4
Bipolar Logic	11.3	9.0	-14.6	-2.9	-12.6
MOS Digital	36.3	54.5	15.4	-3.2	13.8
MOS Memory	34.2	93.1	31.8	-21.3	5.9
MOS Microcomponent	46.4	39.9	9.3	22.7	22.9
MOS Logic	31.0	29.2	-2.8	6.5	14.9
Analog	18.2	16.0	3.1	10.6	7.7
Total Discrete	16.1	14.4	-3.8	4.8	4.7
Total Optoelectronic	15.0	27.5	10.4	.2	16.3

Source: Dataquest (June 1992)

Table 4
Revenue Growth from All Semiconductors Shipped to the World for Use in All Applications, 1992-1996 (Percent Change)

	1992	1993	1994	1995	1996	CAGR 91-96
Total Semiconductor	5.4	15.5	13.7	6.7	7.8	9.7
Total IC	6.6	17.0	14.9	6.6	8.2	10.6
Bipolar Digital	-9.8	-8.6	-8.6	-8.6	-9.8	-9.1
Bipolar Memory	-4.9	-19.1	-23.7	-11.6	-4.9	-13.2
Bipolar Logic	-10.4	-7.4	-7.0	-8.4	-10.2	-8.7
MOS Digital	8.7	20.7	17.9	6.6	9.1	12.5
MOS Memory	14.3	28.9	20.9	-4.0	7.7	13.0
MOS Microcomponent	10.3	14.0	16.6	16.0	9.5	13.2
MOS Logic	-.8	17.2	14.6	12.6	10.9	10.7
Analog	5.5	12.1	10.1	9.6	7.6	9.0
Total Discrete	1.1	7.4	6.4	6.2	5.4	5.3
Total Optoelectronic	-2.8	11.4	9.8	9.3	6.1	6.6

Source: Dataquest (June 1992)

Table 5
Revenue from All Semiconductors Shipped to North America for Use in All Applications, 1987-1991 (Millions of U.S. Dollars)

	1987	1988	1989	1990	1991
Total Semiconductor	12,858	15,844	17,070	16,540	16,990
Total IC	10,886	13,815	15,102	14,616	15,269
Bipolar Digital	2,099	2,012	1,635	1,577	1,331
Bipolar Memory	271	235	180	160	131
Bipolar Logic	1,828	1,777	1,455	1,417	1,200
MOS Digital	6,738	9,606	10,988	10,390	11,296
MOS Memory	2,497	4,298	5,772	4,325	4,510
MOS Microcomponent	2,012	2,707	2,796	3,381	3,916
MOS Logic	2,229	2,601	2,420	2,684	2,870
Analog	2,049	2,197	2,479	2,649	2,642
Total Discrete	1,642	1,676	1,639	1,611	1,389
Total Optoelectronic	330	353	329	313	332

Source: Dataquest (June 1992)

Table 6
Revenue from All Semiconductors Shipped to North America for Use in All Applications, 1992-1996 (Millions of U.S. Dollars)

	1992	1993	1994	1995	1996
Total Semiconductor	19,564	22,613	25,456	26,127	27,579
Total IC	17,674	20,603	23,331	23,887	25,229
Bipolar Digital	1,332	1,170	1,042	935	828
Bipolar Memory	147	109	75	65	62
Bipolar Logic	1,185	1,061	967	870	766
MOS Digital	13,342	16,003	18,449	18,722	19,801
MOS Memory	5,477	7,133	8,360	7,507	7,820
MOS Microcomponent	4,698	5,149	5,847	6,464	6,754
MOS Logic	3,167	3,721	4,242	4,751	5,227
Analog	3,000	3,430	3,840	4,230	4,600
Total Discrete	1,530	1,630	1,725	1,820	1,915
Total Optoelectronic	360	380	400	420	435

Source: Dataquest (June 1992)

Table 7
Revenue Growth from All Semiconductors Shipped to North America for Use in All Applications, 1987-1991
(Percent Change)

	1987	1988	1989	1990	1991
Total Semiconductor	18.6	23.2	7.7	-3.1	2.7
Total IC	21.1	26.9	9.3	-3.2	4.5
Bipolar Digital	3.4	-4.1	-18.7	-3.6	-15.6
Bipolar Memory	1.5	-13.3	-23.4	-11.1	-18.1
Bipolar Logic	3.7	-2.8	-18.1	-2.6	-15.3
MOS Digital	37.2	42.6	14.4	-5.4	8.7
MOS Memory	40.7	72.1	34.3	-25.1	4.3
MOS Microcomponent	47.7	34.5	3.3	20.9	15.8
MOS Logic	25.6	16.7	-7.0	10.9	6.9
Analog	.2	7.2	12.8	6.9	-.3
Total Discrete	6.5	2.1	-2.2	-1.7	-13.8
Total Optoelectronic	4.4	7.0	-6.8	-4.9	6.1

Source: Dataquest (June 1992)

Table 8
Revenue Growth from All Semiconductors Shipped to North America for Use in All Applications, 1992-1996
(Percent Change)

	1992	1993	1994	1995	1996	CAGR 91-96
Total Semiconductor	15.1	15.6	12.6	2.6	5.6	10.2
Total IC	15.8	16.6	13.2	2.4	5.6	10.6
Bipolar Digital	.1	-12.2	-10.9	-10.3	-11.4	-9.1
Bipolar Memory	12.2	-25.9	-31.2	-13.3	-4.6	-13.9
Bipolar Logic	-1.2	-10.5	-8.9	-10.0	-12.0	-8.6
MOS Digital	18.1	19.9	15.3	1.5	5.8	11.9
MOS Memory	21.4	30.2	17.2	-10.2	4.2	11.6
MOS Microcomponent	20.0	9.6	13.6	10.6	4.5	11.5
MOS Logic	10.3	17.5	14.0	12.0	10.0	12.7
Analog	13.5	14.3	12.0	10.2	8.7	11.7
Total Discrete	10.2	6.5	5.8	5.5	5.2	6.6
Total Optoelectronic	8.4	5.6	5.3	5.0	3.6	5.6

Source: Dataquest (June 1992)

Table 9
Revenue from All Semiconductors Shipped to Japan for Use in All Applications, 1987-1991 (Millions of U.S. Dollars)

	1987	1988	1989	1990	1991
Total Semiconductor	14,927	20,772	21,491	20,257	22,496
Total IC	11,263	16,127	16,860	15,794	17,277
Bipolar Digital	1,523	1,906	1,648	1,635	1,442
Bipolar Memory	227	348	191	194	165
Bipolar Logic	1,296	1,558	1,457	1,441	1,277
MOS Digital	6,424	10,501	11,636	10,660	11,881
MOS Memory	2,268	4,424	5,629	4,196	4,228
MOS Microcomponent	1,902	2,573	2,662	2,974	3,579
MOS Logic	2,254	3,504	3,345	3,490	4,074
Analog	3,316	3,720	3,576	3,499	3,954
Total Discrete	2,693	3,282	3,080	2,969	3,432
Total Optoelectronic	971	1,363	1,551	1,494	1,787

Source: Dataquest (June 1992)

Table 10
Revenue from All Semiconductors Shipped to Japan for Use in All Applications, 1992-1996 (Millions of U.S. Dollars)

	1992	1993	1994	1995	1996
Total Semiconductor	20,371	22,975	25,870	27,810	29,645
Total IC	15,650	17,836	20,343	21,941	23,499
Bipolar Digital	1,121	1,078	1,016	951	880
Bipolar Memory	137	118	94	84	82
Bipolar Logic	984	960	922	867	797
MOS Digital	10,707	12,743	15,038	16,454	17,801
MOS Memory	4,150	5,163	6,295	6,379	6,784
MOS Microcomponent	3,252	3,807	4,405	5,127	5,477
MOS Logic	3,304	3,773	4,338	4,947	5,540
Analog	3,823	4,015	4,289	4,536	4,819
Total Discrete	3,125	3,353	3,543	3,695	3,860
Total Optoelectronic	1,596	1,785	1,984	2,174	2,286

Source: Dataquest (June 1992)

Table 11
Revenue Growth from All Semiconductors Shipped to Japan for Use in All Applications, 1987-1991 (Percent Change)

	1987	1988	1989	1990	1991
Total Semiconductor	25.9	39.2	3.5	-5.7	11.1
Total IC	28.0	43.2	4.5	-6.3	9.4
Bipolar Digital	17.6	25.1	-13.5	-.8	-11.8
Bipolar Memory	34.3	53.3	-45.1	1.6	-14.9
Bipolar Logic	15.1	20.2	-6.5	-1.1	-11.4
MOS Digital	34.9	63.5	10.8	-8.4	11.5
MOS Memory	30.5	95.1	27.2	-25.5	.8
MOS Microcomponent	39.0	35.3	3.5	11.7	20.3
MOS Logic	36.1	55.5	-4.5	4.3	16.7
Analog	20.8	12.2	-3.9	-2.2	13.0
Total Discrete	20.1	21.9	-6.2	-3.6	15.6
Total Optoelectronic	19.7	40.4	13.8	-3.7	19.6

Source: Dataquest (June 1992)

Table 12
Revenue Growth from All Semiconductors Shipped to Japan for Use in All Applications, 1992-1996 (Percent Change)

	1992	1993	1994	1995	1996	CAGR 91-96
Total Semiconductor	-9.4	12.8	12.6	7.5	6.6	5.7
Total IC	-9.4	14.0	14.1	7.9	7.1	6.3
Bipolar Digital	-22.3	-3.8	-5.8	-6.4	-7.5	-9.4
Bipolar Memory	-17.1	-13.7	-20.8	-10.1	-2.3	-13.0
Bipolar Logic	-23.0	-2.4	-3.9	-6.0	-8.0	-9.0
MOS Digital	-9.9	19.0	18.0	9.4	8.2	8.4
MOS Memory	-1.8	24.4	21.9	1.3	6.3	9.9
MOS Microcomponent	-9.1	17.0	15.7	16.4	6.8	8.9
MOS Logic	-18.9	14.2	15.0	14.0	12.0	6.3
Analog	-3.3	5.0	6.8	5.8	6.2	4.0
Total Discrete	-8.9	7.3	5.6	4.3	4.4	2.4
Total Optoelectronic	-10.7	11.9	11.1	9.6	5.2	5.1

Source: Dataquest (June 1992)

Table 13
Revenue from All Semiconductors Shipped to Europe for Use in All Applications, 1987-1991 (Millions of U.S. Dollars)

	1987	1988	1989	1990	1991
Total Semiconductor	6,498	8,491	9,498	10,415	11,014
Total IC	4,840	6,669	7,570	8,115	8,701
Bipolar Digital	727	772	627	565	486
Bipolar Memory	88	74	71	55	43
Bipolar Logic	639	698	556	510	443
MOS Digital	2,761	4,364	5,251	5,224	5,853
MOS Memory	854	1,797	2,417	2,050	2,129
MOS Microcomponent	805	1,212	1,442	1,802	2,082
MOS Logic	1,102	1,355	1,392	1,372	1,642
Analog	1,352	1,533	1,692	2,326	2,362
Total Discrete	1,377	1,516	1,574	1,895	1,828
Total Optoelectronic	281	306	354	405	485

Source: Dataquest (June 1992)

Table 14
Revenue from All Semiconductors Shipped to Europe for Use in All Applications, 1992-1996 (Millions of U.S. Dollars)

	1992	1993	1994	1995	1996
Total Semiconductor	11,809	13,663	15,603	16,493	17,828
Total IC	9,428	11,163	12,985	13,756	14,974
Bipolar Digital	452	408	376	338	301
Bipolar Memory	42	36	32	28	25
Bipolar Logic	410	372	345	310	277
MOS Digital	6,614	7,999	9,537	10,021	11,080
MOS Memory	2,418	3,100	3,824	3,825	4,275
MOS Microcomponent	2,377	2,713	3,215	3,508	3,867
MOS Logic	1,819	2,186	2,498	2,688	2,938
Analog	2,362	2,756	3,071	3,397	3,592
Total Discrete	1,869	1,939	2,018	2,097	2,165
Total Optoelectronic	511	561	600	640	689

Source: Dataquest (June 1992)

Table 15
Revenue Growth from All Semiconductors Shipped to Europe for Use in All Applications, 1987-1991 (Percent Change)

	1987	1988	1989	1990	1991
Total Semiconductor	16.3	30.7	11.9	9.7	5.8
Total IC	17.6	37.8	13.5	7.2	7.2
Bipolar Digital	1.1	6.2	-18.8	-9.9	-14.0
Bipolar Memory	-40.1	-15.9	-4.1	-22.5	-21.8
Bipolar Logic	11.7	9.2	-20.3	-8.3	-13.1
MOS Digital	21.6	58.1	20.3	-.5	12.0
MOS Memory	5.0	110.4	34.5	-15.2	3.9
MOS Microcomponent	40.2	50.6	19.0	25.0	15.5
MOS Logic	24.8	23.0	2.7	-1.4	19.7
Analog	20.0	13.4	10.4	37.5	1.5
Total Discrete	14.1	10.1	3.8	20.4	-3.5
Total Optoelectronic	6.4	8.9	15.7	14.4	19.8

Source: Dataquest (June 1992)

Table 16
Revenue Growth from All Semiconductors Shipped to Europe for Use in All Applications, 1992-1996 (Percent Change)

	1992	1993	1994	1995	1996	CAGR 91-96
Total Semiconductor	7.2	15.7	14.2	5.7	8.1	10.1
Total IC	8.4	18.4	16.3	5.9	8.9	11.5
Bipolar Digital	-7.0	-9.6	-7.9	-10.2	-10.8	-9.1
Bipolar Memory	-1.5	-14.0	-13.5	-12.5	-10.7	-10.6
Bipolar Logic	-7.5	-9.2	-7.4	-10.0	-10.8	-9.0
MOS Digital	13.0	20.9	19.2	5.1	10.6	13.6
MOS Memory	13.6	28.2	23.3	.0	11.8	15.0
MOS Microcomponent	14.2	14.1	18.5	9.1	10.2	13.2
MOS Logic	10.8	20.2	14.3	7.6	9.3	12.3
Analog	-.0	16.7	11.4	10.6	5.8	8.7
Total Discrete	2.3	3.7	4.1	3.9	3.2	3.4
Total Optoelectronic	5.4	9.7	7.0	6.6	7.7	7.3

Source: Dataquest (June 1992)

Table 17
Revenue from All Semiconductors Shipped to All Other Regions for Use in All Applications, 1987-1991 (Millions of U.S. Dollars)

	1987	1988	1989	1990	1991
Total Semiconductor	3,967	5,752	6,280	7,333	9,194
Total IC	2,898	4,457	5,081	5,934	7,608
Bipolar Digital	411	510	404	396	369
Bipolar Memory	35	32	18	22	17
Bipolar Logic	376	478	386	374	352
MOS Digital	1,550	2,517	3,265	3,878	5,285
MOS Memory	437	1,173	1,587	1,557	1,974
MOS Microcomponent	389	652	908	1,427	2,197
MOS Logic	724	692	770	894	1,114
Analog	937	1,430	1,412	1,660	1,954
Total Discrete	943	1,138	1,027	1,199	1,386
Total Optoelectronic	127	157	172	200	200

Source: Dataquest (June 1992)

Table 18
Revenue from All Semiconductors Shipped to All Other Regions for Use in All Applications, 1992-1996 (Millions of U.S. Dollars)

	1992	1993	1994	1995	1996
Total Semiconductor	11,181	13,417	15,698	17,692	19,939
Total IC	9,322	11,300	13,344	15,026	17,018
Bipolar Digital	366	333	300	275	243
Bipolar Memory	12	10	9	8	7
Bipolar Logic	354	322	291	267	236
MOS Digital	6,624	8,261	10,038	11,343	13,031
MOS Memory	2,638	3,530	4,408	4,267	4,782
MOS Microcomponent	2,657	3,136	3,791	4,917	5,822
MOS Logic	1,329	1,596	1,839	2,159	2,426
Analog	2,332	2,706	3,006	3,408	3,744
Total Discrete	1,601	1,807	2,004	2,255	2,463
Total Optoelectronic	258	310	351	411	458

Source: Dataquest (June 1992)

Table 19
Revenue Growth from All Semiconductors Shipped to All Other Regions for Use in All Applications, 1987-1991
(Percent Change)

	1987	1988	1989	1990	1991
Total Semiconductor	55.7	45.0	9.2	16.8	25.4
Total IC	69.0	53.8	14.0	16.8	28.2
Bipolar Digital	46.2	24.1	-20.8	-2.0	-6.8
Bipolar Memory	52.1	-8.5	-43.8	22.3	-22.8
Bipolar Logic	45.7	27.1	-19.2	-3.1	-5.9
MOS Digital	77.9	62.4	29.7	18.8	36.3
MOS Memory	136.2	168.4	35.3	-1.9	26.8
MOS Microcomponent	110.0	67.8	39.3	57.2	54.0
MOS Logic	44.5	-4.4	11.3	16.1	24.6
Analog	66.7	52.6	-1.3	17.6	17.7
Total Discrete	27.6	20.7	-9.8	16.7	15.6
Total Optoelectronic	33.7	23.6	9.6	16.3	-.0

Source: Dataquest (June 1992)

Table 20
Revenue Growth from All Semiconductors Shipped to All Other Regions for Use in All Applications, 1992-1996
(Percent Change)

	1992	1993	1994	1995	1996	CAGR 91-96
Total Semiconductor	21.6	20.0	17.0	12.7	12.7	16.7
Total IC	22.5	21.2	18.1	12.6	13.3	17.5
Bipolar Digital	-.7	-9.2	-9.9	-8.3	-11.4	-8.0
Bipolar Memory	-27.0	-16.7	-12.8	-11.1	-14.0	-16.5
Bipolar Logic	.6	-9.0	-9.8	-8.2	-11.3	-7.7
MOS Digital	25.3	24.7	21.5	13.0	14.9	19.8
MOS Memory	33.6	33.8	24.9	-3.2	12.1	19.4
MOS Microcomponent	20.9	18.0	20.9	29.7	18.4	21.5
MOS Logic	19.4	20.0	15.2	17.4	12.4	16.9
Analog	19.3	16.0	11.1	13.4	9.9	13.9
Total Discrete	15.5	12.9	10.9	12.5	9.2	12.2
Total Optoelectronic	28.9	20.2	13.2	17.2	11.5	18.0

Source: Dataquest (June 1992)

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Silicon Wafer Market Share

May 25, 1992

Source: Dataquest

Market Statistics

Semiconductor Equipment, Manufacturing, and Materials

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Silicon Wafer Market Share

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Market Statistics

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Silicon Wafer Market Share

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*Includes prime, test, and monitor wafers
Note: All tables show estimated data.(Continued)

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Note: All tables show estimated data.

Silicon Wafer Market Share

Section 1. Introduction

Dataquest's Semiconductor Equipment, Manufacturing, and Materials service tracks the silicon wafer industry by examining the merchant silicon and epitaxial wafer market, captive silicon production, wafer price trends, and silicon square-inch consumption.

The information in this document is focused on the silicon and epitaxial wafers used in the manufacturing of integrated circuits.

Definitions and Conventions

The calendar year sales of merchant silicon and epitaxial wafer suppliers are estimated in U.S. dollars and converted to millions of square inches using an average selling price for each region. Currency fluctuations over the last several years affect the dollar value of wafer sales of Japanese and European companies. Dataquest uses average exchange rates supplied by the International Monetary Fund (IMF) to convert from local currency to U.S. dollars. The average exchange rates for the Japanese yen and German deutsche mark for 1986 through 1991 are shown below.

Please note the convention that the regional designation "United States" includes Canadian semiconductor manufacturing activities.

Silicon Products

The merchant silicon wafer market is categorized into two product segments—silicon wafers and silicon epitaxial wafers. Silicon wafers include prime, test, and monitor wafers grown by both Czochralski and float zone methods. In the silicon database, Dataquest does not include sales of polysilicon, single-crystal silicon ingots (unless noted), silicon materials used in solar applications, or compound semiconductor material substrates such as gallium arsenide.

Japanese and German Exchange Rates

	1986	1987	1988	1989	1990	1991
Yen/Dollar	167	144	128	138	144	135
Deutsche Mark/ Dollar	2.17	1.80	1.78	1.88	1.62	1.66

Source: IMF

Silicon Producers

Companies that produce silicon and epitaxial wafers are defined as either merchant silicon companies or captive silicon producers. Merchant silicon companies are suppliers such as Shin-Etsu Handotai (SEH) of Japan and Wacker of Germany.

Silicon also is produced, to a lesser extent, by both merchant and captive semiconductor manufacturers. These semiconductor manufacturers collectively are referred to as captive silicon producers because they grow single-crystal silicon to produce wafers for their own internal consumption. Examples of captive producers with significant internal silicon production include Motorola and Texas Instruments in the United States and Hitachi in Japan.

Merchant or Captive?

Some captive silicon producers have sold small amounts of material on the merchant silicon market. These producers have sold wafers to ensure that internal production methods continue to produce material of competitive quality and cost. Dataquest estimates that merchant sales for these companies historically have represented a small percentage of their total captive silicon production, and thus these companies are identified as captive rather than merchant silicon producers.

Dataquest identifies Toshiba Ceramics, a subsidiary of Toshiba Corporation, as a merchant silicon company even though a substantial amount of its silicon production is consumed by its semiconductor parent. However, because Toshiba Ceramics is actively marketing its material on the merchant market, Toshiba Ceramics is considered a merchant rather than a captive silicon producer. Toshiba Corporation is considered a customer of Toshiba Ceramics.

Merchant Silicon and Epitaxial Wafer Suppliers

Table 1-1 contains a list of merchant silicon manufacturers that were active in the worldwide market in 1991. This table, organized by region of corporate ownership, summarizes whether a company offers silicon and/or epitaxial wafers.

Forecast Assumptions

Dataquest forecasts the U.S. economy to eke out a small level of growth in GNP through 1993. Growth will average in the range of 2 to 3 percent per year. By 1994, the United States will be in a stronger position to increase spending, having paid its debts for several years and worked through a large share of its real estate problems. In 1994 and 1995, the pace of the U.S. economy is expected to pick up, with GNP growing moderately in the range of 4 percent. Growth is expected to peak in 1995 and fall off in 1996.

The general trend in global interest rates is permitting the Bank of Japan to loosen the reins. Interest rates are expected to decrease through most of 1992 as the Japanese economy decelerates. The trends in interest rates should set the stage for a recovery in 1993.

Dataquest believes that the upturn is sustainable through 1996. The recovery in Japan will depend on strong domestic consumption, as there will be little opportunity to increase exports to the United States.

A slow recovery from the recession in the United Kingdom, plus the reunification-induced drag on the German economy, is expected to lower European GNP growth in 1992. Growth in GNP in 1993 is expected to pick up as domestic consumption improves and projects to rebuild Eastern Europe gain steam. GNP is expected to increase 4 to 6 percent from 1994 to 1996.

The Asia/Pacific region will continue to see strong growth relative to the other regions of the world. The growth in the newly industrialized nations of Southeast Asia will benefit as they build their industrial infrastructure. Dataquest believes that individual country GNPs will grow in the range of 5 to 9 percent through 1996. However, in 1992 growth rates will fall toward the lower end of this range. Industries such as the semiconductor industry, which relies on exports, will feel the drag of weak export markets and mounting trade friction.

Table 1-1
Worldwide Merchant Silicon and Epitaxial Companies, 1991

	Silicon Wafers	Epitaxial Wafers
U.S. Companies		
Crysteco Inc.	X	
Epitaxy Inc.		X
General Instrument		
Power Semiconductor Division		X
M/A-COM Semiconductor Products		X
Pensilco	X	
Spire Corporation		X
Unisil	X	X
Virginia Semiconductor	X	
Japanese Companies		
Kawasaki Steel		
Kawatec	X	X
Komatsu Electronic Metals	X	X
Mitsubishi Materials		
Mitsubishi Materials Silicon	X	X
Siltec Corporation	X	X
Nittetsu Denshi	X	X
Osaka Titanium Company	X	X
Cincinnati Semiconductor	X	X
U.S. Semiconductor		X
Shin-Etsu Handotai	X	X
Showa Denko	X	X
Toshiba Ceramics	X	X
European Companies		
Hüls		
MEMC Electronic Materials	X	X
Okmetic	X	
Siltronix SA	X	
Topsil Semiconductor Materials A/S	X	
Wacker	X	X
Rest of World Companies		
Korea		
Posco-Hüls	X	X
Oriental Electronic Metals	X	X
Siltron	X	
Taiwan		
Hermes Epitaxy		X
Sino-America	X	
Tatung Company	X	

Source: Dataquest (May 1992)

Section 2. Forecast of Silicon and Epitaxial Wafers

Table 2-1
Shipments of Merchant and Captive Silicon Wafers* and Merchant Epitaxial Wafers to Each Region, 1991-1996
(Millions of Square Inches)

Company: All
Product: Merchant and Captive Silicon Wafers and Merchant Epitaxial Wafers
Region: Each

	1991	1992	1993	1994	1995	1996	CAGR (%) 1991-1996
North America	611.3	642.0	688.7	745.5	788.6	824.5	6.2
Growth (%)	-4.5	5.0	7.3	8.2	5.8	4.6	
Japan	1046	1,011.8	1,081.2	1,161.1	1,239.0	1,319.1	4.8
Growth (%)	5.4	-3.2	6.9	7.4	6.7	.1	
Europe	208	212.6	227.5	245.7	267.4	295.6	7.3
Growth (%)	-11.7	2.3	7.0	8.0	8.8	10.5	
Asia/Pacific-ROW	194	218.1	247.8	283.3	316.1	353.4	12.7
Growth (%)	7.5	12.2	13.6	14.3	11.6	11.8	
Worldwide	2,059	2,084.6	2,245.1	2,435.6	2,611.0	2,792.5	6.3
Growth (%)	.5	1.2	7.7	8.5	7.2	7.0	

*Includes prime, test, and monitor wafers
Source: Dataquest (May 1992)

Table 2-2
Shipments of Merchant Epitaxial Wafers to Each Region, 1991-1996
(Millions of Square Inches)

Company: All
Product: Merchant Epitaxial Wafers
Region Of Consumption: Each

	1991	1992	1993	1994	1995	1996	CAGR (%) 1991-1996
North America	91.6	98.9	110.6	123.2	130.4	136.9	8.4
Growth (%)	4.0	8.0	11.8	11.4	5.8	5.0	
Japan	103.7	106.1	118.3	124.4	127.5	132.6	5.0
Growth (%)	11.6	2.3	11.5	5.2	2.5	4.0	
Europe	20.3	21.4	26.0	30.3	33.0	36.0	12.1
Growth (%)	7.4	5.4	21.5	16.4	9.0	9.0	
Asia/Pacific	6.6	7.8	9.1	10.1	13.0	16.9	20.6
Growth (%)	43.5	17.9	16.7	11.7	27.9	30.0	
Worldwide	222.2	234.2	264.0	288.0	303.9	322.3	7.7
Growth (%)	8.7	5.4	12.7	9.1	5.5	6.1	

Source: Dataquest (May 1992)

Table 2-3
Shipments of Merchant and Captive Silicon Wafers* to Each Region, 1991-1996
(Millions of Square Inches)

Company:	All
Product:	Merchant and Captive Silicon Wafers
Region Of Consumption:	Each

	1991	1992	1993	1994	1995	1996	CAGR (%) 1991-1996
North America	519.7	543.1	578.1	622.3	658.2	687.6	5.8
Growth (%)	-5.9	4.5	6.4	7.6	5.8	4.5	
Japan	941.8	905.7	962.9	1,036.7	1,111.4	1,186.4	4.7
Growth (%)	4.8	-3.8	6.3	7.7	7.2	6.7	
Europe	187.6	191.3	201.5	215.4	234.4	259.6	6.7
Growth (%)	-13.3	1.9	5.4	6.9	8.8	10.8	
Asia/Pacific-ROW	187.8	210.3	238.7	273.1	303.2	336.5	12.4
Growth (%)	6.6	12.0	13.5	14.4	11.0	11.0	
Worldwide	1,836.9	1,850.4	1,981.2	2,147.5	2,307.2	2,470.2	6.1
Growth (%)	-.4	.7	7.1	8.4	7.4	7.1	

*Includes prime, test, and monitor wafers

Source: Dataquest (May 1992)

Table 2-4
Shipments of Captive Silicon Wafers* to Each Region, 1991-1996
(Millions of Square Inches)

Company: All
Product: Captive Silicon Wafers
Region Of Consumption: Each

	1991	1992	1993	1994	1995	1996
North America	70.0	70.0	70.0	70.0	70.0	70.0
Japan	40.0	40.0	40.0	40.0	40.0	40.0
Europe	5.0	5.0	5.0	5.0	5.0	5.0
Asia/Pacific-ROW	.0	0.0	0.0	0.0	0.0	0.0
Worldwide	115.0	115.0	115.0	115.0	115.0	115.0

*Includes prime, test, and monitor wafers
Source: Dataquest (May 1992)

Table 2-5
Shipments of Merchant Silicon Wafers* to Each Region, 1991-1996
(Millions of Square Inches)

Company: All
Product: Merchant Silicon Wafers
Region Of Consumption: Each

	1991	1992	1993	1994	1995	1996	CAGR (%) 1991-1996
North America	449.7	473.1	508.1	552.3	588.2	617.6	6.6
Growth (%)	-4.7	5.2	7.4	8.7	6.5	5.0	
Japan	901.8	865.7	922.9	996.7	1,071.4	1,146.4	4.9
Growth (%)	5.7	-4.0	6.6	8.0	7.5	7.0	
Europe	182.6	186.3	196.5	210.4	229.4	254.6	6.9
Growth (%)	-12.4	2.0	5.5	7.1	9.0	11.0	
Asia/Pacific-ROW	187.8	210.3	238.7	273.1	303.2	336.5	12.4
Growth (%)	6.6	12.0	13.5	14.4	11.0	11.0	
Worldwide	1,721.9	1,735.4	1,866.2	2,032.5	2,192.2	2,355.2	6.5
Growth (%)	.7	.8	7.5	8.9	7.9	7.4	

*Includes prime, test, and monitor wafers
Source: Dataquest (May 1992)

Table 2-6
Shipments of Merchant Test and Monitor Wafers to Each Region, 1991-1996
(Millions of Square Inches)

Company: All
Product: Merchant Test and Monitor Wafers
Region Of Consumption: Each

	1991	1992	1993	1994	1995	1996	CAGR (%) 1991-1996
North America	89.9	94.6	101.6	110.5	117.6	123.5	6.6
Japan	180.4	173.1	184.6	199.3	214.3	229.3	4.9
Europe	36.5	37.3	39.3	42.1	45.9	50.9	6.9
Asia/Pacific-ROW	37.6	42.1	47.7	54.6	60.6	67.3	12.4
Worldwide	344.4	347.1	373.2	406.5	438.4	471.0	6.5

Source: Dataquest (May 1992)

Table 2-7
Shipments of Merchant and Captive Silicon Wafers* and Merchant Epitaxial Wafers to Asia/Pacific-ROW, 1991-1996
(Millions of Square Inches)

Company:	All
Product:	Merchant and Captive Silicon Wafers and Merchant Epitaxial Wafers
Region of Consumption:	Asia/Pacific-ROW

	1991	1992	1993	1994	1995	1996	CAGR (%) 1991-1996
Total Prime, Test, and Monitor Wafers	187.8	210.3	238.7	273.1	303.2	336.5	12.4
Korea	126.0	137.0	157.0	180.0	199.0	216.0	11.4
Taiwan	39.0	48.0	52.0	55.0	57.0	58.0	8.3
ROW	22.8	25.3	29.7	38.1	47.2	62.5	22.3
Total Epitaxial Wafers	6.6	7.8	9.1	10.1	13.0	16.9	20.6
Total Silicon	194	218	248	283	316	353	12.7

*Includes prime, test, and monitor wafers
Source: Dataquest (May 1992)

Section 3. Historical Unit Data in Millions of Square Inches

Table 3-1
Shipments of Merchant and Captive Silicon Wafers* and Merchant Epitaxial Wafers to Each Region, 1985-1991
(Millions of Square Inches)

Company: All
Product: Merchant and Captive Silicon Wafers and Merchant Epitaxial Wafers
Region Of Consumption: Each

	1985	1986	1987	1988	1989	1990	1991
North America	397.8	405.4	441.6	546.4	582.0	640.2	611.3
Growth (%)		1.9	8.9	23.7	6.5	10.0	-4.5
Japan	588.1	641.8	670.2	777.3	912.5	991.9	1,045.5
Growth (%)		9.1	4.4	16.0	17.4	8.7	5.4
Europe	148.4	155.3	172.2	196.3	231.2	235.4	207.9
Growth (%)		4.6	10.9	14.0	17.8	1.8	-11.7
Asia/Pacific-ROW	43.0	63.6	69.5	83.8	129.9	180.8	194.4
Growth (%)		47.9	9.3	20.6	55.0	39.2	7.5
Worldwide	1,177.3	1,266.1	1,353.5	1,603.8	1,855.6	2,048.3	2,059.1
Growth (%)		7.5	6.9	18.5	15.7	10.4	.5

*Includes prime, test, and monitor wafers (src>Dataquest (May 1992)

Table 3-2
Shipments of Merchant Epitaxial Wafers to Each Region, 1985-1991
(Millions of Square Inches)

Company: All
Product: Merchant Epitaxial Wafers
Region Of Consumption: Each

	1985	1986	1987	1988	1989	1990	1991
North America	25.4	28.6	41.6	55.8	81.7	88.1	91.6
Growth (%)	-43.7	16.0	45.5	34.1	46.4	7.8	4.0
Japan	49.2	64.5	70.8	75.3	83.1	92.9	103.7
Growth (%)	-11.0	32.7	9.8	6.4	10.4	11.8	11.6
Europe	6.0	9.0	11.6	15.1	17.5	18.9	20.3
Growth (%)	-7.5	50.0	28.9	30.2	15.9	8.0	7.4
Asia/Pacific-ROW	1.8	2.1	2.8	3.6	4.5	4.6	6.6
Growth (%)	-15.7	16.7	33.3	28.6	25.0	2.2	43.5
Worldwide	82.4	104.2	126.8	149.8	186.8	204.5	222.2
Growth (%)		26.5	21.7	18.1	24.7	9.5	8.7

Source: Dataquest (May 1992)

Table 3-3
Shipments of Merchant and Captive Silicon Wafers* to Each Region, 1985-1991
(Millions of Square Inches)

Company: All
Product: Merchant and Captive Silicon Wafers
Region Of Consumption: Each

	1985	1986	1987	1988	1989	1990	1991
North America	372.4	376.8	400.0	490.6	500.3	552.1	519.7
Growth (%)	-43.7	1.2	6.2	22.7	2.0	10.4	-5.9
Japan	538.9	577.3	599.4	702.0	829.4	899.0	941.8
Growth (%)	-11.0	7.1	3.8	17.1	18.1	8.4	4.8
Europe	142.4	146.3	160.6	181.2	213.7	216.5	187.6
Growth (%)	-7.5	2.7	9.8	12.8	17.9	1.3	-13.3
Asia/Pacific-ROW	41.2	61.5	66.7	80.2	125.4	176.2	187.8
Growth (%)	-15.7	49.3	8.5	20.2	56.4	40.5	6.6
Worldwide	1,094.9	1,161.9	1,226.7	1,454.0	1,668.8	1,843.8	1,836.9
Growth (%)		6.1	5.6	18.5	14.8	10.5	-.4

*Includes prime, test, and monitor wafers

Source: Dataquest (May 1992)

Table 3-4
Shipments of Captive Silicon Wafers* to Each Region, 1985-1991
(Millions of Square Inches)

Company: All
Product: Captive Silicon Wafers
Region Of Consumption: Each

	1985	1986	1987	1988	1989	1990	1991
North America	91.0	81.0	75.0	87.0	82.0	80.0	70.0
Growth (%)	-43.7	-11.0	-7.4	16.0	-5.7	-2.4	-12.5
Japan	24.0	29.0	34.0	36.0	37.0	46.0	40.0
Growth (%)	-11.0	20.8	17.2	5.9	2.8	24.3	-13.0
Europe	8.0	8.0	6.0	7.0	5.0	8.0	5.0
Growth (%)	-7.5	.0	-25.0	16.7	-28.6	60.0	-37.5
Asia/Pacific-ROW	.0	.0	.0	.0	.0	.0	.0
Growth (%)	N/M	N/M	N/M	N/M	N/M	N/M	N/M
Worldwide	123.0	118.0	115.0	130.0	124.0	134.0	115.0
Growth (%)		-4.1	-2.5	13.0	-4.6	8.1	-14.2

*Includes prime, test, and monitor wafers
N/M = Not Meaningful
Source: Dataquest (May 1992)

Table 3-5
Shipments of Merchant Silicon Wafers* to Each Region, 1985-1991
(Millions of Square Inches)

Company: All
Product: Merchant Silicon Wafers
Region Of Consumption: Each

	1985	1986	1987	1988	1989	1990	1991
North America	281.4	295.8	325.0	403.6	418.3	472.1	449.7
Growth (%)	-43.7	5.1	9.9	24.2	3.6	12.9	-4.7
Japan	514.9	548.3	565.4	666.0	792.4	853.0	901.8
Growth (%)	-11.0	6.5	3.1	17.8	19.0	7.6	5.7
Europe	134.4	138.3	154.6	174.2	208.7	208.5	182.6
Growth (%)	-7.5	2.9	11.8	12.7	19.8	-.1	-12.4
Asia/Pacific-ROW	41.2	61.5	66.7	80.2	125.4	176.2	187.8
Growth (%)	-15.7	49.3	8.5	20.2	56.4	40.5	6.6
Worldwide	971.9	1,043.9	1,111.7	1,324.0	1,544.8	1,709.8	1,721.9
Growth (%)		7.4	6.5	19.1	16.7	10.7	.7

*Includes prime, test, and monitor wafers
Source: Dataquest (May 1992)

Table 3-6
Shipments of Merchant Test and Monitor Wafers to Each Region, 1985-1991
(Millions of Square Inches)

Company: All
Product: Merchant Test and Monitor Wafers
Region Of Consumption: Each

	1985	1986	1987	1988	1989	1990	1991
North America	56.3	59.2	65.0	80.7	83.7	94.4	89.9
Japan	103.0	109.7	113.1	133.2	158.5	170.6	180.4
Europe	26.9	27.7	30.9	34.8	41.7	41.7	36.5
Asia/Pacific-ROW	8.2	12.3	13.3	16.0	25.1	35.2	37.6
Worldwide	194.4	208.8	222.3	264.8	309.0	342.0	344.4
Growth (%)		7.4	6.5	19.1	16.7	10.7	.7

Source: Dataquest (May 1992)

Table 3-7
Shipments of Merchant and Captive Silicon Wafers* and Merchant Epitaxial Wafers to Asia/Pacific-ROW, 1985-1991
(Millions of Square Inches)

Company: All
Product: Merchant and Captive Silicon Wafers and Merchant Epitaxial Wafers
Region Of Consumption: Asia/Pacific-ROW

	1985	1986	1987	1988	1989	1990	1991
Total Prime, Test, and Monitor Wafers	41.2	61.5	66.7	80.2	125.4	176.2	187.8
Korea	N/A	N/A	53.0	61.0	89.0	116.0	126.0
Taiwan	N/A	N/A	12.0	16.0	29.0	37.0	39.0
ROW	N/A	N/A	1.7	3.2	7.4	23.2	22.8
Total Epitaxial Wafers	1.8	2.1	2.8	3.6	4.5	4.6	6.6
Total Silicon Wafers	43.0	63.6	69.5	83.8	129.9	180.8	194.4

*Includes prime, test, and monitor wafers
N/A = Not Applicable
Source: Dataquest (May 1992)

Section 4. Regional Wafer Size Distribution by Diameter

Table 4-1
World Wafer Size Distribution, 1985-1996
(Percent Square Inches by Diameter and Unit Distribution by Wafer Starts)

Diameter	Area	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996
Percent Square Inches by Diameter													
2 Inches	3.14	.9%	.8%	.5%	.4%	.3%	.2%	.2%	.1%	.1%	.0%	.0%	.0%
3 Inches	7.07	7.2%	6.0%	3.5%	3.0%	3.7%	3.0%	2.5%	2.1%	1.5%	.5%	.5%	.5%
100 mm	12.17	42.9%	35.4%	30.1%	28.0%	26.0%	23.3%	20.3%	18.6%	15.5%	14.4%	14.4%	14.4%
125 mm	19.02	38.3%	41.9%	45.1%	43.4%	40.0%	37.4%	34.8%	33.1%	30.0%	27.4%	27.4%	27.4%
150 mm	27.38	10.7%	15.8%	20.5%	24.4%	29.1%	34.2%	39.6%	42.9%	48.7%	47.1%	47.1%	47.1%
200 mm	48.67	.0%	.0%	.3%	.8%	.9%	1.7%	2.6%	3.2%	4.2%	10.6%	10.6%	10.6%
Total		100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%
Total - MSI		1,177.3	1,266.1	1,353.5	1,603.8	1,855.6	2,048.3	2,059.1	2,084.6	2,245.1	2,435.6	2,611.0	2,792.5
Unit Distribution by Wafer Starts (Millions of Wafers)													
2 Inches	3.14	3.4	3.4	2.3	2.3	1.5	1.5	1.2	1.0	.6	.3	.1	.1
3 Inches	7.07	12.0	10.8	6.7	6.9	9.7	8.7	7.4	6.1	4.9	3.4	2.3	2.5
100 mm	12.17	41.5	36.8	33.5	36.9	39.7	39.3	34.3	31.8	28.7	26.5	23.6	23.6
125 mm	19.02	23.7	27.9	32.1	36.6	39.0	40.3	37.7	36.3	35.4	33.3	31.7	33.9
150 mm	27.38	4.6	7.3	10.1	14.3	19.7	25.6	29.8	32.7	39.9	45.4	51.6	55.4
200 mm	48.67	.0	.0	.1	.3	.3	.7	1.1	1.4	1.9	4.3	6.0	6.7
		85.2	86.2	84.8	97.1	110.0	116.2	111.4	109.2	111.3	113.3	115.2	122.2
		4.2	4.3	4.5	4.6	4.6	4.7	4.8	4.9	5.1	5.2	5.4	5.4

Source: Dataquest (May 1992)

Table 4-2 North American Wafer Size Distribution, 1985-1996
(Percent Square Inches by Diameter and Unit Distribution by Wafer Starts)

Diameter	Area	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996
Percent Square Inches by Diameter													
2 Inches	3.14	.5%	.4%	.1%	.1%	.2%	.1%	.1%	.1%	.1%	.0%	.0%	.0%
3 Inches	7.07	6.8%	5.9%	3.3%	2.2%	3.2%	1.8%	1.5%	1.3%	1.1%	.8%	.5%	.5%
100 mm	12.17	55.3%	44.9%	36.3%	33.4%	31.5%	28.8%	26.8%	26.3%	22.1%	19.8%	19.7%	17.5%
125 mm	19.02	29.9%	33.9%	40.1%	41.9%	36.7%	35.4%	32.5%	31.9%	25.9%	23.4%	21.6%	21.6%
150 mm	27.38	7.5%	14.9%	19.4%	20.7%	26.9%	30.5%	35.0%	35.9%	45.3%	48.0%	49.3%	49.9%
200 mm	48.67	.0%	.0%	.7%	1.7%	1.5%	3.4%	4.1%	4.5%	5.6%	8.0%	8.9%	10.5%
Total		100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
Total - MSI		397.8	405.4	441.6	546.4	582.0	640.2	611.3	642.0	688.7	745.5	788.6	824.5
Growth (%)			1.9%	8.9%	23.7%	6.5%	10.0%	-4.5%	5.0%	7.3%	8.2%	5.8%	4.6%
Unit Distribution by Wafer Starts (Millions of Wafers)													
2 Inches	3.14	.6	.5	.1	.2	.1	.1	.1	.1	.0	.1	.0	.0
3 Inches	7.07	3.8	3.4	2.1	1.7	2.6	1.6	1.3	1.2	1.0	.9	.6	.6
100 mm	12.17	18.1	15.0	13.2	15.0	15.1	15.2	13.5	13.9	12.5	12.1	12.8	11.9
125 mm	19.02	6.3	7.2	9.3	12.0	11.2	11.9	10.4	10.8	9.4	9.2	9.0	9.4
150 mm	27.38	1.1	2.2	3.1	4.1	5.7	7.1	7.8	8.4	11.4	13.1	14.2	15.0
200 mm	48.67	.0	.0	.1	.2	.2	.4	.5	.6	.8	1.2	1.4	1.8
Total Wafers (M)		29.9	28.3	27.9	33.2	35.0	36.4	33.7	34.9	35.1	36.6	37.9	38.6
Avg. Wafer Diam (")		4.1	4.3	4.5	4.6	4.6	4.7	4.8	4.8	5.0	5.1	5.1	5.2

Source: Dataquest (May 1992)

Table 4-3
Japanese Wafer Size Distribution, 1985-1996
(Percent Square Inches by Diameter and Unit Distribution by Wafer Starts)

Diameter	Area	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996
Percent Square Inches by Diameter													
2 Inches	3.14	.5%	.4%	.2%	.1%	.1%	.1%	.1%	.0%	.0%	.0%	.0%	.0%
3 Inches	7.07	6.8%	5.9%	2.8%	2.8%	2.6%	2.3%	2.0%	1.7%	1.4%	1.1%	.7%	.7%
100 mm	12.17	31.0%	25.0%	22.4%	21.4%	20.2%	17.9%	15.6%	13.2%	10.9%	8.6%	5.4%	5.4%
125 mm	19.02	47.4%	51.0%	53.0%	48.1%	46.5%	42.9%	39.3%	36.7%	34.3%	28.4%	24.5%	24.5%
150 mm	27.38	14.3%	17.7%	21.5%	27.4%	30.3%	36.4%	41.6%	46.4%	50.5%	52.0%	56.5%	56.5%
200 mm	48.67	.0%	.0%	.1%	.2%	.3%	.5%	1.5%	2.0%	2.9%	9.9%	12.9%	12.9%
Total		100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%
Total - MSI		588	642	670	777	913	992	1046	1012	1081	1161	1239	1319
Growth (%)			9.1%	4.4%	16.0%	17.4%	8.7%	5.4%	-3.2%	6.9%	7.4%	6.7%	6.5%
Unit Distribution by Wafer Starts (Millions of Wafers)													
2 Inches	3.14	.9	.8	.4	.2	.3	.2	.2	.1	.1	.0	.0	.0
3 Inches	7.07	5.7	5.4	2.7	3.1	3.3	3.2	2.9	2.4	2.1	1.8	1.2	1.3
100 mm	12.17	15.0	13.2	12.3	13.7	15.1	14.6	13.4	11.0	9.7	8.2	5.5	5.9
125 mm	19.02	14.7	17.2	18.7	19.7	22.3	22.4	21.6	19.5	19.5	17.4	16.0	17.0
150 mm	27.38	3.1	4.1	5.3	7.8	10.1	13.2	15.9	17.1	19.9	22.1	25.6	27.2
200 mm	48.67	.0	.0	.0	.0	.1	.1	.3	.4	.6	2.4	3.3	3.5
		39.3	40.7	39.4	44.5	51.2	53.6	54.3	50.6	52.0	51.8	51.5	54.9
		4.4	4.5	4.7	4.7	4.8	4.9	5.0	5.0	5.1	5.3	5.5	5.5

Source: Dataquest (May 1992)

Table 4-4
European Wafer Size Distribution, 1985-1996
(Percent Square Inches by Diameter and Unit Distribution by Wafer Starts)

Diameter	Area	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996
Percent Square Inches by Diameter													
2 Inches	3.14	1.0%	.5%	.4%	.4%	.4%	.3%	.3%	.3%	.2%	.2%	.1%	.1%
3 Inches	7.07	10.0%	6.8%	5.9%	5.0%	4.3%	3.7%	3.1%	2.5%	1.9%	1.2%	.8%	.8%
100 mm	12.17	60.0%	55.3%	44.9%	40.1%	35.9%	32.5%	29.1%	25.7%	22.3%	19.0%	15.3%	15.3%
125 mm	19.02	25.0%	29.9%	33.9%	34.3%	33.0%	31.9%	30.8%	29.7%	28.7%	27.6%	23.0%	23.0%
150 mm	27.38	4.0%	7.5%	14.9%	19.5%	24.4%	28.3%	32.3%	36.2%	40.2%	44.1%	47.9%	47.9%
200 mm	48.67	.0%	.0%	.0%	.7%	2.1%	3.3%	4.4%	5.6%	6.7%	7.9%	12.9%	12.9%
Total		100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%
Total - MSI		148	155	172	196	231	235	208	213	227	246	267	296
Growth (%)			4.6	10.9	14.0	17.8	1.8	-11.7	2.3	7.0	8.0	8.8	10.5
Unit Distribution by Wafers Starts (Millions of Wafers)													
2 Inches	3.14	.5	.2	.2	.3	.3	.2	.2	.2	.2	.2	.1	.1
3 Inches	7.07	2.1	1.5	1.4	1.4	1.4	1.2	.9	.7	.6	.4	.3	.3
100 mm	12.17	7.3	7.1	6.4	6.5	6.8	6.3	5.0	4.5	4.2	3.8	3.4	3.7
125 mm	19.02	2.0	2.4	3.1	3.5	4.0	3.9	3.4	3.3	3.4	3.6	3.2	3.6
150 mm	27.38	.2	.4	.9	1.4	2.1	2.4	2.4	2.8	3.3	4.0	4.7	5.2
200 mm	48.67	.0	.0	.0	.0	.1	.2	.2	.2	.3	.4	.7	.8
Total Wafers (M)		12.1	11.7	12.0	13.1	14.7	14.3	12.1	11.8	12.0	12.3	12.4	13.7
Avg. Wafer Diam (")		4.0	4.1	4.3	4.4	4.5	4.6	4.7	4.8	4.9	5.0	5.2	5.2

Source: Dataquest (May 1992)

Table 4-5
Asia/Pacific-ROW Wafer Size Distribution, 1985-1996
(Percent Square Inches by Diameter and Unit Distribution by Wafer Starts)

Diameter	Area	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996
Percent Square Inches By Diameter													
2 Inches	3.14	10.0%	9.0%	7.0%	6.0%	2.0%	1.6%	1.2%	.8%	.4%	.0%	.0%	.0%
3 Inches	7.07	7.0%	6.0%	6.0%	6.0%	13.0%	10.5%	8.1%	5.6%	3.2%	.7%	.5%	.5%
100 mm	12.17	33.0%	31.0%	28.0%	25.5%	25.1%	22.1%	15.5%	13.7%	11.4%	10.3%	7.5%	7.5%
125 mm	19.02	37.0%	31.0%	28.0%	30.0%	21.2%	21.8%	22.4%	23.1%	23.5%	21.7%	21.3%	21.3%
150 mm	27.38	13.0%	23.0%	31.0%	32.5%	38.7%	43.2%	51.0%	54.1%	58.0%	61.1%	61.8%	61.8%
200 mm	48.67	.0%	.0%	.0%	.0%	.0%	.7%	1.8%	2.7%	3.5%	6.2%	8.9%	8.9%
Total		100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%
Total - MSI		43	64	70	84	130	181	194	218	248	283	316	353
Growth (%)			47.9%	9.3%	20.6%	55.0%	39.2%	7.5%	12.2%	13.6%	14.3%	11.6%	11.8%
Unit Distribution by Wafer Starts (Millions of Wafers)													
2 Inches	3.14	1.4	1.8	1.5	1.6	.8	.9	.7	.6	.3	.0	.0	.0
3 Inches	7.07	.4	.5	.6	.7	2.4	2.7	2.2	1.7	1.1	.3	.2	.2
100 mm	12.17	1.2	1.6	1.6	1.8	2.7	3.3	2.5	2.5	2.3	2.4	1.9	2.2
125 mm	19.02	.8	1.0	1.0	1.3	1.4	2.1	2.3	2.6	3.1	3.2	3.5	4.0
150 mm	27.38	.2	.5	.8	1.0	1.8	2.9	3.6	4.3	5.2	6.3	7.1	8.0
200 mm	48.67	.0	.0	.0	.0	.0	.0	.1	.1	.2	.4	.6	.6
Total Wafers (M)		4.0	5.6	5.5	6.4	9.2	11.9	11.4	11.8	12.2	12.6	13.4	15.0
Avg. Wafer Diam (")		3.7	3.8	4.0	4.1	4.2	4.4	4.7	4.8	5.1	5.3	5.5	5.5

Source: Dataquest (May 1992)

Section 5. Historical Revenue Data by Company

Table 5-1
Each Company's Revenue from Shipments of Merchant Silicon Wafers* and Epitaxial Wafers to the World, 1985-1991
(End-User Revenue in Millions of U.S. Dollars)

Company: All
Product: Merchant Silicon Wafers and Merchant Epitaxial Wafers
Region Of Consumption: World

Company	1985	1986	1987	1988	1989	1990	1991
North American Companies							
Cincinnati Milacron	42.1	37.9	34.0	30.2	N/M	N/M	N/M
Crysteco	8.5	8.5	9.5	11.0	11.6	14.1	16.8
Epitaxy, Inc.	6.0	6.2	7.0	7.5	9.6	10.7	10.7
Monsanto	137.0	154.0	185.0	254.0	N/M	N/M	N/M
NBK Corporation	7.0	N/M	N/M	N/M	N/M	N/M	N/M
Recticon	4.7	4.1	4.5	5.5	7.0	8.0	N/M
Siltec	24.8	21.3	N/M	N/M	N/M	N/M	N/M
Unisil	N/M	N/M	N/M	N/M	8.5	12.5	16.6
U.S. Semiconductor	3.0	4.0	N/M	N/M	N/M	N/M	N/M
Other U.S. Companies	16.8	14.0	12.4	11.2	11.9	14.6	11.9
Total	249.9	250.0	252.4	319.4	48.6	59.9	56.0
Japanese Companies							
Kawasaki Steel, NBK Corp.	N/M	7.1	7.0	11.0	8.0	11.0	11.3
Komatsu Electronic Metals	113.8	168.5	197.3	256.9	254.2	279.0	332.6
Mitsubishi Materials	123.2	195.0	241.3	300.2	303.4	317.4	352.4
Osaka Titanium Company[1]	132.3	197.6	235.5	281.6	317.4	348.1	389.3
Shin-Etsu Handotai	298.9	408.0	452.1	567.3	645.3	691.5	750.3
Toshiba Ceramics	35.1	61.0	78.9	94.5	112.0	129.7	148.2
Other Japanese Companies	.0	.0	11.4	23.8	31.3	42.2	68.3
Total	703.3	1,037.2	1,223.5	1,535.3	1,671.6	1,818.9	2,052.4
European Companies							
DNS Electronic Materials	43.0	53.0	63.0	74.5	N/M	N/M	N/M
Hüls AG	N/M	N/M	N/M	N/M	358.5	410.9	446.6
Topsil	8.7	8.5	9.0	10.5	13.1	15.5	18.8
Wacker	160.4	162.1	177.0	253.8	312.8	313.6	303.2
Other European Companies	2.0	3.0	3.0	1.9	6.4	6.4	6.5
Total	214.1	226.6	252.0	340.7	690.8	746.4	775.1
Asia/Pacific-ROW Companies							
Korsil[2]	.0	.0	5.0	25.0	15.0	N/M	N/M
Siltron	.0	.0	.7	7.6	14.5	26.2	35.4
Other ROW Companies	.5	1.3	2.2	3.3	4.3	13.0	15.7
Total	.5	1.3	7.9	35.9	33.8	39.2	51.1
Worldwide	1,167.8	1,515.1	1,735.8	2,231.3	2,444.8	2,664.4	2,934.6

N/M = Not Meaningful
*Includes prime, test, and monitor wafers
[1] Includes U.S. Semiconductor sales from 1987, Cincinnati Semiconductor from 1989.
[2] Korsil ended operations in 5/89.
Source: Dataquest (May 1992)

Table 5-2
Each Company's Revenue from Shipments of Merchant Silicon Wafers* to the World, 1985-1991
(End-User Revenue in Millions of U.S. Dollars)

Company: Each
Product: Merchant Silicon Wafers
Region Of Consumption: World

Company	1985	1986	1987	1988	1989	1990	1991
North American Companies							
Cincinnati Milacron	.0	.0	.0	.0	N/M	N/M	N/M
Crysteco	8.5	8.5	9.5	11.0	11.6	14.1	16.8
Epitaxy, Inc.	.0	.0	.0	.0	.0	.0	.0
Monsanto	126.5	131.0	147.9	195.1	N/M	N/M	N/M
NBK Corporation	7.0	N/M	N/M	N/M	N/M	N/M	N/M
Recticon	4.7	4.1	4.5	5.5	7.0	8.0	N/M
Siltec	24.8	21.3	N/M	N/M	N/M	N/M	N/M
Unisil		N/M	N/M	N/M	8.5	12.5	16.6
U.S. Semiconductor	.0	.0	N/M	N/M	N/M	N/M	N/M
Other U.S. Companies	6.5	7.0	7.0	5.7	5.7	6.1	5.6
Total	178.0	171.9	168.9	217.3	32.8	40.7	39.0
Japanese Companies							
Kawasaki Steel, NBK Corp.	N/A	7.1	7.0	7.5	6.8	10.7	10.3
Komatsu Electronic Metals	90.7	133.7	155.1	200.8	200.8	225.2	261.9
Mitsubishi Materials	91.2	138.5	173.8	216.4	216.4	227.2	248.2
Osaka Titanium Company[1]	124.3	181.4	203.0	237.8	247.6	272.7	286.3
Shin-Etsu Handotai	233.4	304.0	328.4	412.2	461.0	499.9	543.8
Toshiba Ceramics	28.1	47.6	62.3	74.7	78.5	80.8	90.7
Other Japanese Companies	.0	.0	11.1	21.5	31.3	42.2	68.3
Total	567.7	812.3	940.7	1170.9	1242.4	1358.7	1509.5
European Companies							
DNS Electronic Materials	43.0	53.0	63.0	72.5	N/M	N/M	N/M
Hüls AG	N/M	N/M	N/M	N/M	287.1	320.9	346.5
Topsil	8.7	8.5	9.0	10.5	13.1	15.5	19.5
Wacker	143.0	140.1	130.9	189.2	216.0	220.3	224.4
Other European Companies	2.0	3.0	3.0	1.9	6.4	6.4	6.5
Total	196.7	204.6	205.9	274.1	522.6	563.1	596.9
Asia/Pacific-ROW Companies							
Korsil[2]	.0	.0	5.0	25.0	15.0	N/M	N/M
Siltron	.0	.0	.7	7.6	14.5	26.2	35.4
Other ROW Companies	.3	.6	1.0	1.8	2.8	10.0	12.5
Total	.3	.6	6.7	34.4	32.3	36.2	47.9
Worldwide	942.7	1189.4	1322.2	1696.7	1830.1	1998.7	2193.3

N/M= Not Meaningful
*Includes prime, test, and monitor wafers
[1]Includes U.S. Semiconductor sales from 1987, Cincinnati Semiconductor from 1989.
[2]Korsil ended operations in 5/89.
Source: Dataquest (May 1992)

Table 5-3
Each Company's Revenue from Shipments of Merchant Epitaxial Wafers to the World, 1985-1991
(End-User Revenue in Millions of U.S. Dollars)

Company: All
Product: Merchant Epitaxial Wafers
Region Of Consumption: World

Company	1985	1986	1987	1988	1989	1990	1991
North American Companies							
Cincinnati Milacron	42.1	37.9	34.0	30.2	N/M	N/M	N/M
Crysteco	.0	.0	.0	.0	.0	.0	.0
Epitaxy, Inc.	6.0	6.2	7.0	7.5	9.6	10.7	10.7
Monsanto	10.5	23.0	37.1	58.9	N/M	N/M	N/M
NBK Corporation	.0	N/M	N/M	N/M	N/M	N/M	N/M
Recticon	.0	.0	.0	.0	.0	.0	N/M
Siltec	.0	.0	N/M	N/M	N/M	N/M	N/M
Unisil	N/M	N/M	N/M	N/M	0	0	0
U.S. Semiconductor	3.0	4.0	N/M	N/M	N/M	N/M	N/M
Other U.S. Companies	10.3	7.0	5.4	5.5	6.2	8.5	6.3
Total	71.9	78.1	83.5	102.1	15.8	19.2	17.0
Japanese Companies							
Kawasaki Steel, NBK Corp.	N/M	.0	.0	3.5	1.2	.3	1.0
Komatsu Electronic Metals	23.1	34.8	42.2	56.1	53.4	53.8	70.7
Mitsubishi Materials	32.0	56.5	67.5	83.8	87.0	90.2	104.2
Osaka Titanium Company[1]	8.0	16.2	32.5	43.8	69.8	75.4	103.0
Shin-Etsu Handotai	65.5	104.0	123.7	155.1	184.3	191.6	206.5
Toshiba Ceramics	7.0	13.4	16.6	19.8	33.5	48.9	57.5
Other Japanese Companies	.0	.0	.3	2.3	.0	.0	.0
Total	135.6	224.9	282.8	364.4	429.2	460.2	542.9
European Companies							
DNS Electronic Materials	.0	.0	.0	2.0	N/M	N/M	N/M
Hüls AG	N/M	N/M	N/M	N/M	71.4	90	100.1
Topsil	.0	.0	.0	.0	.0	.0	.0
Wacker	17.4	22.0	46.1	64.6	96.8	93.3	78.8
Other European Companies	.0	.0	.0	.0	.0	.0	.0
Total	17.4	22.0	46.1	66.6	168.2	183.3	178.9
Asia/Pacific-ROW Companies							
Korsil[2]	.0	.0	.0	.0	.0	N/M	N/M
Siltron	.0	.0	.0	.0	.0	.0	.0
Other ROW Companies	.2	.7	1.2	1.5	1.5	3.0	3.2
Total	.2	.7	1.2	1.5	1.5	3.0	3.2
Worldwide	225.1	325.7	413.6	534.6	614.7	665.7	742.0

N/M = Not Meaningful
*Includes prime, test, and monitor wafers
[1]Includes U.S. Semiconductor sales from 1987, Cincinnati Semiconductor from 1989.
[2]Korsil ended operations in 5/89.
Source: Dataquest (May 1992)

Table 5-4
Each Company's Revenue from Shipments of Merchant Silicon Wafers* and Epitaxial Wafers to North America, 1985-1991
(End-User Revenue in Millions of Dollars)

Company: Each
Product: Merchant Silicon Wafers and Merchant Epitaxial Wafers
Region of Consumption North America

Company	1985	1986	1987	1988	1989	1990	1991
North American Companies							
Cincinnati Milacron	39.1	35.3	31.6	27.0	N/M	N/M	N/M
Crysteco	8.0	8.0	9.0	10.4	10.6	11.0	13.6
Epitaxy, Inc.	2.7	2.5	2.5	2.6	3.8	4.7	4.7
Monsanto	107.3	106.3	115.0	144.1	N/M	N/M	N/M
NBK Corporation	6.7	N/M	N/M	N/M	N/M	N/M	N/M
Recticon	4.7	4.1	4.5	5.5	7.0	8.0	N/M
Siltec	23.8	20.4	N/M	N/M	N/M	N/M	N/M
Unisil	N/M	N/M	N/M	N/M	8.5	12.5	13.9
U.S. Semiconductor	2.8	3.8	N/M	N/M	N/M	N/M	N/M
Other U.S. Companies	14.0	12.3	11.1	10.5	10.5	13.2	10.5
Total	209.1	192.7	173.7	200.1	40.4	49.4	42.7
Japanese Companies							
Kawasaki Steel, NBK Corp.	N/M	6.2	5.5	8.9	5.4	5.7	5.8
Komatsu Electronic Metals	4.9	6.6	8.5	10.6	10.7	7.0	7.5
Mitsubishi Materials	1.2	2.0	28.3	38.0	50.0	55.0	67.1
Osaka Titanium Company[1]	12.9	17.3	21.8	29.7	61.0	66.9	94.3
Shin-Etsu Handotai	49.6	53.9	60.8	73.2	126.0	138.5	146.1
Toshiba Ceramics	.2	.2	.2	.2	.0	.0	.0
Other Japanese Companies	.0	.0	.0	.0	.0	.0	.0
Total	68.8	86.2	125.1	160.6	253.1	273.1	320.8
European Companies							
DNS Electronic Materials	18.9	19.6	23.3	28.5	N/M	N/M	N/M
Hüels AG	N/M	N/M	N/M	N/M	184.1	199	201.6
Topsil	2.2	1.9	2.1	2.1	2.9	2.8	3.0
Wacker	56.1	49.4	71.0	127.0	153.0	152.0	126.7
Other European Companies	.0	.0	.0	.0	.0	.0	.0
Total	77.2	70.9	96.4	157.6	340.0	353.8	331.3
Asia/Pacific-ROW Companies							
Korsil[2]	.0	.0	.0	.0	.0	N/M	N/M
Siltron	.0	.0	.0	1.2	.5	.5	.5
Other ROW Companies	.0	.0	.0	.0	.0	.0	.0
Total	.0	.0	.0	1.2	.5	.5	.5
Total North America	355.1	349.8	395.2	519.5	634.0	676.8	695.3

N/M = Not Meaningful
*Includes prime, test, and monitor wafers
[1]Includes U.S. Semiconductor sales from 1987, Cincinnati Semiconductor from 1989.
[2]Korsil ended operations in 5/89.
Source: Dataquest (May 1992)

Table 5-5
Each Company's Revenue from Shipments of Merchant Silicon Wafers* to North America, 1985-1991
(End-User Revenue in Millions of U.S. Dollars)

Company: All
Product: Merchant Silicon Wafers
Region Of Consumption: North America

Company	1985	1986	1987	1988	1989	1990	1991
North American Companies							
Cincinnati Milacron	.0	.0	.0	.0	N/M	N/M	N/M
Crysteco	8.0	8.0	9.0	10.4	10.6	11.0	13.6
Epitaxy, Inc.	.0	.0	.0	.0	.0	.0	.0
Monsanto	97.7	87.9	88.4	104.3	N/M	N/M	N/M
NBK Corporation	6.7	N/M	N/M	N/M	N/M	N/M	N/M
Recticon	4.7	4.1	4.5	5.5	7.0	8.0	N/M
Siltec	23.8	20.4	N/M	N/M	N/M	N/M	N/M
Unisil	N/M	N/M	N/M	N/M	8.5	12.5	13.9
U.S. Semiconductor	.0	.0	N/M	N/M	N/M	N/M	N/M
Other U.S. Companies	5.6	6.4	6.7	5.3	5.3	5.7	5.2
Total	146.5	126.8	108.6	125.5	31.4	37.2	32.7
Japanese Companies							
Kawasaki Steel, NBK Corp.	N/M	6.2	5.5	5.4	4.2	5.4	4.8
Komatsu Electronic Metals	4.5	6.0	7.5	9.4	9.4	5.6	4.7
Mitsubishi Materials	.9	1.4	27.6	37.2	44.8	47.8	48.9
Osaka Titanium Company[1]	12.4	16.3	15.6	13.3	17.1	18.0	22.8
Shin-Etsu Handotai	44.6	45.8	48.6	57.0	81.0	86.7	89.9
Toshiba Ceramics	.2	.2	.2	.2	.0	.0	.0
Other Japanese Companies	.0	.0	.0	.0	.0	.0	.0
Total	62.6	75.9	105.0	122.5	156.5	163.5	171.1
European Companies							
DNS Electronic Materials	18.9	19.6	23.3	27.0	N/M	N/M	N/M
Hüls AG	N/M	N/M	N/M	N/M	136.8	137.0	135.4
Topsil	2.2	1.9	2.1	2.1	2.9	2.8	2.8
Wacker	50.5	43.9	45.0	85.0	85.0	90.0	88.0
Other European Companies	.0	.0	.0	.0	.0	.0	.0
Total	71.6	65.4	70.4	114.1	224.7	229.8	226.2
Asia/Pacific-ROW Companies							
Korsil[2]	.0	.0	.0	.0	.0	N/M	N/M
Siltron	.0	.0	.0	1.2	.5	.5	.5
Other ROW Companies	.0	.0	.0	.0	.0	.0	.0
Total	.0	.0	.0	1.2	.5	.5	.5
Total North America	280.7	268.1	284.0	363.3	413.1	431.0	430.5

N/M = Not Meaningful
*Includes prime, test, and monitor wafers
[1] Includes U.S. Semiconductor sales from 1987, Cincinnati Semiconductor from 1989.
[2] Korsil ended operations in 5/89.
Source: Dataquest (May 1992)

Table 5-6
Each Company's Revenue from Shipments of Silicon Epitaxial Wafers to North America, 1985-1991 (End-User Revenue in Millions of U.S. Dollars)

Company: All
Product: Silicon Epitaxial Wafers
Region Of Consumption: North America

Company	1985	1986	1987	1988	1989	1990	1991
North American Companies							
Cincinnati Milacron	39.1	35.3	31.6	27.0	N/M	N/M	N/M
Crysteco	.0	.0	.0	.0	.0	.0	.0
Epitaxy, Inc.	2.7	2.5	2.5	2.6	3.8	4.7	4.7
Monsanto	9.6	18.4	26.6	39.8	N/M	N/M	N/M
NBK Corporation	.0	N/M	N/M	N/M	N/M	N/M	N/M
Recticon	.0	.0	.0	.0	.0	.0	N/M
Siltec	.0	.0	N/M	N/M	N/M	N/M	N/M
Unisil	N/M	N/M	N/M	N/M	0	0	0
U.S. Semiconductor	2.8	3.8	N/M	N/M	N/M	N/M	N/M
Other U.S. Companies	8.4	5.9	4.4	5.2	5.2	7.5	5.3
Total	62.6	65.9	65.1	74.6	9.0	12.2	10.0
Japanese Companies							
Kawasaki Steel, NBK Corp.	N/M	.0	.0	3.5	1.2	.3	1.0
Komatsu Electronic Metals	.4	.6	1.0	1.2	1.3	1.4	2.8
Mitsubishi Materials	.3	.6	.7	.8	5.2	7.2	18.2
Osaka Titanium Company[1]	.5	1.0	6.2	16.4	43.9	48.9	71.5
Shin-Etsu Handotai	5.0	8.1	12.2	16.2	45.0	51.8	56.2
Toshiba Ceramics	.0	.0	.0	.0	.0	.0	.0
Other Japanese Companies	.0	.0	.0	.0	.0	.0	.0
Total	6.2	10.3	20.1	38.1	96.6	109.6	149.7
European Companies							
DNS Electronic Materials	.0	.0	.0	1.5	N/M	N/M	N/M
Hüls AG	N/M	N/M	N/M	N/M	47.3	62	66.2
Topsil	.0	.0	.0	.0	.0	.0	.0
Wacker	5.6	5.5	26.0	42.0	68.0	62.0	38.7
Other European Companies	.0	.0	.0	.0	.0	.0	.0
Total	5.6	5.5	26.0	43.5	115.3	124.0	104.9
Asia/Pacific-ROW Companies							
Korsil[2]	.0	.0	.0	.0	.0	N/M	N/M
Siltron	.0	.0	.0	.0	.0	.0	.0
Other ROW Companies	.0	.0	.0	.0	.0	.0	.0
Total	.0	.0	.0	.0	.0	.0	.0
Total North America	74.4	81.7	111.2	156.2	220.9	245.8	264.6

N/M = Not Meaningful
[1] Includes U.S. Semiconductor sales from 1987, Cincinnati Semiconductor from 1989.
[2] Korsil ended operations in 5/89.
Source: Dataquest (May 1992)

Table 5-7
Each Company's Revenue from Shipments of Merchant Silicon Wafers* and Merchant Epitaxial Wafers to Japan, 1985-1991
(End-User Revenue in Millions of U.S. Dollars)

Company: All
Product: Merchant Silicon Wafers and Merchant Epitaxial Wafers
Region Of Consumption: Japan

Company	1985	1986	1987	1988	1989	1990	1991
North American Companies							
Cincinnati Milacron	.0	.0	.0	.0	N/M	N/M	N/M
Crysteco	.2	.3	.3	.3	.5	.8	.8
Epitaxy, Inc.	.0	.0	.0	.0	.0	.0	.0
Monsanto	8.2	12.6	23.4	41.0	N/M	N/M	N/M
NBK Corporation	.1	N/M	N/M	N/M	N/M	N/M	N/M
Recticon	.0	.0	.0	.0	.0	.0	N/M
Siltec	.0	.0	N/M	N/M	N/M	N/M	N/M
Unisil	N/M	N/M	N/M	N/M	.0	.0	.1
U.S. Semiconductor	.0	.0	N/M	N/M	N/M	N/M	N/M
Other U.S. Companies	.1	.1	.1	.0	.0	.0	.0
Total	8.6	13.0	23.8	41.3	.5	.8	.9
Japanese Companies							
Kawasaki Steel, NBK Corp.	N/M	.3	.4	.6	.6	2.1	2.7
Komatsu Electronic Metals	107.8	160.2	186.8	242.2	241.2	265.0	318.3
Mitsubishi Materials	118.5	189.4	208.4	257.8	249.1	258.0	281.9
Osaka Titanium Company[1]	115.5	170.9	197.4	233.6	228.9	250.5	264.9
Shin-Etsu Handotai	241.2	338.3	366.6	468.7	492.0	492.5	534.5
Toshiba Ceramics	34.9	60.8	78.7	94.3	109.5	127.4	145.8
Other Japanese Companies	.0	.0	11.4	23.8	31.3	42.2	68.3
Total	617.9	919.9	1,049.7	1,321.0	1,352.6	1,437.7	1,616.4
European Companies							
DNS Electronic Materials	.0	.0	.0	.0	N/M	N/M	N/M
Hüls AG	N/M	N/M	N/M	N/M	45.0	54.4	66.2
Topsil	2.6	3.1	4.7	4.9	5.0	6.0	9.2
Wacker	3.2	3.0	4.9	16.0	22.0	30.0	39.7
Other European Companies	.0	.0	.0	.0	.0	.0	.0
Total	5.8	6.1	9.6	20.9	72.0	90.4	115.1
Asia/Pacific-ROW Companies							
Korsil[2]	.0	.0	.0	.0	.0	N/M	N/M
Siltron	.0	.0	.0	.0	.0	.0	.0
Other ROW Companies	.0	.0	.0	.0	.0	.0	.0
Total	.0	.0	.0	.0	.0	.0	.0
Total Japan	632.3	939.0	1,083.1	1,383.2	1,425.1	1,528.9	1,732.4

N/M = Not Meaningful
*Includes prime, test, and monitor wafers
[1] Includes U.S. Semiconductor sales from 1987, Cincinnati Semiconductor from 1989.
[2] Korsil ended operations in 5/89.
Source: Dataquest (May 1992)

Table 5-8
Each Company's Revenue from Shipments of Merchant Silicon Wafers* to Japan, 1985-1991
(End-User Revenue in Millions of U.S. Dollars)

Company: All
Product: Merchant Silicon Wafers
Region Of Consumption: Japan

Company	1985	1986	1987	1988	1989	1990	1991
North American Companies							
Cincinnati Milacron	.0	.0	.0	.0	N/M	N/M	N/M
Crysteco	.2	.3	.3	.3	.5	.8	.8
Epitaxy, Inc.	.0	.0	.0	.0	.0	.0	.0
Monsanto	8.2	12.6	21.7	38.4	N/M	N/M	N/M
NBK Corporation	.1	N/M	N/M	N/M	N/M	N/M	N/M
Recticon	.0	.0	.0	.0	.0	.0	N/M
Siltec	.0	.0	N/M	N/M	N/M	N/M	N/M
Unisil	N/M	N/M	N/M	N/M	.0	.0	.1
U.S. Semiconductor	.0	.0	N/M	N/M	N/M	N/M	N/M
Other U.S. Companies	.0	.0	.0	.0	.0	.0	.0
Total	8.5	12.9	22.0	38.7	.5	.8	.9
Japanese Companies							
Kawasaki Steel, NBK Corp.	N/M	.3	.4	.6	.6	2.1	2.7
Komatsu Electronic Metals	85.2	126.1	145.7	187.5	189.2	212.6	250.4
Mitsubishi Materials	87.6	134.3	142.4	175.8	168.3	176.0	196.5
Osaka Titanium Company[1]	108.2	156.0	172.2	207.8	207.1	227.0	236.1
Shin-Etsu Handotai	180.9	243.6	256.9	332.0	340.0	355.5	387.1
Toshiba Ceramics	27.9	47.4	62.1	74.5	77.5	80.0	89.9
Other Japanese Companies	.0	.0	11.1	21.5	31.3	42.2	68.3
Total	489.8	707.7	790.8	999.7	1,014.0	1,095.4	1,231.0
European Companies							
DNS Electronic Materials	.0	.0	.0	.0	N/M	N/M	N/M
Hüls AG	N/M	N/M	N/M	N/M	42.2	51.5	63.3
Topsil	2.6	3.1	4.7	4.9	5.0	6.0	8.5
Wacker	3.2	3.0	4.9	16.0	20.0	25.8	30.4
Other European Companies	.0	.0	.0	.0	.0	.0	.0
Total	5.8	6.1	9.6	20.9	67.2	83.3	102.2
Asia/Pacific-ROW Companies							
Korsil[2]	.0	.0	.0	.0	.0	N/M	N/M
Siltron	.0	.0	.0	.0	.0	.0	.0
Other ROW Companies	.0	.0	.0	.0	.0	.0	.0
Total	.0	.0	.0	.0	.0	.0	.0
Total Japan	504.1	726.7	822.4	1,059.3	1,081.7	1,179.5	1,334.1

N/M = Not Meaningful
*Includes prime, test, and monitor wafers
[1] Includes U.S. Semiconductor sales from 1987, Cincinnati Semiconductor from 1989.
[2] Korsil ended operations in 5/89.
Source: Dataquest (May 1992)

Table 5-9
Each Company's Revenues from Shipments of Silicon Epitaxial Wafers to Japan, 1985-1991
(End-User Revenue in Millions of U.S. Dollars)

Company: All
Product: Silicon Epitaxial Wafers
Region of Consumption Japan

Company	1985	1986	1987	1988	1989	1990	1991
North American Companies							
Cincinnati Milacron	.0	.0	.0	.0	N/M	N/M	N/M
Crysteco	.0	.0	.0	.0	.0	.0	.0
Epitaxy, Inc.	.0	.0	.0	.0	.0	.0	.0
Monsanto	.0	.0	1.7	2.6	N/M	N/M	N/M
NBK Corporation	.0	N/M	N/M	N/M	N/M	N/M	N/M
Recticon	.0	.0	.0	.0	.0	.0	N/M
Siltec	.0	.0	N/M	N/M	N/M	N/M	N/M
Unisil	N/M	N/M	N/M	N/M	0	0	0
U.S. Semiconductor	.0	.0	N/M	N/M	N/M	N/M	N/M
Other U.S. Companies	.1	.1	.1	.0	.0	.0	.0
Total	.1	.1	1.8	2.6	.0	.0	.0
Japanese Companies							
Kawasaki Steel, NBK Corp.	N/M	.0	.0	.0	.0	.0	.0
Komatsu Electronic Metals	22.6	34.1	41.1	54.7	52.0	52.4	67.9
Mitsubishi Materials	30.9	55.1	66.0	82.0	80.8	82.0	85.4
Osaka Titanium Company[1]	7.3	14.9	25.2	25.8	21.8	23.5	28.8
Shin-Etsu Handotai	60.3	94.7	109.7	136.7	137.0	137.0	147.4
Toshiba Ceramics	7.0	13.4	16.6	19.8	32.0	47.4	55.9
Other Japanese Companies	.0	.0	.3	2.3	.0	.0	.0
Total	128.1	212.2	258.9	321.3	323.6	342.3	385.4
European Companies							
DNS Electronic Materials	.0	.0	.0	.0	N/M	N/M	N/M
Hüls AG	N/M	N/M	N/M	N/M	2.8	2.9	2.9
Topsil	.0	.0	.0	.0	.0	.0	.0
Wacker	.0	.0	.0	.0	2.0	4.2	9.3
Other European Companies	.0	.0	.0	.0	.0	.0	.0
Total	.0	.0	.0	.0	4.8	7.1	12.2
Asia/Pacific-ROW Companies							
Korsil[2]	.0	.0	.0	.0	.0	N/M	N/M
Siltron	.0	.0	.0	.0	.0	.0	.0
Other ROW Companies	.0	.0	.0	.0	.0	.0	.0
Total	.0	.0	.0	.0	.0	.0	.0
Total Japan	128.2	212.3	260.7	323.9	328.4	349.4	397.6

N/M = Not Meaningful
[1]Includes U.S. Semiconductor sales from 1987, Cincinnati Semiconductor from 1989.
[2]Korsil ended operations in 5/89.
Source: Dataquest (May 1992)

Table 5-10
Each Company's Revenue from Shipments of Merchant Silicon Wafers* and Merchant Epitaxial Wafers to Europe, 1985-1991
(End-User Revenue in Millions of U.S. Dollars)

Company:	All
Product:	Merchant Silicon Wafer and Merchant Epitaxial Wafers
Region of Consumption	Europe

Company	1985	1986	1987	1988	1989	1990	1991
North American Companies							
Cincinnati Milacron	1.7	1.5	1.4	1.7	N/M	N/M	N/M
Crysteco	.3	.2	.2	.3	.5	2.3	2.4
Epitaxy, Inc.	.6	.3	.1	.4	.7	.9	.9
Monsanto	15.1	20.7	29.4	43.6	N/M	N/M	N/M
NBK Corporation	.0	N/M	N/M	N/M	N/M	N/M	N/M
Recticon	.0	.0	.0	.0	.0	.0	N/M
Siltec	.0	.0	N/M	N/M	N/M	N/M	N/M
Unisil	N/M	N/M	N/M	N/M	0	0	.1
U.S. Semiconductor	.1	.1	N/M	N/M	N/M	N/M	N/M
Other U.S. Companies	1.8	1.2	.9	.5	.9	.9	.9
Total	19.6	24.0	32.0	46.5	2.1	4.1	4.3
Japanese Companies							
Kawasaki Steel, NBK Corp.	N/M	.0	.0	.0	.0	.0	.0
Komatsu Electronic Metals	.0	.0	.0	1.2	1.2	7.0	6.8
Mitsubishi Materials	2.4	2.0	2.0	2.5	2.5	2.6	1.5
Osaka Titanium Company[1]	2.6	8.0	14.7	16.4	23.0	24.3	23.0
Shin-Etsu Handotai	6.7	13.2	20.4	20.2	21.6	23.5	27.4
Toshiba Ceramics	.0	.0	.0	.0	.0	.0	.0
Other Japanese Companies	.0	.0	.0	.0	.0	.0	.0
Total	11.7	23.2	37.1	40.3	48.3	57.4	58.7
European Companies							
DNS Electronic Materials	21.5	29.7	34.0	39.0	N/M	N/M	N/M
Hüls AG		N/M	N/M	N/M	92.7	103.7	101.8
Topsil	3.5	3.0	2.0	3.3	4.5	5.2	5.3
Wacker	78.6	84.7	79.8	92.0	116.7	105.7	105.7
Other European Companies	2.0	3.0	3.0	1.9	5.7	5.7	6.0
Total	105.6	120.4	118.8	136.2	219.6	220.3	218.8
Asia/Pacific-ROW Companies							
Korsil[2]	.0	.0	.0	.0	.0	N/M	N/M
Siltron	.0	.0	.0	.0	.0	.0	.0
Other ROW Companies	.0	.0	.0	.0	.0	.0	.0
Total	.0	.0	.0	.0	.0	.0	.0
Total Europe	136.9	167.6	187.9	223.0	270.0	281.8	281.8

N/M = Not Meaningful
*Includes prime, test, and monitor wafers
[1] Includes U.S. Semiconductor sales from 1987, Cincinnati Semiconductor from 1989.
[2] Korsil ended operations in 5/89.
Source: Dataquest (May 1992)

Table 5-11
Each Company's Revenue from Shipments of Merchant Silicon Wafers* to Europe, 1985-1991 (End-User Revenue in Millions of U.S. Dollars)

Company: All
Product: Merchant Silicon Wafers
Region Of Consumption: Europe

Company	1985	1986	1987	1988	1989	1990	1991
North American Companies							
Cincinnati Milacron	.0	.0	.0	.0	N/M	N/M	N/M
Crysteco	.3	.2	.2	.3	.5	2.3	2.4
Epitaxy, Inc.	.0	.0	.0	.0	.0	.0	.0
Monsanto	14.2	16.1	20.9	27.6	N/M	N/M	N/M
NBK Corporation	.0	N/M	N/M	N/M	N/M	N/M	N/M
Recticon	.0	.0	.0	.0	.0	.0	N/M
Siltec	.0	.0	N/M	N/M	N/M	N/M	N/M
Unisil	N/M	N/M	N/M	N/M	0	0	.1
U.S. Semiconductor	.0	.0	N/M	N/M	N/M	N/M	N/M
Other U.S. Companies	.5	.4	.2	.2	.2	.2	.2
Total	15.0	16.7	21.3	28.1	.7	2.5	2.7
Japanese Companies							
Kawasaki Steel, NBK Corp.	N/M	.0	.0	.0	.0	.0	.0
Komatsu Electronic Metals	.0	.0	.0	1.2	1.2	7.0	6.8
Mitsubishi Materials	1.8	1.4	1.4	1.7	1.7	1.8	1.1
Osaka Titanium Company[1]	2.5	7.8	13.8	15.2	20.8	22.0	20.4
Shin-Etsu Handotai	6.5	12.1	18.7	18.2	19.5	21.0	24.8
Toshiba Ceramics	.0	.0	.0	.0	.0	.0	.0
Other Japanese Companies	.0	.0	.0	.0	.0	.0	.0
Total	10.8	21.3	33.9	36.3	43.2	51.8	53.1
European Companies							
DNS Electronic Materials	21.5	29.7	34.0	38.5	N/M	N/M	N/M
Hüls AG	N/M	N/M	N/M	N/M	72.2	79.4	75.3
Topsil	3.5	3.0	2.0	3.3	4.5	5.2	6.3
Wacker	66.8	68.2	60.0	70.2	91.0	80.0	78.6
Other European Companies	2.0	3.0	3.0	1.9	5.7	5.7	6.0
Total	93.8	103.9	99.0	113.9	173.4	170.3	166.2
Asia/Pacific-ROW Companies							
Korsil[2]	.0	.0	.0	.0	.0	N/M	N/M
Siltron	.0	.0	.0	.0	.0	.0	.0
Other ROW Companies	.0	.0	.0	.0	.0	.0	.0
Total	.0	.0	.0	.0	.0	.0	.0
Total Europe	119.6	141.9	154.2	178.3	217.3	224.6	222.0

N/M = Not meaningful
*Includes prime, test, and monitor wafers
[1]Includes U.S. Semiconductor sales from 1987, Cincinnati Semiconductor from 1989.
[2]Korsil ended operations in 5/89.
Source: Dataquest (May 1992)

Table 5-12
Each Company's Revenue from Shipments of Merchant Silicon Epitaxial Wafers to Europe, 1985-1991 (End-User Revenue in Millions of U.S. Dollars)

Product: Merchant Silicon Epitaxial Wafers
Region Of Consumption: Europe
Company All

Company	1985	1986	1987	1988	1989	1990	1991
North American Companies							
Cincinnati Milacron	1.7	1.5	1.4	1.7	N/M	N/M	N/M
Crysteco	.0	.0	.0	.0	.0	.0	.0
Epitaxy, Inc.	.6	.3	.1	.4	.7	.9	.9
Monsanto	.9	4.6	8.5	16.0	N/M	N/M	N/M
NBK Corporation	.0	N/M	N/M	N/M	N/M	N/M	N/M
Recticon	.0	.0	.0	.0	.0	.0	N/M
Siltec	.0	.0	N/M	N/M	N/M	N/M	N/M
Unisil	N/M	N/M	N/M	N/M	0	0	0
U.S. Semiconductor	.1	.1	N/M	N/M	N/M	N/M	N/M
Other U.S. Companies	1.3	.8	.7	.3	.7	.7	.7
Total	4.6	7.3	10.7	18.4	1.4	1.6	1.6
Japanese Companies							
Kawasaki Steel, NBK Corp.	N/M	.0	.0	.0	.0	.0	.0
Komatsu Electronic Metals	.0	.0	.0	.0	.0	.0	.0
Mitsubishi Materials	.6	.6	.6	.8	.8	.8	.4
Osaka Titanium Company[1]	.1	.2	.9	1.2	2.2	2.3	2.6
Shin-Etsu Handotai	.2	1.1	1.7	2.0	2.1	2.5	2.6
Toshiba Ceramics	.0	.0	.0	.0	.0	.0	.0
Other Japanese Companies	.0	.0	.0	.0	.0	.0	.0
Total	.9	1.9	3.2	4.0	5.1	5.6	5.6
European Companies							
DNS Electronic Materials	.0	.0	.0	.5	N/M	N/M	N/M
Hüls AG	N/M	N/M	N/M	N/M	20.5	24.3	26.5
Topsil	.0	.0	.0	.0	.0	.0	.0
Wacker	11.8	16.5	19.8	21.8	25.7	25.7	27.1
Other European Companies	.0	.0	.0	.0	.0	.0	.0
Total	11.8	16.5	19.8	22.3	46.2	50.0	53.6
Asia/Pacific-ROW Companies							
Korsil[2]	.0	.0	.0	.0	.0	N/M	N/M
Siltron	.0	.0	.0	.0	.0	.0	.0
Other ROW Companies	.0	.0	.0	.0	.0	.0	.0
Total	.0	.0	.0	.0	.0	.0	.0
Total Europe	17.3	25.7	33.7	44.7	52.7	57.2	60.8

N/M = Not Meaningful
[1]Includes U.S. Semiconductor sales from 1987, Cincinnati Semiconductor from 1989.
[2]Korsil ended operations in 5/89.
Source: Dataquest (May 1992)

Table 5-13
Each Company's Revenue from Shipments of Merchant Silicon Wafers* and Epitaxial Wafers to Asia/Pacific-ROW, 1985-1991
(End-User Revenue in Millions of U.S. Dollars)

Company: All
Product: Merchant Silicon Wafers and Merchant Epitaxial Wafers
Region Of Consumption: Asia/Pacific-ROW

Company	1985	1986	1987	1988	1989	1990	1991
North American Companies							
Cincinnati Milacron	1.3	1.1	1.0	1.5	N/M	N/M	N/M
Crysteco	.0	.0	.0	.0	.0	.0	.0
Epitaxy, Inc.	2.7	3.4	4.4	4.5	5.1	5.1	5.1
Monsanto	6.4	14.4	17.2	25.3	N/M	N/M	N/M
NBK Corporation	.2	N/M	N/M	N/M	N/M	N/M	N/M
Recticon	.0	.0	.0	.0	.0	.0	N/M
Siltec	1.0	.9	N/M	N/M	N/M	N/M	N/M
Unisil	N/M	N/M	N/M	N/M	0	0	2.5
U.S. Semiconductor	.1	.1	N/M	N/M	N/M	N/M	N/M
Other U.S. Companies	.9	.4	.3	.2	.5	.5	.5
Total	12.6	20.3	22.9	31.5	5.6	5.6	8.1
Japanese Companies							
Kawasaki Steel, NBK Corp.	N/M	.6	1.1	1.5	2.0	3.2	2.8
Komatsu Electronic Metals	1.1	1.7	2.0	2.9	1.1	.0	.0
Mitsubishi Materials	1.1	1.6	2.6	1.9	1.8	1.8	1.9
Osaka Titanium Company[1]	1.3	1.4	1.6	1.9	4.5	6.4	7.1
Shin-Etsu Handotai	1.4	2.6	4.3	5.2	5.7	37.0	42.3
Toshiba Ceramics	.0	.0	.0	.0	2.5	2.3	2.4
Other Japanese Companies	.0	.0	.0	.0	.0	.0	.0
Total	4.9	7.9	11.6	13.4	17.6	50.7	56.5
European Companies							
DNS Electronic Materials	2.6	3.7	5.7	7.0	N/M	N/M	N/M
Hüls AG	N/M	N/M	N/M	N/M	36.7	53.8	77
Topsil	.4	.5	.2	.2	.7	1.5	1.3
Wacker	22.5	25.0	21.3	18.8	21.1	25.9	31.1
Other European Companies	.0	.0	.0	.0	.7	.7	.5
Total	25.5	29.2	27.2	26.0	59.2	81.9	109.9
Asia/Pacific-ROW Companies							
Korsil[2]	.0	.0	5.0	25.0	15.0	N/M	N/M
Siltron	.0	.0	.7	6.4	14.0	25.7	34.9
Other ROW Companies	.5	1.3	2.2	3.3	4.3	13.0	15.7
Total	.5	1.3	7.9	34.7	33.3	38.7	50.6
Total	43.5	58.7	69.6	105.6	115.7	176.9	225.1

N/M = Not Meaningful
*Includes prime, test, and monitor wafers
[1]Includes U.S. Semiconductor sales from 1987, Cincinnati Semiconductor from 1989.
[2]Korsil ended operations in 5/89.
Source: Dataquest (May 1992)

Table 5-14
Each Company's Revenue from Shipments of Merchant Silicon Wafers* to Asia/Pacific-ROW, 1985-1991 (End-User Revenue in Millions of U.S. Dollars)

Company: All
Product: Merchant Silicon Wafers
Region Of Consumption: Asia/Pacific-ROW

Company	1985	1986	1987	1988	1989	1990	1991
North American Companies							
Cincinnati Milacron	.0	.0	.0	.0	N/M	N/M	N/M
Crysteco	.0	.0	.0	.0	.0	.0	.0
Epitaxy, Inc.	.0	.0	.0	.0	.0	.0	.0
Monsanto	6.4	14.4	16.9	24.8	N/M	N/M	N/M
NBK Corporation	.2	N/M	N/M	N/M	N/M	N/M	N/M
Recticon	.0	.0	.0	.0	.0	.0	N/M
Siltec	1.0	.9	N/M	N/M	N/M	N/M	N/M
Unisil	N/M	N/M	N/M	N/M	0	0	2.5
U.S. Semiconductor	.0	.0	N/M	N/M	N/M	N/M	N/M
Other U.S. Companies	.4	.2	.1	.2	.2	.2	.2
Total	8.0	15.5	17.0	25.0	.2	.2	2.7
Japanese Companies							
Kawasaki Steel, NBK Corp.	N/M	.6	1.1	1.5	2.0	3.2	2.8
Komatsu Electronic Metals	1.0	1.6	1.9	2.7	1.0	.0	.0
Mitsubishi Materials	.9	1.4	2.4	1.7	1.6	1.6	1.7
Osaka Titanium Company[1]	1.2	1.3	1.4	1.5	2.6	5.7	7.0
Shin-Etsu Handotai	1.4	2.5	4.2	5.0	20.5	36.7	42.0
Toshiba Ceramics	.0	.0	.0	.0	1.0	.8	.8
Other Japanese Companies	.0	.0	.0	.0	.0	.0	.0
Total	4.5	7.4	11.0	12.4	28.7	48.0	54.3
European Companies							
DNS Electronic Materials	2.6	3.7	5.7	7.0	N/M	N/M	N/M
Hüls AG	N/M	N/M	N/M	N/M	35.9	53	72.5
Topsil	.4	.5	.2	.2	.7	1.5	1.9
Wacker	22.5	25.0	21.0	18.0	20.0	24.5	27.4
Other European Companies	.0	.0	.0	.0	.7	.7	.5
Total	25.5	29.2	26.9	25.2	57.3	79.7	102.3
Asia/Pacific-ROW Companies							
Korsil[2]	.0	.0	5.0	25.0	15.0	N/M	N/M
Siltron	.0	.0	.7	6.4	14.0	25.7	34.9
Other ROW Companies	.3	.6	1.0	1.8	2.8	10.0	12.5
Total	.3	.6	6.7	33.2	31.8	35.7	47.4
Total A/P-ROW	38.3	52.7	61.6	95.8	118.0	163.6	206.7

N/M = Not Meaningful
*Includes prime, test, and monitor wafers
[1] Includes U.S. Semiconductor sales from 1987, Cincinnati Semiconductor from 1989.
[2] Korsil ended operations in 5/89.
Source: Dataquest (May 1992)

Table 5-15
Each Company's Revenue from Shipments of Silicon Epitaxial Wafers to Asia/Pacific-ROW, 1985-1991 (End-User Revenue in Millions of U.S. Dollars)

Company: Each
Product: Silicon Epitaxial Wafers
Region Of Consumption: Asia/Pacific-ROW

	1985	1986	1987	1988	1989	1990	1991
North American Companies							
Cincinnati Milacron	1.3	1.1	1.0	1.5	N/M	N/M	N/M
Crysteco	.0	.0	.0	.0	.0	.0	.0
Epitaxy, Inc.	2.7	3.4	4.4	4.5	5.1	5.1	5.1
Monsanto	.0	.0	.3	.5	N/M	N/M	N/M
NBK Corporation	.0	N/M	N/M	N/M	N/M	N/M	N/M
Recticon	.0	.0	.0	.0	.0	.0	N/M
Siltec	.0	.0	N/M	N/M	N/M	NA	N/M
Unisil	N/M	N/M	N/M	N/M	0	0	0
U.S. Semiconductor	.1	.1	N/M	N/M	N/M	N/M	N/M
Other U.S. Companies	.5	.2	.2	.0	.3	.3	.3
Total	4.6	4.8	5.9	6.5	5.4	5.4	5.4
Japanese Companies							
Kawasaki Steel, NBK Corp.	NA	.0	.0	.0	.0	.0	.0
Komatsu Electronic Metals	.1	.1	.1	.2	.1	.0	.0
Mitsubishi Materials	.2	.2	.2	.2	.2	.2	.2
Osaka Titanium Company[1]	.1	.1	.2	.4	1.9	.7	.1
Shin-Etsu Handotai	.0	.1	.1	.2	.2	.3	.3
Toshiba Ceramics	.0	.0	.0	.0	1.5	1.5	1.6
Other Japanese Companies	.0	.0	.0	.0	.0	.0	.0
Total	.4	.5	.6	1.0	3.9	2.7	2.2
European Companies							
DNS Electronic Materials	.0	.0	.0	.0	N/M	N/M	N/M
Hüls AG	N/M	N/M	N/M	N/M	.8	.8	4.5
Topsil	.0	.0	.0	.0	.0	.0	.0
Wacker	.0	.0	.3	.8	1.1	1.4	3.7
Other European Companies	.0	.0	.0	.0	.0	.0	.0
Total	.0	.0	.3	.8	1.9	2.2	8.2
A/P-ROW Companies							
Korsil[2]	.0	.0	.0	.0	.0	N/M	N/M
Siltron	.0	.0	.0	.0	.0	.0	.0
Other ROW Companies	.2	.7	1.2	1.5	1.5	3.0	3.2
Total	.2	.7	1.2	1.5	1.5	3.0	3.2
Total A/P-ROW	5.2	6.0	8.0	9.8	12.7	13.3	19.0

N/M = Not Meaningful
[1] Includes U.S. Semiconductor sales from 1987, Cincinnati Semiconductor from 1989.
[2] Korsil ended operations in 5/89.
Source: Dataquest (May 1992)

Section 6. 1991 Average Selling Prices by Region

Table 6-1
Regional Average Selling Price of Polished and Epitaxial Wafers In U.S. Dollars*, 1986-1991
(By Wafer Diameter, Per Unit)

	Wafer Area	1986	1987	1988	1989	1990	1991	February 1992
Polished CZ ASP: United States								
3 Inch	7.07	6.01	6.22	6.43	6.35	7.25	7.10	7.04
100 mm	12.17	10.83	10.22	10.34	9.64	9.98	9.96	10.47
125 mm	19.02	19.21	18.64	19.40	17.44	18.75	18.80	19.05
150 mm	27.39	33.96	32.87	34.24	30.49	31.50	32.44	31.75
200 mm	48.70	N/A	187.98	166.55	120.48	121.05	109.80	104.71
Epi Wafer ASP: United States								
3 Inch	7.07	24.39	24.39	24.39	24.39	24.39	24.39	24.39
100 mm	12.17	31.64	29.57	31.40	31.64	32.30	32.30	32.30
125 mm	19.02	58.01	51.16	53.26	50.46	51.50	51.50	51.50
150 mm	27.39	84.64	83.27	85.73	80.03	83.25	83.25	83.25
200 mm	48.70	N/A	N/A	N/A	N/A	204.25	195.75	181.40
Polished CZ ASP: Japan								
3 Inch	7.07	1,817	1,803	1,511	1,511	1,525	1,525	1,525
100 mm	12.17	2,130	1,947	2,056	1,692	1,805	1,870	1,865
125 mm	19.02	4,089	3,861	3,384	3,405	3,410	3,320	3,300
150 mm	27.39	7,587	7,067	6,837	5,889	6,100	6,100	5,900
200 mm	48.70	N/A	37,986	28,986	28,587	27,450	22,470	19,750
Epi Wafer ASP: Japan								
3 Inch	7.07	5,147	4,949	4,949	4,949	5,127	5,127	5,127
100 mm	12.17	6,061	5,829	6,487	6,487	5,700	5,700	5,600
125 mm	19.02	10,404	10,005	9,966	9,966	10,000	10,000	9,875
150 mm	27.39	18,707	17,995	15,968	15,968	18,754	18,754	16,750
200 mm	48.70	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Polished CZ ASP: Europe								
3 Inch	7.07	6.01	6.01	5.87	7.81	8.05	8.05	8.05
100 mm	12.17	10.83	10.22	10.22	11.26	11.75	11.80	11.40
125 mm	19.02	20.75	20.13	21.11	18.47	19.03	21.35	21.30
150 mm	27.39	36.68	35.50	37.25	31.88	32.45	33.09	33.15
200 mm	48.70	N/A	N/A	133.93	123.06	123.39	115.40	115.75

(Continued)

Table 6-1 (Continued)
Regional Average Selling Price of Polished and Epitaxial Wafers In U.S. Dollars*, 1986-1991
(By Wafer Diameter, Per Unit)

	Wafer Area	1986	1987	1988	1989	1990	1991	February 1992
Epi Wafer ASP: Europe								
3 Inch	7.07	24.39	24.39	24.39	24.39	25.01	23.70	24.01
100 mm	12.17	31.64	32.86	33.83	34.92	35.07	34.69	33.40
125 mm	19.02	58.01	57.06	55.16	57.12	57.02	57.09	55.41
150 mm	27.39	84.64	86.28	92.03	87.98	88.31	86.75	87.40
200 mm	48.70	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Polished CZ ASP:Asia/Pacific								
3 Inch	7.07	5.51	5.51	6.50	6.50	7.25	7.25	7.25
100 mm	12.17	8.15	8.88	8.64	10.00	9.50	10.66	10.47
125 mm	19.02	16.17	16.74	16.55	17.82	17.50	18.63	19.61
150 mm	27.39	30.40	32.05	31.22	29.12	29.12	33.75	34.95
200 mm	48.70	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Epi Wafer ASP: Asia/Pacific								
3 Inch	7.07	N/A	N/A	20.81	20.81	25.10	25.10	25.10
100 mm	12.17	N/A	N/A	28.11	34.08	34.71	35.05	35.00
125 mm	19.02	N/A	N/A	52.69	52.69	53.87	53.87	51.90
150 mm	27.39	N/A	95.04	91.76	86.44	86.23	85.70	83.20
200 mm	48.70	N/A	N/A	N/A	N/A	N/A	N/A	N/A

N/A = Not Applicable
*Japanese ASPs are quoted in millions of yen
Source: Dataquest (May 1992)

Table 6-2
Regional Average Selling Price of Polished and Epitaxial Wafers, 1986-1991
(By Wafer Diameter, Per Square Inch, in U.S.$)

	Wafer Area	1986	1987	1988	1989	1990	1991	February 1992
Polished CZ ASP: United States								
3 Inch	7.07	.85	.88	.91	.90	1.03	1.00	1.00
100 mm	12.17	.89	.84	.85	.79	.82	.82	.86
125 mm	19.02	1.01	.98	1.02	.92	.99	.99	1.00
150 mm	27.39	1.24	1.20	1.25	1.11	1.15	1.18	1.16
200 mm	48.70	N/A	3.86	3.42	2.47	2.49	2.25	2.15
Epi Wafer ASP: United States								
3 Inch	7.07	3.45	3.45	3.45	3.45	3.45	3.45	3.45
100 mm	12.17	2.60	2.43	2.58	2.60	2.65	2.65	2.65
125 mm	19.02	3.05	2.69	2.80	2.65	2.71	2.71	2.71
150 mm	27.39	3.09	3.04	3.13	2.92	3.04	3.04	3.04
200 mm	48.70	N/A	N/A	N/A	N/A	4.19	4.02	3.72
Polished CZ ASP: Japan*								
3 Inch	7.07	257	255	214	214	216	216	216
100 mm	12.17	175	160	169	139	148	154	153
125 mm	19.02	215	203	178	179	179	175	174
150 mm	27.39	277	258	250	215	223	223	215
200 mm	48.70	N/A	780	595	587	564	461	406
Epi Wafer ASP: Japan*								
3 Inch	7.07	728	700	700	700	725	725	725
100 mm	12.17	498	479	533	533	468	468	460
125 mm	19.02	547	526	524	524	526	526	519
150 mm	27.39	683	657	583	583	685	685	612
200 mm	48.70	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Polished CZ ASP: Europe								
3 Inch	7.07	.85	.85	.83	1.11	1.14	1.14	1.14
100 mm	12.17	.89	.84	.84	.93	.97	.97	.94
125 mm	19.02	1.09	1.06	1.11	.97	1.00	1.12	1.12
150 mm	27.39	1.34	1.30	1.36	1.16	1.18	1.21	1.21
200 mm	48.70	N/A	N/A	2.75	2.53	2.53	2.37	2.38
Epi Wafer ASP: Europe								
3 Inch	7.07	3.45	3.45	3.45	3.45	3.54	3.35	3.40
100 mm	12.17	2.60	2.70	2.78	2.87	2.88	2.85	2.74
125 mm	19.02	3.05	3.00	2.90	3.00	3.00	3.00	2.91
150 mm	27.39	3.09	3.15	3.36	3.21	3.22	3.17	3.19
200 mm	48.70	N/A	N/A	N/A	N/A	N/A	N/A	N/A

(Continued)

Table 6-2 (Continued)
Regional Average Selling Price of Polished and Epitaxial Wafers, 1986-1991
(By Wafer Diameter, Per Square Inch, in U.S.$)

	Wafer Area	1986	1987	1988	1989	1990	1991	February 1992
Polished CZ ASP:Asia/Pacific								
3 Inch	7.07	.78	.78	.92	.92	1.03	1.03	1.03
100 mm	12.17	.67	.73	.71	.82	.78	.88	.86
125 mm	19.02	.85	.88	.87	.94	.92	.98	1.03
150 mm	27.39	1.11	1.17	1.14	1.06	1.06	1.23	1.28
200 mm	48.70	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Epi Wafer ASP: Asia/Pacific								
3 Inch	7.07	N/A	N/A	2.94	2.94	3.55	3.55	3.55
100 mm	12.17	N/A	N/A	2.31	2.80	2.85	2.88	2.88
125 mm	19.02	N/A	N/A	2.77	2.77	2.83	2.83	2.73
150 mm	27.39	N/A	3.47	3.35	3.16	3.15	3.13	3.04
200 mm	48.70	N/A	N/A	N/A	N/A	N/A	N/A	N/A

N/A = Not Applicable
*Japanese ASPs are quoted in millions of yen
Source: Dataquest (May 1992)

Table 6-3
Current Unit Average Selling Price by Product Type (February 1992)
(U.S. Dollars*)

	Diameter	Prime	Test	Epi
North America				
3 Inch	7.07	7.04	4.75	N/A
100 mm	12.17	10.47	6.93	27.90
125 mm	19.02	19.05	12.89	48.85
150 mm	27.39	32.44	21.81	81.54
200 mm	48.70	104.71	81.40	181.90
Japan				
3 Inch	7.07	10.29	8.80	40.27
100 mm	12.17	11.86	9.43	43.99
125 mm	19.02	24.35	14.14	77.57
150 mm	27.39	36.14	25.14	131.58
200 mm	48.70	155.15	100.16	304.40
Japan (Yen)				
3 Inch	7.07	1310	1120	5127
100 mm	12.17	1510	1200	5600
125 mm	19.02	3100	1800	9875
150 mm	27.39	4600	3200	16750
200 mm	48.70	19750	12750	38750
Europe				
3 Inch	7.07	8.05	6.05	24.10
100 mm	12.17	11.66	8.91	33.40
125 mm	19.02	21.07	14.53	55.41
150 mm	27.39	33.40	27.36	87.40
200 mm	48.70	104.71	81.40	181.90
Taiwan				
3 Inch	7.07	N/A	N/A	N/A
100 mm	12.17	10.33	6.44	N/A
125 mm	19.02	18.71	9.52	N/A
150 mm	27.39	32.68	18.75	N/A
200 mm	48.70	N/A	N/A	N/A
Korea				
3 Inch	7.07	N/A	N/A	N/A
100 mm	12.17	10.50	8.50	N/A
125 mm	19.02	19.50	15.00	N/A
150 mm	27.39	35.00	23.50	N/A
200 mm	48.70	N/A	N/A	N/A

N/A = Not Applicable
*Japan Quoted in millions of yen
Source: Dataquest (April 1992)

Section 7. Silicon Wafer Plant Expansion/New Lines

Table 7-1
Silicon Wafer Plant Expansions/New Lines Since 1990

Company	Location	Status	Size	Wafers per Month (000's)	Start Date	Capital Spending ($U.S. M)	Capital Spending (Yen Billion)
Shin-Etsu Handotai	Shirakawa	R&D			1990/3	14.3	2,000
	Isobe	Epi Expand				14.3	2,000
	Nagano	New Volume Production Line	6"		1991/2	25.0	3,500
	Naoetsu	New Volume Production Line	6"		1991/3	32.1	4,500
	Mimasu	Polishing Line			1991/4	39.3	5,500
	Shirakawa	8" Volume Production	8"	30	1992/4	107.1	15,000
	Camus, OR	8" Volume Production	8"	10	1991/2	7.1	1,000
	England	6" Volume Production	6"	200	1991/1Q	32.1	4,500
Total						271.4	38,000
Osaka Titanium	Imari	#3 Volume Production Line	6", 8"	300	1991/1Q	8.6	1,200
	Mainville, OH	Expansion Cancelled				N/A	N/A
Total						8.6	1,200
Mitsubishi Materials	Noda	Pilot Line	8"	5	1990/9	28.6	4,000
	Yonezawa	Volume Production	6"	250	1991/1Q	28.6	4,000
	Noda	R&D For 4M			1990/4	14.3	2,000
	Central Research	R&D for 16M	8"		1990	14.3	2,000
	Ikuno	8" Volume Production	8"	20	1991/1Q	53.6	7,500
	Chitose	Epi Production Line Delayed			1992/4Q	71.4	10,000
Total						210.7	29,500
Komatsu Electronic Metals	Nagasaki	Volume Production Line	6", 8"	200	1992/1Q	28.6	4,000
	Miyazaki	R&D Delayed				14.3	2,000
	Hiratsuka	Technical Center			1991/3Q	14.3	2,000
	Portland, OR	Delayed					
Total						57.1	8,000

(Continued)

Table 7-1 (Continued)
Silicon Wafer Plant Expansions/New Lines Since 1990

Company	Location	Status	Size	Wafers per Month (000's)	Start Date	Capital Spending ($U.S. M)	Capital Spending (Yen Billion)
Toshiba Ceramics	Yamagata	Expand at Okuni Plant	6"	300		28.6	4,000
	Central Research	Pilot Line	8"		1990/9	3.6	500
	Niigata	Volume Production Line Delayed	8"	100	1993/1	158.6	22,210
	Tokuyama	Epi Expansion	5"	90	1994	35.7	5,000
Total						226.5	31,710
Kawatec	Santa Clara, CA	First Expansion	5", 6", 8	70	1990/7	44.3	6,200
		Second Expansion	5", 6", 8	80	1992/7	20.0	2,800
Total						64.3	9,000
Showa Denko	Chichibu	Expand	6", 8"	30	1990/4Q	14.3	2,000
Nittetsu	Hikari	Expand	8"		1991	21.4	3,000
MEMC	St. Peters, MO	Expand	8"	30	1991/11	31.0	4,340
Posco-Huels	Korea	Volume Production Line	6", 8"		1992/3	110.0	15,400
Oriental Electronic Metals	Korea	Volume Production	5",6", 8"		1992/2Q	45.0	6,300
Wacker-Chemitronic	Wasserburg, Germany	Expansion of Epi	6"		1990/6	5.0	700
	Portland, OR	New Volume Production Delayed	8"		1994	100.0	14,000
	Portland, OR	Upgrade Facility Delayed	6", 8"		1993	45.0	6,300
Total						150.0	21,000
China Steel	Hsinchu Park, Taiwan	Volume Production	6"		1993/4Q	98.1	
Total						1,308.5	169,450.0

N/A = Not Applicable
Source: Dataquest (May 1992)

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Dataquest Vendor Profile

Semiconductor Equipment, Manufacturing, and Materials

December 21, 1992

Texas Instruments

Corporate Statistics

Headquarters	Dallas, Texas
Chairman and CEO	Jerry Junkins
President, Semiconductor Group	Pat Weber
Executive Vice President, Semiconductor Group	Wally Rhines
Fiscal Year-End	December 31
Exchange	NYSE
Ticker Symbol	TXN
Employees (1991)	62,939
FY1991 Total Sales	$6.78 billion
FY1991 Net Income	($409 million)
FY1991 Earnings per Share	($5.40)
FY1991 Royalty Income	$256 million

A View from the Top

Texas Instruments Inc. (TI), headquartered in Dallas, Texas, was formed in 1951 as a division of Geophysical Service Inc. In 1952, TI obtained licenses to manufacture transistors and by 1953 had become a volume producer of these devices. TI has since evolved into a high-technology company with sales and/or manufacturing operations in more than 30 countries. TI develops, manufactures, and markets semiconductors, defense electronics systems, software productivity tools, computer systems and peripheral products, custom engineering and manufacturing services, electrical controls, metallurgical materials, and consumer electronic products. Table 1 shows the company's revenue growth and profitability over the past five years.

In the first half of the 1980s, the company was on a revenue and profit roller coaster. Respective profit and revenue losses in 1983 were $145 million and $4.58 billion, followed by profits of $316 million on revenue of $5.74 billion in 1984. The roller coaster ride continued in 1985, when the company lost $119 million on sales of $4.92 billion and

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Table 1
Five-Year Financial Summary

	1987	1988	1989	1990	1991
Revenue ($B)	5.82	6.45	6.52	6.57	6.78
Net Income ($M)	321	366	292	(39)	(409)
Earnings per Share ($)	3.74	4.05	3.04	(0.92)	(5.40)

Source: Texas Instruments, Dataquest (December 1992)

laid off 7,000 employees. A recovery started in 1986 and lasted four years, peaking in 1988 with sales of $6.45 billion and net income of $366 million. However, TI was not positioned to sustain this growth, and beginning in late 1989 its revenue growth began to slow dramatically and profits turned down, culminating with a significant loss in 1991 of $409 million.

Recent financial results indicate that the company is once again on the upswing. On a quarter-to-quarter basis, the first three quarters of 1992 compared with the same quarters of 1991 provide quantitative evidence that a turnaround is in the making (see Table 2).

When compared with the same quarter in 1991, the first quarter of 1992 experienced a modest 3 percent growth rate. However, net income experienced a $94 million turnaround. The same comparisons applied to the second and third quarters show a strong 11.3 percent growth in revenue and a $229 million turnaround in net income for the second quarter. The third quarter experienced an 8 percent revenue improvement combined with a $170 million turnaround in net income.

Table 3 is an aggregate comparison of the first nine months of 1992 with those of 1991. On a revenue basis, TI has thus far shown a respectable 10.5 percent growth over 1991. On a net profit basis, the company has shown a remarkable $493 million turnaround.

Based upon an unusually strong demand for semiconductors this summer and the continued strong book-to-bill rate, we expect that TI's fourth-quarter results will continue the growth pattern established in the first three quarters and that 1992 will be a strong year for the

Table 2
Quarterly Comparison

	Q1/91	Q1/92	Q2/91	Q2/92	Q3/91	Q3/92
Revenue ($B)	1.64	1.69	1.68	1.87	1.75	1.89
Net Income ($M)	(54)	40	(157)	72	(113)	57
Earnings per Share ($)	(0.77)	0.35	(1.99)	0.73	(1.45)	0.58

Source: Texas Instruments, Dataquest (December 1992)

Table 3
First Half of 1992 versus First Half of 1991

	Nine Months Ended 9/30/91	Nine Months Ended 9/30/92
Revenue ($B)	4.93	5.45
Net Income ($M)	(324)	169

Source: Texas Instruments, Dataquest (December 1992)

company. What makes this all the more astounding is the fact that, as late as the second quarter of this year, many securities analysts had written TI off as a loss leader for the foreseeable future. Is this just another wild upswing for TI, to be followed by another drastic downturn, or will the company's efforts to position itself for long-term sustained and profitable growth pay off?

Integrated Circuits: TI's Key to Future Success

TI, which employed nearly 63,000 in 1991, is segmented into four main product groups (see Table 4).

The components group is TI's largest product segment, with 50 percent of total revenue. It comprises semiconductors, subassemblies, and electrical and electronic control devices. Of these product categories, semiconductors accounts for more than 80 percent of the components segment's total sales. The semiconductor product category within components is made up of integrated circuits (ICs) and optoelectronic and discrete devices. Integrated circuits made up 97 percent of total semiconductor sales in 1991, or 40 percent of TI's total revenue. Consequently, the health of the integrated circuit sector, which is the focus of this profile, has a first-order impact on the health of the whole corporation and is the prime factor driving the company's recent success.

Table 4
1991 Segment Analysis (Millions of Dollars)

Segment	Sales	Percentage of Sales	Operating Income
Components	3,421	50	(188)
Defense Electronics	1,933	29	111
Digital Products	1,306	19	(52)
Metallurgical Materials	121	2	2

Source: Texas Instruments, Dataquest (December 1992)

An Awakening

The year 1985 was one of significant import for Texas Instruments. It lost $119 million on sales of $4.92 billion, laid off 7,000 employees, froze wages, implemented a broad cost-cutting program, and went through a major management restructure when Jerry Junkins replaced Fred Bucy as president and CEO. TI's decline was further accentuated by the fact that after years of fighting off the challenges of Motorola for the position of No. 1 semiconductor manufacturer, TI almost overnight found itself not only falling behind Motorola, but fighting for a position in the top five. The company was in trouble. It had neither the right products nor the right manufacturing capabilities to fight off the challenges of NEC, Toshiba, Hitachi, Motorola, and Intel, as well as a host of smaller niche-oriented companies.

TI quickly found that the market for its staple product line of bipolar logic was rapidly disappearing and that, with few exceptions, the MOS products it did have were not competitive from a price, performance, or cost point of view with those of the rest of the industry. This problem could not be solved by ramping then-existing capacity and improving factory efficiencies; it necessitated that the company's business model be quickly rewritten and put into effect rapidly. TI was in trouble and had lost the confidence of its customers and the investment community. It needed a new vision and it did not have a lot of time to implement this new vision.

Long-Term Vision, or Smoke and Mirrors?

It is said that necessity is the mother of invention, and out of this necessity TI formulated a game plan that it believed would bring itself back into a position of long-term competitiveness, growth, and profitability. Now, for those who watch the semiconductor industry, it is not news to hear new management of a semiconductor company present a new vision designed to position the company for long-term growth and profitability. This seems to be common in our relatively immature industry. More often than not, this "new vision" is overly optimistic, underfunded, and assumes that employees will instantly see the wisdom behind yet another plan to save them from mediocrity or failure. The only true test for any new vision is the test of time, and it is against this test that TI's new vision is being graded. The six key elements to TI's game plan were, and still are, as follows:

1. Vigorously protect intellectual property
2. Increase capacity at a lower cost of capital
3. Develop and ramp submicron CMOS processes
4. Offer design, manufacturing, sales, and support globally
5. Have a market-driven focus
6. Provide differentiated products

Intellectual Property: An Untapped Revenue Source

The first item, it is argued, has been pursued to a fault. Texas Instruments is intent upon extracting every cent of royalties and/or licensing fees from any company it finds to be in violation of its intellectual property and it makes no apologies for this position. At a Dataquest conference in 1986, a senior executive at TI, Kevin McGarity, stated in a speech that if TI could not make money selling DRAMs that it would make money off its DRAM intellectual property. TI's position is that because it is willing to risk the millions of dollars required to develop new inventions, others should not be allowed to use those inventions without reimbursing TI for its time and trouble. To measure its success in capturing this new source of revenue, one need only look at the royalty revenue in Tables 5 and 6.

Table 5
Royalty Income, 1987 through 1991 (Millions of Dollars)

Year	Royalty Income
1987	191
1988	152
1989	165
1990	172
1991	256

Source: Texas Instruments, Dataquest (December 1992)

Table 6
Royalty Income, First, Second, and Third Quarters of 1992 (Millions of Dollars)

Quarter	Royalty Income
Q1/92	95
Q2/92	124
Q3/92	83

Source: Texas Instruments, Dataquest (December 1992)

How Important Is Royalty Income?

Since 1987 and through the third quarter of 1992, TI has received $1.24 billion in licensing fees and royalty payments. The royalty revenue includes one-time amounts totaling $30 million in the first quarter, $45 million in the second quarter, and $9 million the third quarter. These amounts are based upon recent agreements reached with Rohm Co. Ltd., Mitsubishi Electric Corporation, New Japan Radio Co. Ltd., Nippon Precision Ltd., Seiko Epson Corporation, Toko Inc., and others. If these one-time amounts are subtracted from the quarterly statements, it is readily apparent that the company has substantially increased its royalty income run rate. However, if royalty revenue is factored out of the equation, TI is still operating at a net loss, despite the semiconductor sector returning to profitability in the third quarter of 1992 (see Table 7).

This successful implementation of item No. 1 mentioned earlier—vigorously protect intellectual property—and its resultant income stream, was largely responsible for giving TI the time to try to implement the balance of its six-point recovery program.

Table 7
Texas Instruments' Royalty Income versus Profitability

	Q1/92	Q2/92	Q3/92
Revenue ($B)	1.69	1.87	1.89
Net Income (with Royalty, $M)	40	72	57
Net Income (without Royalty, $M)	(55)	(52)	(26)

Source: Texas Instruments, Dataquest (December 1992)

CMOS Fabs Are Not Cheap

Although the royalty income stream was and is not insignificant, implementing item No. 2—increase capacity at a lower cost of capital—and item No. 3—ramp submicron CMOS processes—still required large expenditure for capital equipment and R&D. In order to add this new submicron CMOS capacity, TI would be forced to build several multihundred-million-dollar facilities. Consequently, it developed a plan involving several different strategic partnerships in which partners share the financial burden of building the new fabs and in return they receive either technology or guaranteed capacity. Table 8 lists the new submicron CMOS fabrication facilities, location, and partners.

Table 8
Texas Instruments' Submicron CMOS Facilities

Facility	Location	Status	Partners
Dallas	Texas	In production	None
Miho	Japan	In production	None
Avezzano	Italy	In production	Italian government
TI-Acer	Taiwan	In production	Acer
KTI	Japan	In qualification	Kobe Steel
Singapore	Singapore	In construction	Canon, HP, Singapore government

Source: Texas Instruments, Dataquest (December 1992)

Singing in Harmony

Another key element to achieving a lower cost of capital is to increase the life of these new fabs. To this end, the company has developed a program it calls "Harmonization," which simply means that the fabs, the equipment, and the processes will be capable of running multiple product types, in this case memory (that is, DRAM and flash) and logic. All processes are to be 95 percent compatible with existing equipment and the individual process recipes should share 65 percent of the same process steps. This technique allows TI to optimize a particular process for a specific product while sharing nearly all of the same equipment. If the company is successful in implementing this program, it should achieve substantial savings in the long run, because it will not be tied to the traditional three-year cycle of a typical DRAM fab. By manufacturing other memory and logic products, TI should add years to the life of its new fab facilities, saving tens of millions of dollars per year per fab. TI believes that its product development costs alone will be reduced by as much as 25 to 35 percent because of the harmonization program.

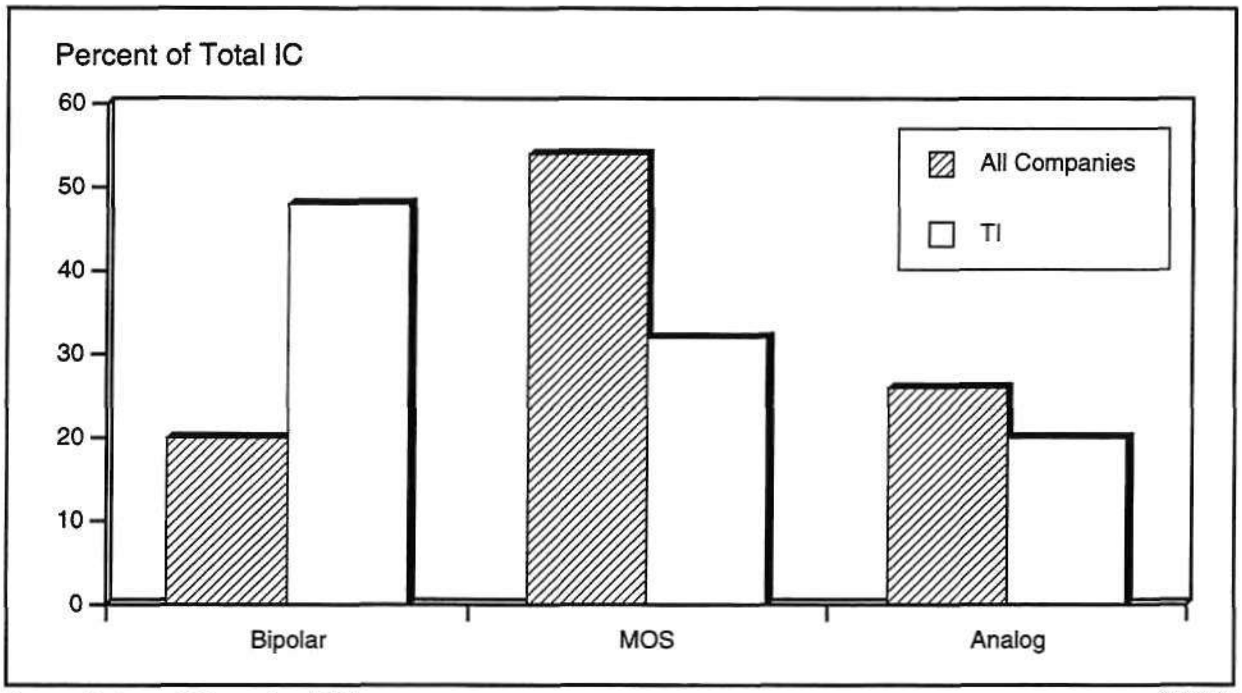
Is Bipolar Still King?

One point not overtly stated in TI's six-point program was the need to obtain or develop a world-class CMOS technology. Figure 1 shows just how far the company was out of step with the rest of the industry in regard to the technological mix of its products.

In 1985 TI derived nearly half its IC revenue from bipolar digital products at a time when bipolar made up only 20 percent of the revenue for the rest of the industry. TI was the undisputed king of bipolar logic. Unfortunately for TI, the rest of the producing and, more importantly, consuming world had begun a massive shift to MOS years earlier.

The company's new management realized that TI's heavy dependence upon products built with bipolar process technology had to change. Although TI had a reputation for a larger than normal "Not Invented

Figure 1
Technology Mix of Products in 1985



Source: Dataquest (December 1992)

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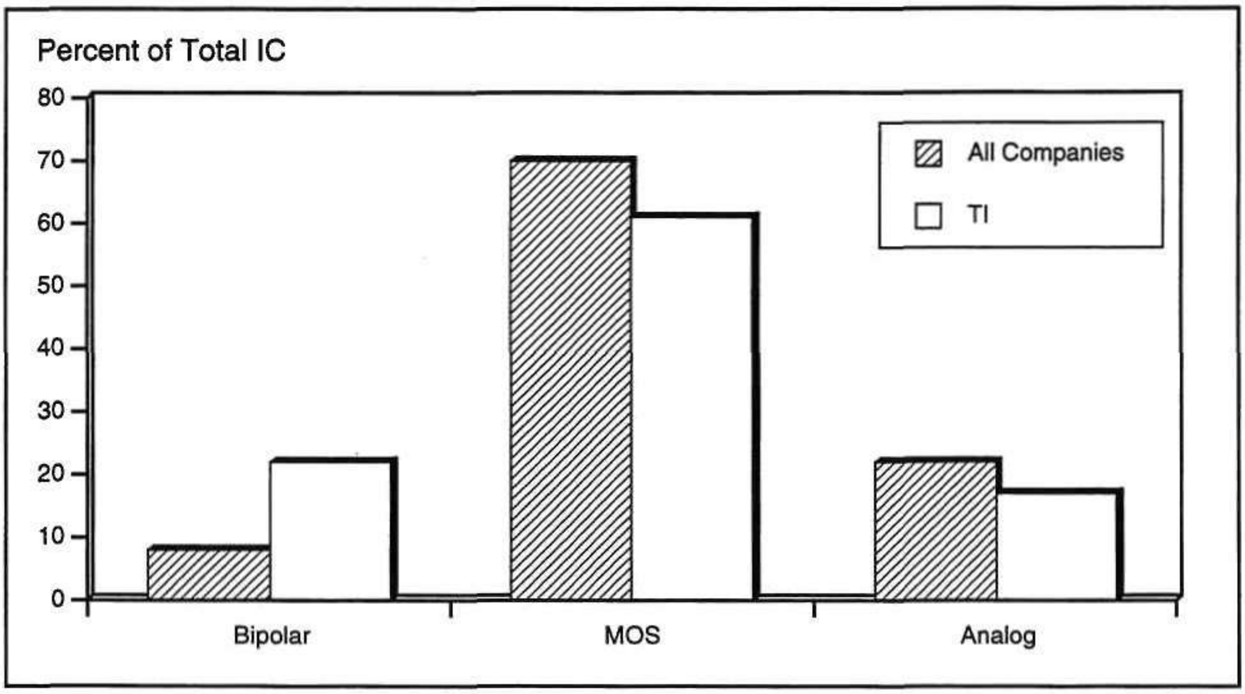
Here" (NIH) bias, it nonetheless developed a relationship with Hitachi, a world leader in CMOS technology, in which the two companies codevelop new technologies. Figure 2 is one indicator of the success of this program.

Figure 2 clearly shows that, when compared with 1985, the company has made dramatic progress in shifting its product technology mix from bipolar to MOS-based products. In 1991, the mix of bipolar products had dropped to 22 percent versus 7.4 percent for the rest of the industry and MOS-based products had risen to 61 percent versus 70.2 percent for the industry. Although it is still not in balance with the rest of the industry, TI is growing its MOS-based revenue—and shrinking its dependence upon bipolar-based products—faster than the rest of the industry.

The most recent major development of the relationship with Hitachi was the announcement of a world-class CMOS 16Mb DRAM technology, which each has separately used to design what appear to be competitive products.

TI's item No. 4—offer design, manufacturing, sales, and support globally—stems from the belief that a company that sells its products on a worldwide basis must design products that meet the needs of the diverse regions of the world. One way to assure that correct products are being defined and built is to regionally locate this responsibility.

Figure 2
Technology Mix of Products in 1991



Source: Dataquest (December 1992)

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Local regional manufacturing assures quick availability of product and when combined with "harmonization" allows TI to shift the mix of products between its worldwide fabs to more closely match the needs of the various regions of the world.

Cultures Are Not Skin Deep

The fifth item of the plan—have a market-driven focus—involved a major cultural change in this historically engineering-driven company. The phrase "market-driven focus" is one normally bandied about by all new management teams when they are repositioning a company. Unfortunately, in most instances it is normally just a hollow shell. However, in TI's case the concept of a market-driven focus is not just a phrase thrown around by management. Late last year when Dataquest met with several levels of TI's engineering staff in different product divisions, the message came out loud and clear that TI must understand the end markets and provide products specifically suited for them. This belief actually went a level below the classic high-level market definitions and into major applications as well as new emerging applications. The company appears to be getting out of the mentality of "they'll buy what we make" and into the mind-set of determining what users want and giving it to them.

No More "Me Too"

The final item of the plan—provide differentiated products—was another new concept to the company. Many products that TI sold were "me-too" kinds of products that required lowest price and fastest delivery. "Added value" was not normally associated with TI's semiconductor group. Although this approach to the market may produce high volumes, it does not produce high margins.

In order for a company to develop products that consistently produce high margins, the products must have some features that differentiate them from those of the competition. Implicit within this goal is that the features provide an added value for the customer. These differentiated products must provide at least three of the following: feature differentiation, higher performance, better price performance, or faster time-to-market.

TI has set about this task by identifying applications within markets in which it chooses to participate. It further makes the effort to learn about those applications, how they are implemented today, and what the needs are for tomorrow. To increase the visibility on this type of application-specific product, TI has set a goal stating that greater than 50 percent of its annual semiconductor product revenue must come from these application-specific products during the latter half of the decade.

The company's stated 50 percent goal is noble and is one it seems intent upon reaching. And although it appears to be making progress toward this end, it is starting from an extremely low base from which high growth is relatively easy. In order to prevent this progress from stalling, TI must continue to drive and reinforce this application-specific spirit throughout the corporation. Decades of NIH and engineering-driven product development are not eliminated overnight.

Have Fabs, Need Products

If one is to assume that, through its worldwide partnerships and alliances, Texas Instruments has overcome its submicron CMOS fabrication dilemma, then all the company must do is make sure it has the right products to fill those new fabs as the industry continues to turn up. Earlier we discussed the progress TI has made in its overall technology mix. Here we look at its product families in more detail.

The short-term outlook for TI's product portfolio is still a question mark. TI breaks into only one of the top five major product categories, bipolar (see Table 9).

Unfortunately, being the No. 1 supplier of bipolar ICs in the world is a rather dubious distinction. In every other category it ranks sixth or lower.

Table 9
Major Product Categories Top Five Rankings in 1991

	No. 1	No. 2	No. 3	No. 4	No. 5
Total IC	NEC	Intel	Toshiba	Hitachi	Motorola
Bipolar	*Texas Instruments*	Fujitsu	Hitachi	Motorola	National
MOS	Intel	NEC	Toshiba	Hitachi	Motorola
Memory	Toshiba	Hitachi	NEC	Samsung	Fujitsu
Micro	Intel	Motorola	NEC	Hitachi	Mitsubishi
Logic	NEC	Toshiba	Fujitsu	Motorola	LSI Logic
Analog	Philips	National	Toshiba	Sanyo	SGS-Thomson

Source: Dataquest (December 1992)

Focus on the Future

Because the heart and soul of the company's recovery strategy is centered around its newfound submicron CMOS fabrication capability, the balance of this discussion will ignore TI's bipolar and analog product revenue and instead focus upon its MOS products, present and future.

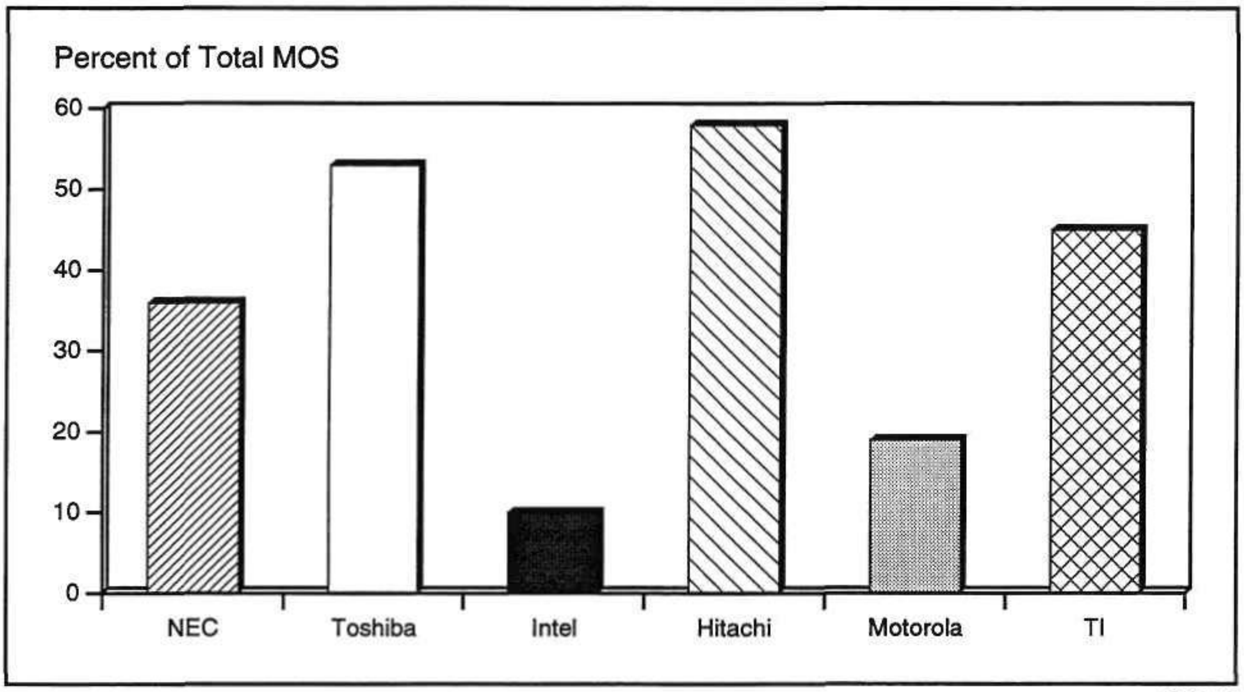
A Relative Comparison

Figure 3 compares the revenue mix of TI's MOS products with that of the top five semiconductor manufacturers in 1991.

It is an understatement that TI relies upon MOS memory revenue far more than either of the two North American companies in the top five. For example, Intel and Motorola rely upon MOS memory for only 10 percent and 19 percent of their total MOS revenue, respectively, while TI relies upon MOS memory for 45 percent of its MOS revenue. Because both Intel and Motorola rely heavily upon foundry services for their MOS memory production, it could be argued that their MOS memory exposure is far less than the numbers shown here. Compared with the three Japanese companies in the top five, TI is surpassed by Toshiba at 53 percent and Hitachi at 58 percent, but its reliance upon MOS memory revenue surpasses the No. 1-ranked semiconductor manufacturer, NEC, by 9 points. Of the remaining top 10 MOS IC manufacturers, only Samsung and Fujitsu have a higher reliance upon MOS memory revenue than TI.

TI appears to be extending its reliance upon MOS memory revenue because it has been quickly ramping its 4Mb DRAM capacity. Although this may produce solid short-term performance, as the Japanese and Korean companies add more capacity, market share battles will grow more fierce and place more price pressure on the 4Mb DRAM, which could easily turn into a long-term negative for the company if other products are not ready to fill in when the DRAM market goes through one of its typical downturns.

Figure 3
MOS Memory As a Percentage of Each Company's Total 1991 MOS Revenue



Source: Dataquest (December 1992)

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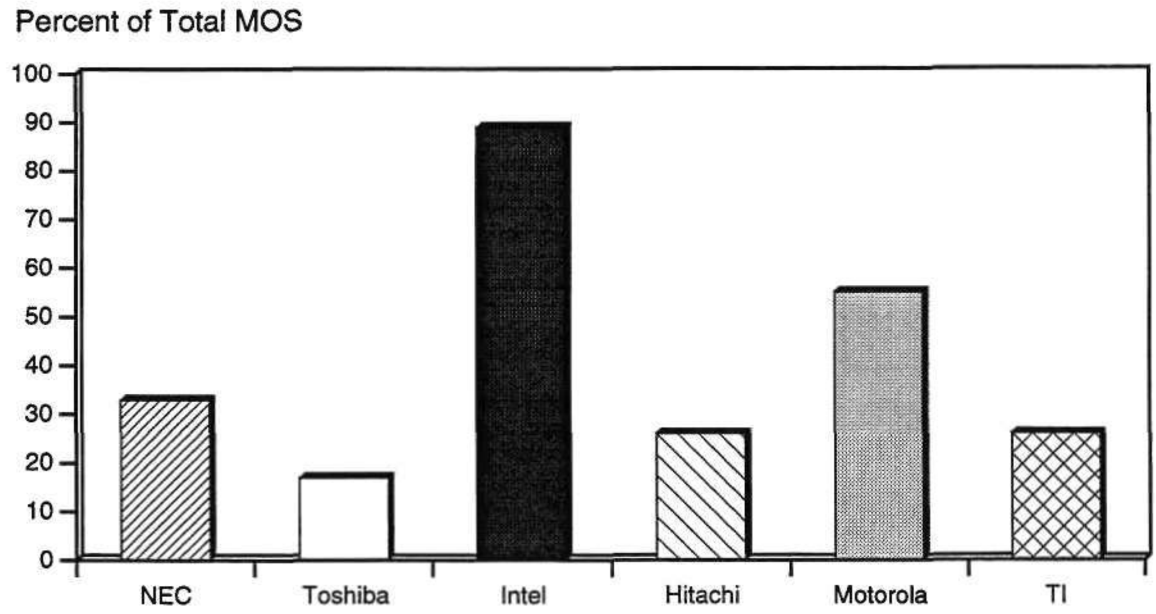
Figure 4 compares TI's MOS microcomponents mix with that of the top five. Compared with the other major semiconductor manufacturers in North America, TI appears to be taking the path less trodden. Only Toshiba had less of a focus in 1991 on MOS microcomponents than did TI. Both Intel at 89 percent and Motorola at 55 percent rely upon MOS microcomponents for the greatest portion of their MOS revenue. This high exposure in MOS microcomponents is relatively safe when compared to MOS memory. Microcomponent architectures are typically proprietary and well protected with intellectual property rights, whereas a strong position in memories can quickly dissipate because of their commodity nature. TI, at 26 percent MOS microcomponents, appears to be more closely modeling itself after the top Japanese companies.

Within the microcomponents arena, one could rightfully argue that TI is by far the No. 1 supplier in the fast-growing and critical area of digital signal processing (DSP) ICs. However, nine years after its first product was introduced, the company's 1991 DSP revenue, while clearly ahead of its competition, was only $143 million and represents about 11 percent of the company's MOS revenue and only 5 percent of its IC revenue.

Figure 4
MOS Microcomponents As a Percentage of Each Company's Total 1991 MOS Revenue



Source: Dataquest (December 1992)

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Integration: Who Owns the Micro Wins the Game

The glaring weakness in TI's MOS microcomponents product line has been the lack of an industry-standard microprocessor. This is a larger problem than the missing revenue stream that the processor could conceivably provide. At higher levels of integration, microprocessors are beginning to swallow up entire peripheral functions. If TI does not have a microprocessor onto which its peripheral products can be integrated, it loses this peripheral revenue stream to the company that does have the microprocessor. TI appears to have recognized this fact and has allied itself with Sun Microsystems to develop SPARC microprocessors, and with Cyrix Corporation, which gives TI access to Cyrix's line of x86 products.

Because TI has just recently begun shipping production volumes of the SuperSPARC microprocessor to Sun, it is still unclear how successful this project will be for TI. Sun has a history of being a rather fickle partner. In the last three-plus years, Sun has had numerous partners committed to developing and manufacturing SPARC microprocessors for the use of Sun and for any clone manufacturers of Sun SPARCstations. The first was with LSI Logic, which lasted about one year. This was followed by agreements with Fujitsu, Cypress, and now TI. In a span of less than four years, Sun has had four primary suppliers of SPARC microprocessors. Being the primary supplier of SPARC microprocessors to Sun is not necessarily a long-term relationship.

Also, if history is any indicator of what we should expect in the future, the market for SPARC microprocessor consumption outside of Sun is rather small and should not be expected to experience rapid growth in the foreseeable future. TI should not count on the SPARC to be its long-term solution for a mainstream microprocessor.

TI's opportunity to significantly increase its microprocessor revenue and become a mainstream supplier of microprocessor products should be based on its relationship with Cyrix. This relationship provides TI with a microprocessor core that is instruction-set-compatible with the industry-standard 486 microprocessor. It is doubtful that TI would be able to compete with Intel's 486 offerings on a product-by-product basis. However, if TI can use its ASIC capabilities to develop highly integrated microprocessors for specific applications where compatibility, cost, and integration are of prime importance, it could carve out defensible niches. ASIC is not Intel's strong suit, and as a result TI can place itself in the position of being able to offer feature differentiation to a customer base desperately looking for ways to differentiate itself from its own competitors, while maintaining instruction-set compatibility with the plethora of software applications that exist for the x86 instruction set.

We believe that this program is of such import to Texas Instruments' long-term product positioning, that management's time would be well spent if it kept this program spotlighted—not micromanaged, but closely observed to determine if NIH or any other TI engineering bias were slowing or stalling the program. The spotlighting should also serve to ensure that this project is not underresourced. The importance or significance of this project should not get lost in the multitude of TI's other engineering projects and alliances.

Dataquest Perspective

The key to TI's future success will be focus. New innovative ideas are not in short supply at this historically engineering-oriented company. It has major efforts going in DSP, graphics, networking, ASIC, mixed-signal, cell-based mixed-signal (or PRISM), DRAMs, Flash, FPGAs, and many more. If TI is to succeed, it must pick its major projects carefully, supply them with adequate resources, give them target dates, and get out of the way. As stated earlier, watch their progress but do not micromanage. The early days of the company's highly successful DSP division would be a good paradigm to follow.

In the short term, the company has made a definite commitment to developing its own world-class manufacturing facilities. But now that it has made this commitment, it most certainly will focus its efforts on finding products that can fill these facilities. It must find existing products that can quickly generate large volumes. In the near term, the only products in TI's product portfolio that can quickly generate the necessary volume are the 1, 4, and 16Mb DRAMs. This will place TI in direct competition with Toshiba, Hitachi, NEC, Samsung, and the fast-rising stars of Goldstar and Hyundai, as well as smaller players such as Micron Technology. Although TI might argue that its new fab lines are second to none and that its new 4 and 16Mb DRAM designs are world class, its current position as the seventh largest supplier of MOS memories indicates that there are at least six other MOS memory manufacturers with state-of-the-art facilities and more experience in manufacturing and selling these devices. Although TI may be in a strong position if any temporary DRAM shortages occur, it greatly increases its risk by not having a more balanced product portfolio.

Texas Instruments must accelerate its pursuit of new application-specific standard products and value-added x86-based products that it can use to fill its fabs when the inevitable MOS memory product crash occurs.

Dataquest Vendor Profile

Semiconductor Equipment, Manufacturing, and Materials

September 28, 1992

Silicon Valley Group Inc.

Corporate Statistics

Location	San Jose, California
Chairman, CEO	Papken Der Torossian
President, COO	Vahe Sarkissian
Fiscal 1991 Revenue	$234.8 Million
Fiscal Year Ends	September 30
Employees	1,605
Founded	1977

Corporate Overview

Silicon Valley Group Inc. (SVG) designs, manufactures, and markets equipment used in the fabrication of advanced semiconductor devices. The company's initial product development and market focus was in the area of automatic photoresist processing equipment (also known as track equipment). SVG expanded into the chemical vapor deposition (CVD) market in 1986 through development of a vertical thermal reactor (VTR) and the subsequent acquisition of Anicon Inc. in 1987. The combination of the VTR and Anicon product lines offered customers a range of capabilities for oxidation, diffusion, and low-pressure chemical vapor deposition (LPCVD) processes. In December 1988, SVG expanded its product offerings in this area through its acquisition of Thermco Systems, one of the world's largest suppliers of diffusion/oxidation furnaces. In May 1990, SVG made another significant acquisition through the purchase of Perkin-Elmer's optical lithography unit. This acquisition provided SVG with the highly advanced step-and-scan lithography technology pioneered by Perkin-Elmer in the late 1980s, in addition to a substantial installed base of projection aligner tools and technology. The outcome of this acquisition was the formation of SVG's first subsidiary, SVG Lithography Systems Inc. (SVGL).

For more information on Silicon Valley Group, please contact Peggy Marie Wood or Charles Boucher of Dataquest's Semiconductor Equipment, Manufacturing, and Materials service.

Corporate Organization and Management Team

SVG is divided into three operating groups. The company's Track Systems Division focuses on automatic photoresist processing equipment; its Thermco Systems Division offers oxidation, diffusion, and LPCVD

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processing systems; and its lithography subsidiary, SVG Lithography, focuses on step-and-scan lithography exposure tools and technology.

In June 1992, SVG announced a number of key executive assignments to augment and strengthen its management team. This reorganization reflects the company's intent to focus its efforts on customer satisfaction and corporate profitability through efficiency and teamwork. In particular, three of the management positions—corporate sales, customer service, and strategic relations—emphasize worldwide cross-divisional responsibility, reflecting the ever-increasing global nature of the SVG's customer base. Table 1 identifies the individuals in SVG's management team.

Corporate Financial History

Table 2 presents a summary of SVG corporate financial highlights for the past five years.

SVG has grown substantially over the past five years, primarily through the acquisition of the operations of other wafer fab equipment companies, specifically Anicon (February 1987), Thermco Systems (December 1988), and the optical lithography group of Perkin-Elmer Corporation (May 1990). Figure 1 shows SVG quarterly revenue and net income figures during the period of January 1986 through June 1992, with these three acquisitions duly noted.

As part of the SVGL acquisition, SVGL obtained R&D funding commitments for the Micrascan program from IBM and Sematech, in which payments are based on meeting specified product development milestones. It incurred costs of $23.8 million in 1991 and $4.7 million in 1990 related to such product development and recognized $22.6 million and $4.6 million, respectively, in related R&D funding. Because of these R&D funding commitments from IBM and Sematech, the ratio of the company's effective R&D funding level to total revenue is somewhat higher than that stated in its official financial figures in Table 2. In particular, the effect of outside R&D funding

Table 1
Silicon Valley Group's Management Team

Papken Der Torossian	Chairman, CEO
Vahe Sarkissian	President, COO
Edward Dohring	President, Track Systems Division
Edward Ward	President, Thermco Systems Division
Robert Richardson	President, SVG Lithography
Steven Jensen	Vice President of Sales
Allan Schwartz	Vice President of Service
Ken Machado	Vice President of Strategic Relations
Russell Weinstock	Chief Financial Officer
Dick Anderson	Vice President of Human Resources

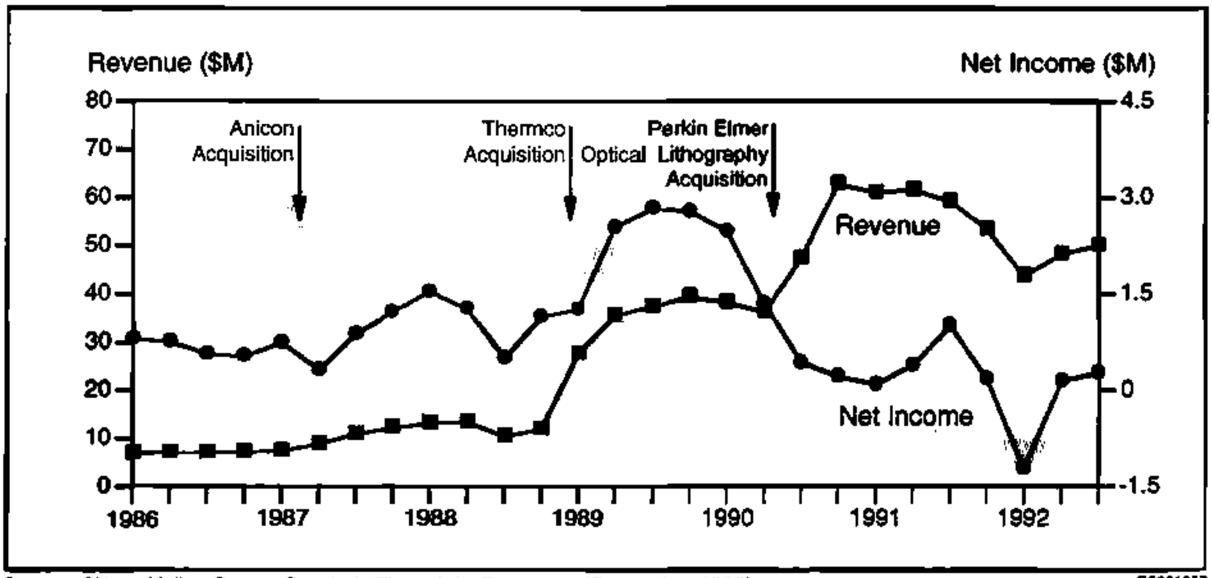
Source: Silicon Valley Group

Table 2
Five-Year Corporate Highlights (Thousands of Dollars)

Fiscal Year	1987	1988	1989	1990	1991
Revenue	39,300	48,969	131,080	184,289	234,798
Percentage Change	41.1	24.6	167.7	40.6	27.4
Net Income	3,148	4,440	9,612	4,449	1,641
Net income As a Percent of Revenue	8.0	9.1	7.3	2.4	0.7
R&D	5,808	7,006	15,177	25,292	30,004
R&D As a Percent of Revenue	14.8	14.3	11.6	13.7	12.8
Employees	344	382	932	1,690	1,605
Revenue per Employee	114	128	141	109	146

Note: Data for 1987 through 1990 have been restated to reflect acquisitions.
Source: Silicon Valley Group Annual Reports and Forms 10-K, Dataquest (September 1992)

Figure 1
Silicon Valley Group Quarterly Revenue and Net Income



Source: Silicon Valley Group, Quarterly Financials, Dataquest (September 1992)
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sources for the company in 1991 was significant, providing an effective R&D-to-revenue ratio of 22 percent. The additional R&D funding of $22.6 million added to the company's $30.0 million R&D level in 1991 totaled $52.6 million, which translated to an R&D investment run rate for the company of about $1.0 million per week.

Regional Market Focus

Table 3 shows Dataquest's estimates for the company's wafer fab equipment revenue by region for the calendar years 1987 through 1991. (Please note that no revenue associated with service and spares is included in Dataquest's revenue estimates. Dataquest also has adopted certain bookkeeping practices to account for equipment revenue associated with SVG's acquisitions during this period. Refer to the notes at the bottom of Table 3 for further details.)

Table 3 shows that SVG has had a negligible presence in Japan, the world's largest regional market for wafer fabrication equipment. Its wafer fab equipment revenue in Japan in 1990, while showing an increase as a percentage of the company's total equipment revenue, primarily reflects the continuation of business activities for the projection aligner product families acquired from Perkin-Elmer's optical lithography group. The company's 1991 equipment revenue in Japan came entirely from the shipment of a handful of projection aligners and two of its advanced Micrascan tools.

Japan represents the world center for high-volume manufacturing of advanced semiconductor devices, and as such has represented the largest market for wafer fab equipment. During the period of 1988

Table 3
Silicon Valley Group Wafer Fab Equipment Revenue, by Region (Percentage of Dollars)

Calendar Year	1987	1988	1989	1990	1991
Total SVG Wafer Fab Equipment Revenue ($M)	39.4	49.0	127.0	188.3	180.3
Percentage Revenue, by Region					
North America	62	62	59	60	60
Japan	2	6	1	5	7
Europe	20	17	20	19	18
Asia/Pacific-ROW	15	14	20	15	15

Notes:
Totals may not add to 100 percent because of rounding.
Calendar year estimates; no revenue associated with service and spares included.
Anicon aquired in February 1987. Dataquest's estimates for SVG in 1987 include all calendar year 1987 Anicon equipment revenue.
Thermco acquired in December 1988. Dataquest's estimates for SVG in 1988 exclude all calendar year 1988 Thermco equipment revenue.
Perkin Elmer's optical lithography group acquired in May 1990. Dataquest's estimates for SVG in 1990 include all calendar year 1990 Perkin-Elmer optical lithography equipment revenue.
Source: Dataquest (September 1992)

through 1991, Japan accounted for about 46 to 51 percent of worldwide wafer fab equipment expenditure. By not actively participating in this regional market, SVG effectively has reduced by half the total available market for its products. In addition, its ability to penetrate Japanese fab accounts in the United States and Europe has been negatively impacted by this policy because most Japanese companies building fabs outside of Japan choose to duplicate the equipment sets and materials used in existing facilities in order to ramp manufacturing as quickly as possible. Dataquest believes that this lack of presence in the Japanese market has serious long-term implications for SVG.

Company Products and Market Position

Table 4 shows Dataquest's estimates of SVG's worldwide wafer fab equipment revenue and market share, by major product segment. The following sections discuss the company's products, market position, and directions for each of its three operating groups.

Track Systems Division

Products

Automatic photoresist processing equipment performs a variety of steps necessary to process semiconductor wafers prior to lithographic exposure, including cleaning, adhesion promotion, and photoresist coating, as well as the steps required to treat wafers after exposure prior to the etching, including such steps as photoresist develop and bake. Track equipment is modular in design to allow configuration to specific customer requirements.

SVG offers four series of photoresist processing equipment. Its most advanced family of track systems, the 90 Series, was introduced in May 1990. This track system is designed for use in advanced fabrication processes with 0.5-micron geometries, such as that required for 16Mb and 64Mb DRAM production. The 90S system, introduced in 1992, is based on the 90 Series platform. By utilizing stacked modules, the 90S reduces system footprint by as much as 30 percent compared to the 90 Series, depending on the process. The 90S is targeted at 0.35-micron device production.

Other SVG track products include the 8800, 8600, and 8100 Series of track systems. The 8800 Series, introduced in 1987, is targeted at processing requirements down to 0.8-micron line geometries and was the first SVG track system to offer beltless wafer handling for improved contamination control. Both the 8600 and 8100 Series systems incorporate belt-based wafer transport systems and are targeted at the 1.0- and 2.0-micron and greater line-width processing regimes, respectively.

Market Position

The worldwide market for track equipment in calendar year 1991 was $369 million, up 13 percent from its 1990 level of $326 million. This healthy growth rate is of significance in light of the fact that the track equipment market is closely tied to purchases of lithography equipment, whose market declined 5 percent last year. Dataquest attributes the healthy growth rate in the 1991 track market to

Table 4
Silicon Valley Group Market Position, by Major Product Segment (Millions of Dollars)

Calendar Year Worldwide Revenue	1987	1988	1989	1990	1991
Track Division					
Track Equipment					
SVG Revenue	33.0	37.4	54.0	44.0	48.9
Total Market Revenue	167.7	253.4	333.6	326.0	368.6
SVG Market Share (%)	20	15	16	13	13
Thermco Division					
Vertical Tube CVD and Diffusion					
SVG Revenue	2.7	7.6	9.0	27.4	42.5
Total Market Revenue	23.3	86.5	176.8	302.6	391.6
SVG Market Share (%)	12	9	5	9	11
Horizontal Tube CVD and Diffusion					
SVG Revenue	0	0	62.0	48.0	37.3
Total Market Revenue	195.0	337.0	320.0	228.0	179.0
SVG Market Share (%)	0	0	19	21	21
Dedicated LPCVD Systems					
SVG Revenue	3.7	4.0	2.0	1.3	0.0
Total Market Revenue	30.2	55.6	79.6	97.2	89.9
SVG Market Share (%)	12	7	3	1	0
SVG Lithography					
Projection Aligners*					
SVG Revenue	0	0	0	37.0	21.2
Total Market Revenue	128.6	147.7	94.3	93.4	68.4
SVG Market Share (%)	0	0	0	40	31
Steppers					
SVG Revenue	0	0	0	30.6	30.4
Total Market Revenue	503.1	921.0	1,180.7	1,052.2	1,029.1
SVG Market Share (%)	0	0	0	3	3
Total SVG Wafer Fab Equipment Revenue	39.4	49.0	127.0	188.3	180.3

*Does not include shipments for nonsemiconductor applications.
Notes: Totals may not add to 100 percent because of rounding.
Calendar year estimates; no revenue associated with service and spares included.
Source: Dataquest (September 1992)

several factors. First, we believe that the average selling price (ASP) associated with a given track system increased at an accelerated pace last year. Track manufacturers are including more and more advanced modules and subsystems on their leading-edge product offerings, including vertical hot plates, random-access robotics, environmentally controlled chambers, and improved chemical dispense nozzles with sophisticated fluid volume controllers. Continued emphasis also is being placed on achieving tighter particle control throughout the entire track system. These items all directly contribute to a higher ASP per track system.

Dataquest also believes that a significant level of replacement systems was purchased for volume production lines and advanced R&D facilities last year, because the newer advanced track tools available in just the last few years have undergone substantial improvements relative to many tools currently in the installed base. Finally, the sluggish DRAM market has led many manufacturers to shift their product strategy from DRAMs to ASICs and other advanced logic products. As a result, we speculate that the market opportunity for standalone track systems last year expanded at a faster pace than might have otherwise been expected if DRAM activity had not been so slow. These three factors contributed to an accelerated growth rate in the track market in 1991. Because the significant shift in the product mix toward more advanced systems has already occurred, we expect future growth in the track market to keep pace with lithography expenditure.

SVG ranked third in the 1991 track market with $49 million in sales. The company has suffered a decline in market share over the years because it has been unsuccessful in breaking into the world's largest regional market, Japan, and has had to face increasing levels of competition from Japanese competitors in the other parts of the world, including its home market of the United States. In 1987, SVG accounted for 20 percent of the worldwide track market. Five years later (1991), this market share position had eroded to 13 percent. Its major competitors in the track market are Japanese companies: Tokyo Electron Ltd. (including its U.S. and European activity through its joint venture partner, Varian/TEL) and Dainippon Screen. These two companies garnered 39 percent and 19 percent, respectively, of the 1991 worldwide track equipment market. In 1991, SVG's major advanced product offering was its 90 Series systems, which Dataquest estimates accounted for about half of SVG's total track revenue in that year.

Directions

The top three players in the track market—Tokyo Electron, Dainippon Screen, and SVG—dominated the track market throughout the 1980s. In 1982, they accounted for a combined share of 52 percent, which by last year had increased to a combined share of 71 percent; 10 other companies split the remaining 29 percent of the 1991 market. Clearly, the combination of advanced technology and random-access product offerings coupled with sufficient critical mass to support a global customer base has been key to the success of these larger players.

As with all of its products, one major concern facing SVG's Track Division is its lack of participation in the Japanese equipment market. For the past seven years, Japanese track companies have commanded greater than 98 percent of the track equipment market in Japan. By 1991, with Japan well established as the world's major semiconductor manufacturing region, the track market in Japan represented 49 percent of the worldwide track market. This means that non-Japanese track companies such as SVG participated in a market only half the size of the total worldwide market. This situation is even more serious for non-Japanese track companies because the Japanese track suppliers and the Varian/TEL joint venture have continued to increase their market penetration and together accounted for 36 percent share of the track market outside of Japan in 1991.

Dataquest recognizes that establishing business activities and relationships in Japan is costly and requires a long-term commitment. However, SVG must seriously evaluate the impact of its future market strategies when it is clear that the market available to the company is steadily shrinking as a percentage of the total. Dataquest believes that SVG's Track Division should focus on working more closely with the major stepper manufacturers, Nikon and Canon, for the development of interfaces to their latest steppers, even if only for beta site installations. This involvement would allow SVG and the Japanese stepper companies to gain a better understanding of the mechanical and electrical interfaces required for directly linking track and exposure tools. However, SVG faces considerable challenges in developing these closer ties. Not only does it face fierce competition from its well-entrenched Japanese track competitors, but its SVGL subsidiary now also competes directly against Nikon and Canon in the advanced stepper product arena.

Thermco Systems Division

Products

SVG's Thermco division designs, manufactures, markets, and services products that address the oxidation/diffusion and LPCVD steps of the semiconductor fabrication process, such as LPCVD oxide and nitride deposition, LPCVD polysilicon deposition, gate oxide growth, and various high-temperature annealing steps. Its current product offerings are designed as horizontal tube systems and vertical thermal reactors. These systems are configured to process large batches of wafers simultaneously, and thereby offer high wafer throughput.

SVG developed its first VTR in 1986 and has continued to upgrade the product to meet increasingly stringent manufacturing requirements. It augmented its SVG product in December 1988 with the acquisition of Thermco Systems, which provided an established horizontal tube diffusion and LPCVD product line, and a large installed base.

The Series 6000 VTR was introduced in 1988 and improved upon the VTR by incorporating the SECS I and SECS II interface to the supervisory computer, and offered a retrofittable upgrade to 200mm wafers. The Series 6000 VTR was positioned to meet manufacturing requirements down to the 0.8-micron technology level. The Series 7000 VTR family was announced in February 1991, and improved upon the Series 6000 in the areas of particle control, process capability, and system reliability. The Series 7000 also incorporated an automatic quartz tube removal system to make tube changes easier and quicker. The Series 7000PLUS VTR was introduced in May 1992, and incorporated additional upgrades to the heating element and gas delivery system to further enhance the reliability and particle control characteristics. The Series 7000PLUS VTR enhancements were developed and tested in conjunction with National Semiconductor and Sematech through a Sematech Equipment Improvement Program (EIP). The series 7000 and 7000PLUS VTR products are designed for use in 4Mb and 16Mb production facilities, which use wafers up to 200mm in diameter and employ processes down to 0.5-micron geometries.

At Semicon/West in June 1992, SVG's Thermco Systems Division announced its most advanced product to date: the Series 8000 Advanced Vertical Processor (AVP), which features improved cost of ownership by increasing the load size for 200mm wafers. The system also provides enhanced wafer automation and supports automated manufacturing needs. The Series 8000 AVP is targeted at 0.35-micron production requirements, which will be utilized in 64Mb DRAM fabs.

Market Position

The worldwide market for horizontal and vertical diffusion and LPCVD equipment grew by a moderate 7.5 percent to $570.6 million in 1991. Steep increases in diffusion tube ASPs were the main contributing factor for the slight market growth. Driving the robust price increases were the rapid displacement of horizontal system shipments by vertical systems, which are more expensive than horizontal systems on a price-per-tube basis, plus the fact that newer systems are incorporating many new features to improve defect control, system reliability, and process capability. Horizontal tube systems shipments had a compound annual growth rate (CAGR) of negative 4.9 percent from 1986 to 1991, while vertical tube systems grew at a CAGR of 99.5 percent for the same period. The industry is moving rapidly toward vertical diffusion and LPCVD systems because of the robust process capability for thermal oxidation and LPCVD oxide, nitride, and polysilicon deposition processes, combined with high wafer throughput and low particle contamination levels. Also fueling the drive toward vertical reactors is the shift toward 200mm wafers, which are very problematic in horizontal systems.

SVG held 14 percent of the combined vertical and horizontal diffusion and LPCVD equipment market in 1991, placing it third behind TEL and Varian/TEL with 31 percent combined share, and Kokusai Electric with 23 percent market share. Dataquest believes that SVG has correctly positioned itself with its early development of vertical reactor technology. As is true for the company's other products, however, SVG has had difficulty penetrating the Japanese market with its VTR products, exhibiting virtually a complete absence in Japan. One reason for this has been the dominant position the Japanese occupy as consumers of vertical reactors. Japanese fabs accounted for 56 percent of all vertical systems shipped worldwide, with North American and Asia/Pacific-Rest of World companies absorbing 19 percent each, and European fabs responsible for the remaining 6 percent. The Japanese equipment suppliers, led by TEL and Kokusai, owned 93.1 percent of the 1991 vertical tube business in Japan, making it difficult for SVG to penetrate. SVG has, not surprisingly, performed the strongest in its home market, capturing 38.4 percent of the North American vertical furnace market in 1991. It has turned in only a lackluster performance in Europe and Asia/Pacific, however. If SVG is to sustain long-term growth in its vertical reactor business unit, it must devise a plan to increase its participation in the Asia/Pacific and Japanese regional markets.

Directions

The vertical systems market will continue to displace the horizontal tube market, and the vertical reactor product market is where SVG will fight for market share. SVG held 11 percent of the vertical tube equipment market in 1991, again in third place behind TEL and Varian/TEL (32 percent) and Kokusai (32 percent). Although SVG has been successful in ramping shipments of its VTR products, it faces stiff competition from the Japanese equipment companies. The heavy use of vertical furnace equipment in Japan has enabled Japanese equipment suppliers to dominate the Japanese market. Dataquest believes that the resurgence of the North American semiconductor market in 1993, driven by the microprocessor and communications product markets, represents an opportunity for SVG to capture market share as the North American equipment market grows as a fraction of the worldwide market. The Asia/Pacific market also represents a significant opportunity for SVG. Dataquest believes that it is essential for SVG to develop a strategy to compete in the Asia/Pacific market, which is expected to display healthy growth in 1993 as new 16Mb DRAM fabs are constructed and existing 4Mb and 16Mb DRAM fabs are expanded. The barriers present in Japan to SVG are not present in Korea, which affords an opportunity for SVG to prosper in that region.

Over the longer term, Dataquest expects the Japanese market for wafer fab equipment to recover as the Japanese economy improves and demand for semiconductors increases. The Japanese fab equipment market, so stagnant in 1992, cannot be dismissed, and will bounce back to its familiar status as one of the largest regional markets in the world. Ultimately, the Japanese market represents and will continue to represent a large portion of the total available market. If SVG is unable to participate in that market, it will severely restrict its total available market. Dataquest believes that it is crucial for SVG to formulate a strategy to allow it to compete in Japan. This may involve a partnership with a Japanese manufacturer of process equipment, which could be clustered with a VTR system, such as a preclean module that would be used prior to gate oxidation, or DRAM capacitor dielectric deposition. Dataquest believes that a successful strategy must add substantial value to the package that SVG will market, preferably with a Japanese company's participation. It is unlikely that the differences between various standalone systems will be adequate to cause the Japanese fabs to turn away from their domestic suppliers.

SVG Lithography

Products

SVG Lithography has two major product families of exposure tools: projection aligners and step-and-scan lithography systems. The most advanced product in the Micralign family of projection aligners is the Micralign 700. This tool is used primarily in the fabrication of devices with minimum feature sizes greater than 1.25 microns, or in the production of less critical layers of more sophisticated integrated circuits. In addition to semiconductor device fabrication, SVGL's projection aligners are used in other nonsemiconductor market applications such as thin film head manufacturing and multichip module processing. A large installed base of Micralign systems exists throughout the world, and a significant portion of SVGL's revenue consists of sales of spares, accessories, refurbished systems, and upgrade kits and servicing of this installed base.

SVGL's Micrascan system is a step-and-scan lithography tool that combines the advantages of scanning projection aligners and step-and-repeat exposure tools (steppers). The step-and-scan technology allows for a larger exposure field than a traditional stepper in addition to the ability to expose the field while the wafer is in motion. Together, these features enable the Micrascan to achieve a high throughput level while maintaining fine-line processing capability.

The initial development work of the Micrascan was performed by Perkin-Elmer in conjunction with IBM. At the time of the acquisition of Perkin-Elmer's optical lithography group in May 1990, SVG took a majority interest in the operation (67 percent), with both Perkin-Elmer and IBM holding minority positions in the SVGL subsidiary. Since that time, SVG has acquired Perkin-Elmer's share in the operation such that today the company's ownership in its SVGL subsidiary has grown to 94 percent, with IBM maintaining its original position of 6 percent. In addition to IBM, Sematech has been actively involved in advanced Micrascan system development.

The first Micrascan systems were shipped in 1989 to IBM, SVGL's development partner, and were targeted at 0.5-micron processing for 16Mb DRAMs. In June 1992, the company introduced its next-generation system, the Micrascan 92. This tool was designed for patterning of 0.35-micron design features but has the ability to be extended to the 0.25-micron processing regime.

Market Position

According to Dataquest estimates, SVGL had projection aligner equipment revenue for semiconductor applications of $21 million in 1991. This revenue level translated to 31 percent share of the $68 million market. SVGL's only competitor in this market segment is Canon, which commanded 69 percent share of the market. Projection aligners represent a mature segment of the semiconductor wafer fab equipment market because of the restriction on their ability to process sub-1.25-micron geometries. Dataquest expects this segment of the semiconductor applications market to experience relatively flat growth over the five-year period from 1991 to 1996. SVG is pursuing opportunities in nonsemiconductor application markets.

Steppers constitute the single largest market segment in the wafer fab equipment industry. Total stepper unit shipments to semiconductor manufacturers were 679 units in 1991, down 12 percent from the 1990 level of 771. Buoyed by the higher ASP of advanced i-line systems, the predominant tool choice of the product mix, worldwide stepper revenue was $1.03 billion in 1991, reflecting a decline of a mere 2 percentage points from its 1990 level of $1.05 billion. SVGL's position in the worldwide stepper market is still negligible. In 1991, it shipped only eight units, representing a little more than 1 percent of worldwide stepper shipments. Export shipments for the company last year included two units to Europe and two units to Japan, one of which was the highly publicized shipment to Toshiba in early 1991. As in the two previous years, IBM continued to be SVGL's major customer for the Micrascan in 1991. With the exception of the Toshiba shipment last year and a shipment to Sematech in 1990, Dataquest believes that all other units in the customer installed base are located at IBM facilities.

Much of SVGL's activity in 1991 was taken up with development of its new advanced Micrascan tool, which was introduced at Semicon/West in June 1992. It has invested significant time and resources to substantially improve the capability and cost of ownership on this advanced lithographic product offering. Designed for the 0.35-micron environment, the Micrascan 92 achieves improved performance and reliability while offering a 50 percent reduction in footprint as compared with its predecessor.

One key feature of the first-generation Micrascan system was its wide field of 20mm x 32.5mm. The Micrascan 92 slightly extends that field size to 22mm x 32.5 mm, which allows three 64Mb DRAM chips to be imaged per exposure. This large field size translates to a 50 percent improvement in exposure throughput as compared with today's advanced wide-field reduction steppers, which can image only two 64Mb DRAM chips per exposure. Although SVGL must first establish its position in the market with its 22mm x 32.5mm field size, Dataquest understands that the company is well positioned to deal with the larger chip sizes of future device generations. The advanced Micrascan series can be readily reconfigured to accept larger reticles (6 x 9 inches) that correspond to an exposure field of 22mm x 50mm.

In a key strategic move, SVGL will offer i-line capability on the Micrascan 92. The system's deep-UV platform has been designed to accept an i-line source and its corresponding optics. Dataquest believes that this may well prove to be a pivotal marketing decision for SVGL. This strategy allows the company to embrace customers already attracted to the benefits of the Micrascan technology but that are reluctant to abandon their i-line processing know-how for the unknown realm of deep-UV.

SVGL has announced an ASP of $3.8 million for a deep-UV version of the Micrascan 92 and a $2.9 million price point for an i-line version of the machine. These prices, while somewhat higher than existing stepper products, are still competitive given the technological capabilities of the system. These price points for the Micrascan 92 are unlikely to generate the sticker shock that occurred when the first-generation Micrascan was introduced in 1989. At that time, the Micrascan's price tag of $4 million was in sharp contrast to the average stepper price of $1.3 million. Since that time, there has been a significant shift in the stepper technology product mix away from the older g-line technology to new advanced systems. This in turn has contributed to higher stepper prices overall.

Directions

The Micrascan family of step-and-scan exposure tools represents not only the heart of the SVGL operations, but Dataquest believes that this one product family is absolutely vital to the entire corporation's long-term growth strategy. Dataquest believes that it is critical that SVG achieve product acceptance of the Micrascan 92 by device manufacturers other than IBM. A key factor in the company's strategy to expand its market position centers on developing a significantly closer relationship with the major Japanese semiconductor companies. Japan represents the world's largest market for not only steppers, but for wafer fab equipment in general. It is the production center for high-volume manufacturing of DRAMs, for which the Micrascan product is particularly well suited. SVG faces significant challenges, however, in opening up this market for a number of reasons.

First, Japanese stepper companies hold an overwhelming share of their home market on a unit basis (96 percent in 1991) and a dominant position in the world market overall (82 percent). Dataquest is aware of step-and-scan technology development programs in place at a number of the major stepper manufacturers, so SVG cannot assume that it will hold its unique technology position in this market for the long term. A second challenge to consider is that SVG as a corporation historically has been unsuccessful in establishing any type of presence in the Japanese market and by neglecting that region of the world throughout the 1980s has effectively cut the total available market for its products in half. Establishing business relationships and a direct presence in Japan takes not only considerable resources but also an extended period. We believe that SVG cannot afford the time it would take to restart its efforts in penetrating the Japanese market from scratch because of the significant competitive forces in the stepper market and the possibility that competitors may introduce step-and-scan technologies of their own. The most effective route, then, is for SVG to partner with another company already active in Japan.

Dataquest believes that discussions have recently been held between SVG corporate management and key personnel of the Canon organization. Canon has one of the largest representative/distributor operations for wafer fab equipment in Japan, and in that sense would provide SVG with a strong partner. At the same time, however, Canon's own stepper operations are particularly strong in the marketplace and it is well positioned to parlay its projection aligner technology with its strong stepper technology base into developing its own step-and-scan machine. Dataquest believes that a partnership between SVG and Canon would hold both significant benefits as well as risks because of these factors. We would expect that, in addition to Canon, SVG is most likely pursuing other avenues for partnering in Japan. Regardless of SVG's ultimate choice for a partner in Japan, we believe that it will be vital that this relationship be firmly established within the next 6 to 18 months so that the company can be well positioned to take advantage of its front-runner position in step-and-scan technology for 64Mb DRAM evaluation, pilot, and production purchases.

One final factor that may also affect the long-term success of the Micrascan product family centers on the deep-UV photoresist material used to transfer the circuit image to the wafer. SVG has entered into an agreement with IBM for IBM to provide certain photoresist material for use with Micrascan systems. The photoresist material is available to SVGL in limited quantities only, can be sold by SVGL only to a limited set of customers, and is available for a limited period. Dataquest understands that although the IBM resist provides good results, it has the reputation for being not particularly user-friendly. SVG has noted that an alternative photoresist material is now available to SVGL and all potential Micrascan customers from a third party, but there can be no assurance that it will achieve acceptance by SVGL's customers. In the event that SVGL or its customers are unable to secure adequate supplies of the IBM photoresist or an acceptable substitute, the results of operations of SVGL and SVG could be adversely affected.

Dataquest Perspective

The size of a company clearly has become increasingly important as the wafer fab equipment industry matures. The sales level is critical because it relates to a company's ability to fund R&D for advanced technology development as well as support and service its customers on an international basis. Through its strategy of acquisitions in the latter half of the 1980s, SVG has successfully grown to be one of the largest independent wafer fab equipment companies in the world, with a broad portfolio of advanced product offerings. According to Dataquest estimates, SVG ranked seventh overall in the 1991 worldwide wafer fab equipment market, third in both the North American and European markets, and ninth in Asia/Pacific-Rest of World.

Dataquest believes that the single most critical issue facing the company will be development and implementation of a strategy to penetrate the Japanese market. SVG, however, faces well-entrenched competition in Japan for the products from both its Track and Thermco divisions. We believe that SVG should rally its efforts in this endeavor around its Micrascan advanced exposure system. The uniqueness of this product in today's marketplace provides SVG with an edge to establish a firm position in advanced lithography in both its traditional regional markets as well as Japan. Time is of the essence, however, because the highly competitive nature of the wafer fab equipment industry dictates that it will be difficult for SVG to hold this competitive edge for long.

Sony Corporation

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Date Founded: 1946

CORPORATE STRATEGIC DIRECTION

Sony Corporation, founded in Tokyo in 1946, is one of the world's leading manufacturers of video and audio equipment, televisions, displays, semiconductors, computers, computer peripherals, factory automation equipment, and engineering workstations.

Sony's business philosophy is to provide innovative and attractive products to its customers worldwide. Sony is one of Japan's leaders in global marketing; it had ¥3.6 trillion (U.S.$25.6 billion) in revenue for the fiscal year ended March 31, 1991. Because of its strong international customer base, the company is especially susceptible to fluctuations in international trade markets. The Gulf War, which occurred during fiscal 1991, had severe repercussions in the world economy and directly affected Sony's performance. The United States entered a recession in the second half of the year, the European economy evidenced sluggish performance, and the Japanese economy faced higher interest rates. Even with this difficult environment, Sony attained the highest sales and profit figures in the company's history. Sony points to strong growth in its electronics and entertainment industries as the key factors in its growth.

Sony's long-term strategy to improve product performance and meet customer expectations includes the following policies:

- In consumer electronics, Sony will strive to accelerate the development and marketing of attractive and original products. Expansion will occur in such areas as high-definition television (HDTV) products and information-related equipment for the home.
- In industrial electronics, Sony will seek to strengthen its operations in broadcast- and professional-use videocassette recorders and players (VTRs) and displays while addressing a varied spectrum of market needs. Other areas of targeted growth include recording media, semiconductors, electronic components, computer systems, information processing, and telecommunications.
- Sony will intensify its activities in the entertainment field by strengthening its music and image-based software operations, and by creating synergy with its electronics business. Efforts will be centered on Sony Music Entertainment Inc. (known before January 1, 1991, as CBS Records Inc.) and Columbia Pictures Entertainment Inc.
- Sony has committed to a companywide efficiency upgrade in all areas of business, as well as to the promotion of more efficient allocation of the company's capital, personnel, and management resources.
- Sony will seek to bring all facets of its overseas operations, including procurement of components, R&D, production, and marketing, in closer contact with local communities.

Sony's ¥3.6 trillion (U.S.$25.6 billion) total revenue for the year ended March 31, 1991, represents an increase of 27.11 percent over the year ended March 31, 1990. The increase in sales was led by a 178.4 percent increase in filmed entertainment revenue. Television sales increased 33.2 percent, video equipment sales grew 23.7 percent, and audio equipment sales increased 23.5 percent. Growth of 30.6 percent in the other products group can be attributed to the strong growth of information-related equipment. (Percentage changes refer to U.S. dollar amounts.)

Sony is an international company with 26.3 percent of its sales occurring in Japan, 29.2 percent in the United States, 28.1 in Europe, and 16.4 percent in all other regions. Europe posted the highest growth rate, increasing sales 43.9 percent, while the United States grew 24.4 percent and other international markets grew 37.3 percent. The Japanese market grew at a significantly lower rate of 10.9 percent.

Net income increased 13.7 percent to ¥116.9 billion (U.S.$829.3 million) in fiscal year 1991 from ¥102.8 billion (U.S.$654.8 million) for fiscal 1990. Sony employed approximately 112,900 people in 1990, an increase of 18.1 percent over the 1990 year-end total of 95,600 employees.

R&D expenditure increased 24.6 percent to ¥205.8 billion (U.S.$1.2 billion) for the year ended March 31, 1991, from ¥165.2 billion (U.S.$1.2 billion) in the year ended March 31, 1990. R&D represented 5.7 percent of revenue for the year ended March 31, 1991. Capital expenditure for the year ended March 31, 1991, increased 27.1 percent from the previous year's ¥323.8 billion (U.S.$2.3 billion) to ¥411.7 billion (U.S.$2.9 billion), representing 11.4 percent of total revenue. The increased expenditure primarily was used for expanding production facilities for semiconductors; image-based devices such as color picture tubes; magnetic products; and audio and video equipment. About 35 percent of the capital development expenses were appropriated for overseas facilities. Sony intends to maintain a high level of capital investment and expects next year's expenditure to exceed this year's figure.

Sony's policy is to base its manufacturing operations in markets where its products are sold. By doing this, Sony brings its products closer to customers and avoids trade problems and exchange rate variations. Accordingly, Sony maintains its principal manufacturing facilities in Japan, the United States, and Europe.

In January 1991, Sony Music Entertainment Inc. (SMEI) and a subsidiary of Time-Warner Inc. formed The Columbia House Company, a 50:50 partnership consisting of the former Columbia House Division of SMEI. Columbia House is a direct marketer of music and home video products in the United States and Canada.

In November 1989, Sony purchased Columbia Pictures Entertainment, adding image-based software to its software business. This purchase emphasized strengthening of the company's software operations primarily through the record and video business.

On January 5, 1988, Sony purchased CBS Records Inc. and now holds 100 percent of the shares. The U.S.$2 billion (¥256.5 billion) acquisition was based on Sony's belief in the important relationship between the software and hardware sides of the consumer electronics business.

More detailed information is available in Tables 1 and 2, which appear after "Business Segment Strategic Direction" and present corporate highlights and revenue by region. Information on revenue by distribution channel is not available. Tables 3 through 7 at the end of this backgrounder present comprehensive financial information.

BUSINESS SEGMENT STRATEGIC DIRECTION

Lines of Business

Video Equipment

The video equipment product group revenue totaled ¥908 billion (U.S.$6.4 billion) for the year ended March 31, 1991, or 25.1 percent of sales. Products include VTRs, video cameras, camcorder systems, videotapes, optical videodisk players, and high-definition video systems.

Audio Equipment

The audio equipment product group revenue totaled ¥883 billion (U.S.$6.2 billion) for the year ended March 31, 1991, or 24.4 percent of total sales. Products include tape recorders, audiotapes, cassette players, car stereos, amplifiers, tuners, turntables, speaker systems, CD players, digital audiotape (DAT) recorders, headphones, microphones, and compact discs.

Music Entertainment

Sony's music entertainment business reported revenue of ¥474 billion (U.S.$3.4 billion) for the year ended March 31, 1991, or 13.1 percent of total revenue. Performers on the Sony label include Mariah Carey, New Kids on the Block, George Michael, Billy Joel, Michael Bolton, Gloria Estefan, the Vaughan Brothers, and Harry Connick, Jr.

TV Equipment

Sony's television product group reported revenue of ¥553.4 billion (U.S.$3.9 billion) for the year ended March 31, 1991, or 15.3 percent of total revenue. Key products include color TVs and monitors, projection TVs, JumboTRON, direct broadcasting satellite reception systems, and security systems.

Filmed Entertainment

Sony's filmed entertainment reported revenue of ¥257 billion (U.S.$1.8 billion), or 7.1 percent of sales for the year ended March 31, 1991. Fiscal 1991 film releases included *Total Recall, Look Who's Talking Too, Misery, Awakenings, Postcards from the Edge,* and *Flatliners.*

Other Products

The groups producing other products reported revenue of ¥543 billion (U.S.$3.8 billion) for the year ended March 31, 1991. Key products include the 3.5-inch microfloppy disk systems, microcomputers, workstations, CD-ROM systems, information processing systems, semiconductor devices, electronic components, dictating machines, word processors, induction cooking ranges, telephones, telecommunications systems, factory automation systems, batteries, accessories, and audio and video software.

Company Positioning

Computer Storage

Sony was one of the leading flexible disk drive (FDD) vendors in 1990. Dataquest estimates that Sony maintained its market leadership in the worldwide 3.5-inch FDD market with a 25 percent market share and $226.5 million in factory revenue. We estimate that Sony shipped 5 million 3.5-inch disk drives in 1989. In the worldwide overall FDD (3.5-inch and 5.25-inch) market, Sony dropped from third in 1989 to fourth in 1990, with a market share of 13.6 percent. Sony continues to emphasize the 3.5-inch market, beginning production of 3.5-inch drives in Malaysia in May 1990.

According to Dataquest estimates, Sony ranked first in the optical disk drive market in 1990 with $125.6 million in factory revenue and a 36.2 percent market share. Sony dominates the rewritable market in optical disk drives with 49.0 percent of the market, 39,200 units shipped, and $49 million in factory revenue. Sony also moved up to second in the 12-inch write-once, read-many (WORM) drive market with a 29.9 percent market share and $19.4 million in factory revenue.

Sony has entered the 3.5-inch rigid disk drive market. Dataquest expects Sony to offer a broad range of rigid drives with capacities between 40MB and 200MB and access times of less than 20ms.

Workstations

Sony Microsystems was formed in February 1988 to market Sony's NEWS workstation, a 32-bit UNIX workstation designed primarily for software development applications. Dataquest estimates that Sony had 6.6 percent of the worldwide workstation market share for calendar 1989. Dataquest estimates that Sony ranked fourth in the entry-level workstation market with U.S.$137.2 million in factory revenue for 1989. Dataquest also estimates that Sony ranked third in the Japanese workstation market, with a 9.8 percent market share and $133.7 million in factory revenue.

In May 1990, Sony introduced its laptop NEWS workstation to the European market and later to the Japanese market. Sony had two major design goals for its new workstation, as follows:

- The same level of performance and functionality as the NEWS desktop workstation
- Compatibility with NEWS software and hardware products

The laptop workstation is priced between $10,000 and $15,000 and is targeted toward the technical user with a requirement for a transportable, fully functional technical workstation.

In 1989, Sony introduced a RISC-based workstation using MIPS R3000 processors. Sony expanded its NEWS line to include lower-priced models, and high-performance 32-bit CPU versions. Sony added desktop publishing software to the NEWS line of workstations.

Personal Computers

In July 1991, Sony released a new PalmTop series of personal computers, featuring the ability to input characters with a light pen. The PTC-300, weighing in at 355g, offers significant improvements in portability. Sony does not market its computers in the United States and held less than 1 percent of the worldwide PC market, according to Dataquest estimates.

Semiconductors

Sony began marketing semiconductors in 1984 and currently produces a range of devices, including static random-access memory (SRAM) chips, charge-coupled devices (CCDs), and bipolar ICs for consumer audiovisual equipment. In capital expansion, Sony completed a new wing at Sony Nagasaki Corporation with a clean room for the manufacture of

SRAMs and other leading-edge semiconductor devices and a design center for large-scale integration (LSI) technologies. In addition, Sony began operations at its first overseas semiconductor manufacturing facility, Sony Semiconductor (Thailand) Company Ltd., which will center on the assembly of bipolar ICs.

In the area of research and development, Sony announced in October 1990 the successful development of the world's fastest large-scale gallium arsenide gate array. The device will be used in workstations, image-processing equipment, and other equipment requiring high-speed data processing capabilities.

Dataquest estimates that Sony's 1990 worldwide semiconductor market share was 1.9 percent, with U.S.$1.1 billion in revenue. Dataquest estimates that Sony ranks 19th in the total worldwide semiconductor market, while in Japan, Sony ranked 9th for the third year in a row, with a 4.0 percent market share. Japan represented 77.7 percent of Sony's semiconductor revenue for 1990.

Computer Software

Sony Computer Science Laboratory Inc. was established by Sony Corporation to develop distributed operating systems, programming languages, system architectures, and user interfaces.

Further Information

For further information about the company's business segments, please contact the appropriate Dataquest industry services.

Table 1
Five-Year Corporate Highlights (Billions of U.S. Dollars)

	1987	1988	1989	1990	1991
Five-Year Revenue	3.4	10.4	16.7	20.1	25.6
Percent Change	-42.67	202.02	41.94	20.84	27.11
Capital Expenditure	0.6	1.0	1.7	2.3	2.9
Percent of Revenue	18.55	9.33	10.05	11.25	11.38
R&D Expenditure	0.8	0.9	1.1	1.2	1.5
Percent of Revenue	9.27	8.91	6.62	5.74	5.69
Number of Employees	47,583	71,000	78,900	95,600	112,900
Revenue (U.S.$K)/Employee	72.15	146.04	212.01	210.76	226.84
Net Income	0.1	0.3	0.6	0.7	0.8
Percent Change	-55.98	218.98	112.61	27.23	15.10
Exchange Rate (U.S.$1=¥)	159.56	138.03	128.25	142.93	141.21

1991 Fiscal Year	Q1	Q2	Q3	Q4
Quarterly Revenue	5.41	6.23	7.84	6.34
Quarterly Profit	0.16	0.19	0.39	0.11

Source: Sony Corporation
Annual Reports
Dataquest (January 1992)

Table 2
Revenue by Geographic Region (Percent)

Region	1987	1988	1989	1990	1991
United States	27	28	27	30	29
Japan	35	35	34	30	26
Europe	24	23	23	25	28
All Other Regions	14	14	16	15	17

Source: Sony Corporation
Annual Reports
Dataquest (January 1992)

1990 SALES OFFICE LOCATIONS (Includes sales subsidiaries only)

Asia/Pacific—19
International—14

MANUFACTURING LOCATIONS

North America

Digital Audio Disc (United States)
CDs
Sony Engineering and Manufacturing of America (United States)
TVs, CRTs, 32-bit workstations, 3.5-inch FDDs, CD-ROM drives, monitors, audio speakers, factory automation equipment
Sony Magnetic Products Inc. (United States)
Magnetic tapes, flexible disks
Sony Microelectronics Corporation (United States)
Semiconductors
Sony Music Entertainment (United States)
Phonograph records, tapes, CDs
Sony Professional Products Company (United States)
Professional AV equipment
Sony USA (United States)
Electronic equipment

Europe

DADC Austria (Austria)
CDs
Sony (United Kingdom)
TVs, CRTs
Sony Espana (Spain)
TVs, VCRs
Sony France (France)
CD players, video cameras, VHS video decks
Sony-Wega Productions (United Kingdom)
TVs
Television Division Europe (France)
Development, design of TVs

Asia/Pacific

Aiwa Company (Japan)
High-fidelity audio systems, headphone stereos
Hagiwara Electronics (Japan)
TV/video equipment
Mac Precision Products (Japan)
Precision parts
Miyagi Video-Tech (Japan)
Magnetic tapes
Motomiya Denshi (Japan)
Trinitron gun, security systems, flat display tubes, TV parts
Nakada Magnetics (Japan)
Ferrites
Sony Akebono Denshi (Japan)
Printed circuit boards
Sony Audio (Japan)
Audio, video, camera, and optical systems
Sony Bonson (Japan)
Tape recorders, flat TVs, radios
Sony Chemicals (Japan)
Magnetic tapes, chemical products
Sony Computer Science Lab (Japan)
R&D of computer systems/software
Sony Denshi (Japan)
TVs and parts
Sony Electronics (Japan)
Radiocassette tape recorders
Sony Ichinomiya (Japan)
VCRs, color TVs
Sony Inazawa (Japan)
Color CRTs
Sony Itakura (Japan)
CD players, radiocassette recorders
Sony Kisarazu (Japan)
VCRs, CD players
Sony Kohda (Japan)
Video equipment
Sony Kokubu Semiconductor (Japan)
Bipolar ICs, CCDs
Sony Magnescale (Japan)
Electronic measuring instruments
Sony Magnetic Products (Japan)
Magnetic tapes, ferrites, videotapes
Sony Minokama (Japan)
Video equipment
Sony Mizunami (Japan)
Color CRTs
Sony Nagasaki (Japan)
Semiconductors
Sony Oita (Japan)
Semiconductors
Sony Precision Engineering (Japan)
Precision parts for audio equipment for Sony's subsidiaries worldwide
Sony Semiconductor (Japan)
Bipolar ICs

Sony Shiroishi Semiconductor (Japan)
  Semiconductors
Sony Sound Tec (Japan)
  Microphones, PA systems, furniture, hearing aids
Sony TV-Video (Japan)
  Color TVs
Sony Tektronix (Japan)
  Electronic measurements, displays, control instruments, computer graphics products
Sony Video Taiwan (Taiwan)
  VCRs
Sound Magnetics (Japan)
  Magnetic heads
Sound System (Japan)
  VCRs, CD players
Taron Corporation (Japan)
  Audio and video products
Tohkai Electronics (Japan)
  PC boards
Toyo Radio (Japan)
  Audio products
Video Magnetics (Japan)
  Ferrites

ROW

Magneticos de Mexico (Mexico)
  Magnetic tapes, floppy disks
Sony da Amazonia (Brazil)
  VCRs
Sony de Venezuela (Venezuela)
  Color TVs
Sony Videobras (Brazil)
  Video cameras, video equipment
Videotec de Mexico (Mexico)
  Video equipment

SUBSIDIARIES

As of March 31, 1991, Sony had 625 consolidated subsidiaries. The list below gives the company's principal subsidiaries and affiliated companies as of April 30, 1991.

North America

Digital Audio Disc Corporation (United States)
Materials Research Corporation (United States)
Sony Corporation of America (United States)
Sony Music Entertainment Inc. (United States)
Sony of Canada Ltd. (Canada)
Sony Pictures Entertainment (United States)
Sony Trans Com Systems Division (United States)
Sony USA Inc. (United States)

Europe

DADC Austria GesmbH (Austria)
Sony Belgium N.V. (Belgium)
Sony Broadcast & Communications Limited (United Kingdom)
Sony Communication Products B.V. (Netherlands)
Sony Deutschland GmbH (Germany)
Sony Espana S.A. (Spain)
Sony Euro-Finance B.V. (Netherlands)
Sony Europa GmbH (Germany)
Sony France S.A. (France)
Sony GesmbH (Austria)
Sony Italia S.p.A. (Italy)
Sony Nederland B.V. (Netherlands)
Sony Overseas S.A. (Switzerland)
Sony Portugal Lda. (Portugal)
Sony Scandinavia A/S (Denmark)
Sony (Schweiz) A.G. (Switzerland)
Sony Service Centre (Europe) N.V. (Belgium)
Sony (U.K.) Limited (United Kingdom)
Sony-Wega Productions GmbH (Germany)

Asia/Pacific

Aiwa Co. Ltd. (Japan)
Akebono Electronics Inc. (Japan)
CBS/Sony Group Inc. (Japan)
Hasso Electronics Corporation (Japan)
Korea Toyo Radio Co. Ltd. (South Korea)
Max Precision Products Corporation (Japan)
Motomiya Denshi Corporation (Japan)
Sony (Australia) Pty. Limited (Australia)
Sony Asco Inc. (Japan)
Sony Bonson Corporation (Japan)
Sony Broadcast Products Corporation (Japan)
Sony Chemicals Corporation (Japan)
Sony Corporation of Hong Kong Limited (Hong Kong)
Sony Creative Products Inc. (Japan)
Sony Denshi Corporation (Japan)
Sony Electronics (Malaysia) Sdn. Bhd. (Malaysia)
Sony Energytec Inc. (Japan)
Sony Engineering Corporation (Japan)
Sony Enterprise Co. Ltd. (Japan)
Sony Finance International Inc. (Japan)
Sony Ichinomiya Corporation (Japan)
Sony Inazawa Corporation (Japan)
Sony International (Singapore) Pte. Ltd. (Singapore)

Sony Kisarazu Corporation (Japan)
Sony Kohda Corporation (Japan)
Sony Kokubu Semiconductor Corporation (Japan)
Sony Logistics (Singapore) Pte. Ltd. (Singapore)
Sony Logistics Corporation (Japan)
Sony Magnescale Inc. (Japan)
Sony Magnetic Products Inc. (Japan)
Sony Magnetic Products (Thailand)
Sony Magnetic Tape Sales Corporation (Japan)
Sony Minokamo Corporation (Japan)
Sony Mizunami Corporation (Japan)
Sony Nagasaki Corporation (Japan)
Sony Oita Corporation (Japan)
Sony PCL Inc. (Japan)
Sony Plaza Co. Ltd. (Japan)
Sony Precision Engineering Center (Singapore) Pte. Ltd. (Singapore)
Sony Procurement Service Corporation (Japan)
Sony Pruco Life Insurance Co. Ltd. (Japan)
Sony Service Co. Ltd. (Japan)
Sony Shiroishi Semiconductor Inc. (Japan)
Sony Shoji Corporation (Japan)
Sony Singapore Pte. Ltd. (Singapore)
Sony Sound Tec Corporation (Japan)
Sony TV Video (Malaysia) Sdn. Bhd. (Malaysia)
Sony Trading Corporation (Japan)
Sony Tsukuba Corporation (Japan)
Sony Video Taiwan Co. Ltd. (Taiwan)
Sony/Tektronix Corporation (Japan)
Sound System Corporation (Japan)
Taron Corporation (Japan)
Tohkai Electronics Corporation (Japan)

ROW

Magneticos de Mexico, S.A. de C.V. (Mexico)
Sony CSA, S.A. (Panama)
Sony Chile Ltda. (Chile)
Sony Corporation of Panama S.A. (Panama)
Sony da Amazonia Ltda. (Brazil)
Sony de Venezuela S.A. (Venezuela)
Sony Saudi Arabian Company Ltd. (Saudi Arabia)

ALLIANCES, JOINT VENTURES, AND LICENSING AGREEMENTS

1991

Advanced Micro Devices Inc. (AMD)
Sony and AMD signed a broad patent and copyright cross-licensing agreement covering wafer processes, design, and architectures for integrated circuits.

Apple Computer Inc.
Sony will manufacture major portions of the laptop Macintosh computer under development by Apple.

Bell Microproducts Inc.
Bell added Sony's read-write optical drives to its current franchise list.

Digital Equipment Corporation
Digital and Sony entered an agreement through which Digital will produce optical subsystems based on Sony optical disk drives.

Matsushita Electric Industrial
Matsushita Electric Industrial and seven other companies (Kyushu Matsushita Electric, Sega Enterprises, Chinon Industries, Casio Computer, Ricoh, Canon, and Sanyo Electric) will make CD-ROMs based on Sony specifications.

Nihon Silicon Graphics K.K. (NSG)
Sony and NSG signed a marketing agreement in which Sony will market a high-definition computer graphics system for NSG's Iris 4-D Power Vision graphics workstation.

Ricoh Company
Ricoh will provide its Design Base Jr. three-dimensional model-generation software package to Sony to be bundled with Sony's new NWB-236 processor.

SGS-Thomson Microelectronics
SGS-Thomson Microelectronics will second-source a chip set for high-speed serial digital video transmission developed by Sony.

Software Toolworks
Sony and Software Toolworks signed a licensing agreement allowing Sony to use special versions of Software Toolworks' CD-ROM software with Sony's CD-ROM optical disk player.

VideoLogic Inc.
Sony signed an agreement with VideoLogic allowing Sony to sell multimedia products through computer resellers and video dealers.

Wave Front Technologies
Wave Front will supply Sony with its TPV computer graphics software, to be bundled with Sony's latest three-dimensional computer graphics board, the NWB-256.

1990

Exabyte Corporation
Exabyte renewed a supply agreement with Sony under which Sony will supply Exabyte with 5.25-inch form factor tape drives.

Compression Labs Inc.
Sony entered into a reseller agreement with Compression Labs under which Sony will resell Compression Labs video coder/decoders. The agreement marks Sony's entry into the U.S. videoconferencing market.

Texas Instruments
Texas Instruments agreed to produce semiconductors in Europe for Sony on a consignment basis.

NJK Ltd.
NJK Ltd. signed as a distributor for Sony's NEWS workstations.

Fujitsu
Sony and Fujitsu jointly developed a trial common rule to develop CD-ROM XA software for their personal computers.

Oracle Corporation
Oracle agreed to supply the Oracle relational database management systems and applications development software products for the Sony NEWS family of UNIX workstations.

Novell K.K.
Novell K.K. was formed as a joint marketing venture to sell NetWare products in Japan. Novell and six partners—Canon, Fujitsu, NEC, Softbank, Sony, and Toshiba—helped fund the project.

Advanced Micro Devices (AMD)
AMD agreed to enter a joint manufacturing and educational pact with Sony to manufacture SRAMs.

Summus Computer Systems
Summus agreed to sell, distribute, and service 4mm DAT drives from Sony. Summus agreed to be an original equipment manufacturer (OEM) of Sony and to integrate hardware and software that offers turnkey storage subsystems for the Apple Macintosh, Digital, and Sun Microsystems Inc. PC markets.

1989

Parallex Graphics Inc.
Sony Microsystems agreed to incorporate Parallex's color graphics and video graphics controllers in Sony's workstations.

Matsushita Philips
Sony, Matsushita, and Philips agreed to develop, manufacture, and market interactive compact disk drives.

Apple Computer Inc.
Sony signed a contract with Apple to supply 40MB rigid disk drives for the Macintosh.

Hewlett-Packard Company (HP)
Sony agreed to supply 5.25-inch rewritable optical disk storage products to HP for the new HP C17QA Optical Disk Library System.

Pinnacle Micro
Sony announced plans to supply $1 million (¥128.3 million) worth of 5.25-inch rewritable optical disk storage products to Pinnacle Micro.

Advanced Micro Devices (AMD)
Sony and AMD entered a joint venture agreement for an SRAM memory product.

1988

Daewoo Electronics
Sony and Daewoo agreed to jointly develop 256K SRAMs, 64K SRAMs, 8- and 16-bit MPUs, and other microchips.

Engineering Mechanics Research (EMR)
Sony and EMR agreed to a joint venture in CAE software technology and sales. EMR is marketing Sony's engineering workstations (EWSs) that employ its software in the United States while Sony supports sales agents of EMR's software in Japan by supplying its EWS.

N.V. *Philips* Gloeilampenfabrieken
Sony and Philips agreed to a joint development of extended architecture CD-ROMs for audio use.

Motorola Inc.
Sony Microsystems agreed to incorporate dual Motorola 68030 MPUs in high-end models of Sony's NEWS UNIX workstation family.

Symbolics
Sony and Symbolics completed a sales agreement for Sony's workstations in the U.S. market. Sony Microsystems began supplying its workstations to Symbolics in May 1988 for sale in the United States under the Symbolics brand name. The two companies agreed to jointly develop a new model of workstation using Symbolics' A1 chips.

Texas Instruments Inc. (TI)
TI Japan and Sony jointly developed the CXD1144AP high-performance digital filter LSI for digital audio equipment.

Advanced Micro Devices (AMD)
Sony and AMD agreed to a sales tie-up for Sony's workstations in South Korea.

MERGERS AND ACQUISITIONS

1991

National Broadcasting Company
Sony purchased NBC's 50 percent stake in RCA/ Columbia Home Video, resulting in Sony's complete ownership of the company.

1989

Trans Com Systems Division
Sony purchased all assets and liabilities of Trans Com Systems, a division of Sundstrand Corporation. Trans Com designed, manufactured, and installed in-flight AV entertainment systems in commercial aircraft worldwide.

Materials Research Corporation (MRC)
Sony acquired all of the outstanding shares of common stock of MRC and its affiliates. MRC manufactured and supplied sputtering and etching equipment, high-purity metals, and ceramics.

Columbia Pictures Entertainment
Sony acquired all of the outstanding shares of common stock of Columbia Pictures, which was primarily in the filmmaking business.

Guber-Peters Entertainment Company (GPEC)
Sony acquired GPEC, which was in the filmmaking business.

1988

CBS Records Inc.
Sony purchased CBS Records for U.S.$2 billion (¥256.5 billion) and held 100 percent of the shares. (The acquisition was made using U.S. currency.)

KEY OFFICERS

Akio Morita
Chairman and representative director

Norio Ohga
President and chief executive officer

Masaaki Morita
Deputy president

Nobuo Kanoi
Deputy president

Ken Iwaki
Deputy president

Tsunao Hashimoto
Deputy president

PRINCIPAL INVESTORS

Information is not available

FOUNDERS

Masaru Ilsuka
Akio Morita

Table 3
Balance Sheet
Fiscal Year Ending March 31
(Billions of U.S. Dollars)

Balance Sheet	1987*	1988	1989	1990	1991
Cash	1.0	1.6	2.3	3.2	3.1
Receivables	1.6	2.4	3.4	5.8	5.8
Marketable Securities	0.8	0.7	0.7	0.4	0.2
Inventory	1.9	2.4	3.8	4.8	5.2
Other Current Assets	0.5	0.7	1.0	1.2	1.5
Total Current Assets	5.8	7.8	11.2	15.4	15.8
Net Property, Plants	2.2	3.1	4.2	6.1	7.4
Other Assets	0.9	2.6	3.0	9.1	9.4
Total Assets	8.8	13.5	18.4	30.6	32.6
Total Current Liabilities	3.7	6.8	8.7	14.0	14.9
Long-Term Debt	0.9	1.4	1.7	4.5	4.9
Other Liabilities	0.5	0.6	0.8	2.0	2.3
Total Liabilities	5.0	8.8	11.2	20.5	22.1
Converted Preferred Stock	0	0	0	0	0
Common Stock	0.1	0.2	0.9	1.9	2.1
Other Equity	0.4	0.4	1.5	3.3	2.9
Retained Earnings	3.4	4.1	4.8	4.9	5.4
Total Shareholders' Equity	3.8	4.7	7.2	10.1	10.5
Total Liabilities and Shareholders' Equity	8.8	13.5	18.4	30.6	32.6
Exchange Rate (U.S.$1=¥)	159.56	138.03	128.25	142.93	141.21

*For the five-month period ending March 31, 1987. Effective March 31, 1987, the parent company and almost all subsidiaries and affiliates changed their fiscal year-end from October 31 to March 31. Accordingly, the fiscal period ended March 31, 1987, included only 5 months of operations, whereas other fiscal years consisted of 12 months.

Source: Sony Corporation Annual Reports
Dataquest (January 1992)

Table 4
Consolidated Income Statement
Fiscal Year Ending March 31
(Billions of U.S. Dollars, except Per Share Data)

Consolidated Income Statement	1987*	1988	1989	1990	1991
Revenue	3.4	10.4	16.7	20.1	25.6
Japanese Revenue	1.1	3.5	5.7	6.1	6.7
Non-Japanese Revenue	2.3	6.9	11.0	14.1	18.9
Cost of Sales	2.6	7.7	11.5	13.6	17.7
R&D Expense	0.8	0.9	1.1	1.2	1.5
SG&A Expense	0.8	2.4	4.4	5.0	6.3
Capital Expense	0.6	1.0	1.7	2.3	2.9
Pretax Income	0.1	0.5	1.3	1.6	1.9
Pretax Margin (%)	4.36	5.14	7.71	7.90	7.32
Effective Tax Rate (%)	58.00	56.00	56.00	54.00	51.00
Net Income	0.1	0.3	0.6	0.7	0.8
Shares Outstanding, Thousands	231,236	238,769	282,603	331,929	338,593
Per Share Data					
Earnings	0.34	1.04	1.88	2.15	2.02
Dividend	0.12	0.32	0.28	0.32	0.32
Book Value	16.50	19.71	25.57	30.50	30.88
Exchange Rate (U.S.$1=¥)	159.56	138.03	128.25	142.93	141.21

*For the five-month period ending March 31, 1987. Effective March 31, 1987, the parent company and almost all subsidiaries and affiliates changed their fiscal year-end from October 31 to March 31. Accordingly, the fiscal period ended March 31, 1987, included only 5 months of operations, whereas other fiscal years consisted of 12 months.

Source: Sony Corporation Annual Reports
Dataquest (January 1992)

Table 5
Balance Sheet
Fiscal Year Ending March 31
(Billions of Yen)

Balance Sheet	1987*	1988	1989	1990	1991
Cash	152.9	218.0	297.9	451.7	442.9
Receivables	256.6	325.7	433.4	832.9	815.1
Marketable Securities	132.2	99.4	91.1	54.8	33.5
Inventory	302.9	334.7	483.7	693.0	731.7
Other Current Assets	77.6	99.1	127.7	169.2	211.2
Total Current Assets	922.2	1,076.9	1,433.8	2,201.6	2,234.4
Net Property, Plants	343.1	426.3	544.7	868.1	1,046.8
Other Assets	145.9	363.7	386.2	1,300.4	1,321.2
Total Assets	1,411.2	1,866.9	2,364.7	4,370.1	4,602.4
Total Current Liabilities	587.0	945.0	1,119.0	1,995.9	2,104.6
Long-Term Debt	143.4	196.0	220.8	646.0	694.5
Other Liabilities	72.1	76.3	98.2	281.3	327.0
Total Liabilities	802.5	1,217.3	1,438.0	2,923.2	3,126.1
Converted Preferred Stock	0	0	0	0	0
Common Stock	12.0	23.7	114.6	278.0	296.4
Other Equity	56.5	60.9	195.6	473.4	413.5
Retained Earnings	540.2	565.0	616.5	695.5	766.4
Total Shareholders' Equity	608.7	649.6	926.7	1,446.9	1,476.3
Total Liabilities and Shareholders' Equity	1,411.2	1,866.9	2,364.7	4,370.1	4,602.4
Exchange Rate (U.S.$1=¥)	159.56	138.03	128.25	142.93	141.21

Source: Sony Corporation
Annual Reports
Dataquest (January 1992)

Table 6
Consolidated Income Statement
Fiscal Year Ending March 31
(Billions of Yen, except Per Share Data)

Consolidated Income Statement	1986	1987	1988	1989	1990
Revenue	547.8	1,431.2	2,145.3	2,879.9	3,616.5
Japanese Revenue	177.5	479.4	731.3	869.5	952.5
Non-Japanese Revenue	370.3	951.8	1,414.0	2,010.4	2,664.0
Cost of Sales	407.8	1,064.6	1,475.4	1,938.0	2,505.6
R&D Expense	131.2	127.5	142.1	165.2	205.8
SG&A Expense	131.0	336.3	565.6	712.0	887.8
Capital Expense	101.6	133.5	215.6	324.0	411.7
Pretax Income	23.6	73.5	165.5	227.4	264.6
Pretax Margin (%)	4.36	5.14	7.71	7.90	7.32
Effective Tax Rate (%)	58.00	56.00	56.00	54.00	51.00
Net Income	13.3	36.7	72.5	102.8	116.9
Shares Outstanding, Thousands	231,236	238,769	282,603	331,929	338,593
Per Share Data					
Earnings	54.2	143.8	219.7	279.0	285.9
Dividend	18.5	44.6	40.5	45.5	45.5
Book Value	0	0	0	0	0
Exchange Rate (U.S.$1=¥)	159.56	138.03	128.25	142.93	141.21

*For the five-month period ending March 31, 1987. Effective March 31, 1987, the parent company and almost all subsidiaries and affiliates changed their fiscal year-end from October 31 to March 31. Accordingly, the fiscal period ended March 31, 1987, included only 5 months of operations, whereas other fiscal years consisted of 12 months.

Source: Sony Corporation
Annual Reports
Dataquest (January 1992)

Table 7
Key Financial Ratios
Fiscal Year Ending March 31

Key Financial Ratios	1987	1988	1989	1990	1991
Liquidity					
Current (Times)	1.57	1.14	1.28	1.10	1.06
Total Assets/Equity (%)	231.85	287.39	255.17	302.03	311.75
Current Liabilities/Equity (%)	96.44	145.47	120.75	137.94	142.56
Total Liabilities/Equity (%)	131.84	187.39	155.17	202.03	211.75
Profitability (%)					
Return on Assets	0.94	2.24	3.43	3.05	2.23
Return on Equity	2.19	5.83	9.20	8.66	6.96
Profit Margin	2.43	2.56	3.38	3.57	2.84
Other Key Ratios					
R&D Spending % of Revenue	23.95	8.91	6.62	5.74	4.57
Capital Spending % of Revenue	18.55	9.33	10.05	11.25	8.96
Employees	47,583	71,000	78,900	95,600	112,900
Revenue (¥M)/Employee	11.51	20.16	27.19	30.12	32.03
Capital Spending % of Assets	7.20	7.15	9.12	7.41	7.04
Exchange Rate (U.S.$1=¥)	159.56	138.03	128.25	142.93	141.21

Source: Sony Corporation
Annual Reports
Dataquest (January 1992)