The Semiconductor Horizon: Silicon Desert or High-Tech Oasis?

October 6-8, 1994
Palm Springs, California
When it comes to semiconductors, the horizon is a hazy one. Sales and profits have been strong, but change is in the wind. Exactly what lies ahead for chip manufacturers and users? Is it a silicon desert — or the next high-tech oasis?

The semiconductor industry has been on a roll. Demand has remained strong, worldwide sales have continued to grow, and profit margins for manufacturers have held steady. But nothing lasts forever—especially in high-tech segments as fast-moving and as volatile as those in semiconductors. Emerging new applications requiring new chip designs, explosive new markets such as interactive TV, potential shortages in 4MB and 16MB DRAMs as well as logic devices, and headline-making joint ventures are all poised to toss the industry into a whirlwind of change and innovation.

For suppliers and purchasers of today's leading-edge chip technologies, it's a time for strategic positioning and planning. How will you transform tomorrow's pitfalls into opportunities for your company's growth and market leadership? Which standards, architectures, and joint ventures should you support—and which should you abandon? For which new applications should your company commit millions of dollars in new chip R&D? And how can you ensure the software support you need for your next generation of semiconductors?
Are you positioned to take advantage of tomorrow's semiconductor opportunities — or will you be left behind?

In 1994, there will be only one opportunity to gain a comprehensive, crystal-clear look at the horizon in semiconductors. It's being held on October 6-8, in beautiful Palm Springs, California. And it's an event you simply can't afford to miss.

- Prominent executives from major vendors will join Dataquest's preeminent analysts in providing hard facts, objective analysis, and bold predictions about dramatic future events in semiconductors and what they'll mean to you.
- Dataquest's latest market forecasts will highlight the hottest future areas of growth in semiconductors as well as pricing and distribution issues — and how both suppliers and users alike can optimize their success in these "hot spots!"
- Informative panels and sessions will cover key trends and emerging applications in the marketplace today and tomorrow, including future semiconductor contract manufacturing strategies, wireless communications, PC architectures, and multimedia delivery methods.

To help celebrate 20 years of semiconductor industry expertise, Dataquest invites you to join us at our Semiconductor Celebrity Golf Tournament featuring celebrity guest and PGA pro Bob Rosburg. Tee off is Saturday, October 8! A portion of the proceeds from this benefit tournament will be donated to the Institute of International Education. We've also put together some exciting day activities during the conference for spouses looking for some fun in the sun in Palm Springs.

See registration page for details on Semiconductor Celebrity Golf Tournament and other activities.
AGENDA

**day One**

**October 6**

7:00 am - 8:15 am  
Registration and Continental Breakfast

8:15 am - 8:45 am  
Welcome and Conference Overview

8:45 am - 9:00 am  
President's Remarks  
Judith H. Hamilton, President and CEO, Dataquest

9:00 am - 9:45 am  
Keynote Address  
Gary L. Tooker, Vice Chairman, CEO, Motorola, Inc.

9:45 am - 10:15 am  
The Semiconductor Outlook: Where are the Surprises?  
Gene Norrett, Corporate Vice President and Director, Semiconductor Group, Dataquest

10:15 am - 10:45 am  
Coffee/Networking Break

10:45 am - 12:15 pm  
Food Chain Forecasts: The Dataquest Vision  
MPRs and MPUs  
MCUs  
Memories  
ASICs  
Analog and Mixed-Signal ICs  
Pricing Trends  
Capital Spending/Equipment Forecasts  
Asia/Pacific Markets and Forecast

12:15 pm - 2:00 pm  
Luncheon

2:00 pm - 2:30 pm  
Solutions for the 10+ Million Transistor Chip  
Walden C. Rhines, President and CEO, Mentor Graphics Corporation

2:30 pm - 4:30 pm  
FORUM  
PC 2000: Chaos or Control

6:00 pm  
Cocktails and Barbecue
Solutions for the 10+ Million Transistor Chip
Walden C. Rhines, President and CEO, Mentor Graphics Corporation

What will be the future trends in design methodologies and tools necessary to create the most advanced chips of tomorrow.

PC 2000: Chaos or Control
Moderator:
Jerry Banks, Director/Principal Analyst, Microcomponents Service, Dataquest

Panelists:
George N. Alexy, Senior Vice President, Marketing, Cirrus Logic, Inc.
Hugh Barnes, Senior Vice President, General Manager, Portable PC Division, Compaq Computer Corporation
Speaker to be announced, IBM
D. Craig Kinnie, Corporate Vice President and Director, Intel Architecture Development Laboratories, Intel Corporation
Carl Stork, Director, Windows Platform Definition and Business Development, Microsoft Corporation

The destiny of the semiconductor industry is inextricably linked to the destiny of the PC. What will the PC of the future look like—and how can your business share in its success? Our experts will debate a number of wide-ranging possibilities in this interactive forum.

- What controls the future destiny of PCs—hardware or software?
- Can the x86 architecture outrun RISC—or does it even matter?
- Which microprocessor vendors can afford to support multiple architectures?
- Who will demand higher performance in a PC—the home or office user?
- Are we entering an era of software consolidation with only two or three major operating systems? How will that influence microprocessor buying decisions? Which horse will you put your money on?
Welcome and Day Two Overview
Joseph Grenier, Vice President, Semiconductor Manufacturing, Applications, and Procurement Group, Dataquest

Wireless Communications: The Second Revolution Unfolds
Moderator:
Gregory L. Sheppard, Director/Principal Analyst, Semiconductor Application Markets (SAM) Worldwide, Dataquest

Panelists:
Emmett B. Hume, Senior Vice President, Strategic Marketing and Business Development, Nationwide Wireless Network (NWN)
Speaker to be announced, Nokia
D. Tony Stelliga, Vice President, General Manager, Telecom Products Division, LSI Logic Corporation
Michael J. Hames, Vice President, Semiconductor Group, Worldwide DSP Manager, Texas Instruments
Robert S. Sellinger, Director, PCS, AT&T Network Wireless Systems

According to some estimates, more than a half-billion people worldwide will be communicating over wireless links by the year 2005. How will we get there from here? This informative forum examines the semiconductor opportunities for companies like yours in PCMCIA cards, handsets, and associated technologies.

- What is the projected ramp-up for digital cellular standards?
- What form will the new PCS/PCN technologies and services take—and what are their rollout plans?
- What kinds of chips will the personal communicators of the future require?
- Will one or two data communications standards become mainstream? What will that mean to you?

Future Manufacturing Strategies: Make or Buy?
Moderator:
Clark J. Fuhs, Senior Industry Analyst, Semiconductor Equipment, Manufacturing, and Materials Service, Dataquest

Panelists:
David N. K. Wang, Senior Vice President, Worldwide Business Operations, Applied Materials, Inc.
John T. Dickson, Vice President, Integrated Circuits, AT&T Microelectronics
Koichi Nishimura, Ph.D., President and CEO, Solectron Corp.
Donald W. Brooks, President, TSMC
Bernard V. Vonderschmitt, President and Co-Founder, Xilinx, Inc.

Contract manufacturing is strengthening its foothold in the semiconductor industry as more companies seek strategies for optimizing profitability and market success. Yet the success of a semiconductor company can ride on the relationship with its outsourcer partner.
Welcome & Conference Overview
Gene Norrett, Corporate Vice President and Director, Semiconductor Group, Dataquest

President's Remarks
Judith H. Hamilton, President and CEO, Dataquest

Keynote Address
Gary L. Tooker, Vice Chairman and CEO, Motorola, Inc.
The impact of tomorrow's wireless communications capabilities on business, society, and each of our individual lives promises to be enormous. Mr. Tooker will give us an insider's look at the next 10 years in wireless communications and the ramifications on the entire electronics food chain, from semiconductors to components to systems. He'll also discuss the emerging wireless service industry.

The Semiconductor Outlook: Where are the Surprises?
Gene Norrett, Corporate Vice President and Director, Semiconductor Group, Dataquest
What are the overall market rankings in the semiconductor industry today? Who's winning and who's losing? Shipments of memories, microprocessors, and more—where do they stand, and where are they heading? Mr. Norrett will present Dataquest's overview of the industry.

Food Chain Forecasts: The Dataquest Vision
Dataquest's annual forecasts, predictions, and analyses on various segments of the semiconductor market. Known for their strong opinions and accurate forecasts, our analysts will tell you what's hot, what's not, and what promises to be at the center of tomorrow's new markets.

MPUs and MPUs
Kenneth A. Lowe, Director/Principal Analyst, Microcomponents Service

MCUs
Jerry Banks, Director/Principal Analyst, Microcomponents Service

Memories
Jim Handy, Director/Principal Analyst, MOS Memories

ASICs
Bryan Lewis, Senior Industry Analyst, ASIC Worldwide

Analog and Mixed-Signal ICs
Gary J. Grandbois, Director/Principal Analyst, Semiconductors Worldwide

Pricing Tends
Mark Giudici, Director/Principal Analyst, Semiconductor Procurement Service
day Two
October 7
7:00 am - 8:15 am  Continental Breakfast
8:15 am - 8:30 am  Welcome and Day Two Overview
8:30 am - 10:30 am  FORUM  Wireless Communications: The Second Revolution Unfolds
10:30 am - 11:00 am  Coffee/Networking Break
11:00 am - 12:30 pm  FORUM  Future Manufacturing Strategies: Make or Buy?
12:30 pm - 2:00 pm  Luncheon and Featured Speaker  Funding Opportunities Along the Superhighway  William R. Hambrecht, Founding Partner, Chairman, and Co-CEO, Hambrecht & Quist Group
2:00 pm - 2:30 pm  Can the Chip Market Live without the PC?
2:30 pm - 4:30 pm  FORUM  PCs vs. TVs: Catering to the Couch Potato
4:30 pm  Conference Ends

day Three
October 8
6:45 am  Clinic with PGA pro Bob Rosburg
7:30 am  Dataquest’s Semiconductor Celebrity Golf Tournament with Bob Rosburg  Marriott’s Desert Springs Golf Course
This fact-filled forum explores the following questions:

- Who’s using foundries for semiconductor contract manufacturing—and how have the relationships evolved?
- How can manufacturing capacity and design security be ensured to eliminate potential capacity shortages?
- How can you grow a fabless business that gains market share?
- Will the outsourcing business grow to adequately support niche companies specializing as foundries?

**Funding Opportunities Along the Superhighway**

William R. Hambrecht, Founding Partner, Chairman, Co-CEO, Hambrecht & Quist Group

Venture capital and specifically Hambrecht & Quist has played a vital role in the growth of the semiconductor and electronics industry. With the advent of the information superhighway, there are a number of ways to invest in these opportunities. Mr. Hambrecht will give us his insights into the companies that are on the superhighway fast track.

**Can the Chip Market Live Without the PC?**

Gregory L. Sheppard, Director/Principal Analyst, Semiconductor Application Markets (SAM) Worldwide, Dataquest

Dale L. Ford, Industry Analyst, Semiconductor Application Markets (SAM) Worldwide, Dataquest

You may have the greatest semiconductor technology in the world, but if there’s weak demand for it, you’ll undoubtedly fail. Here, two Dataquest experts will take a crystal-ball look at the applications that will fuel semiconductor sales in the future. Where is tomorrow’s hottest niche applications growth and how can you capitalize?

**PCs vs. TVs: Catering to the Couch Potato**

Moderator:

Jim Handy, Director/Principal Analyst, MOS Memories, Dataquest

Panelists:

Geoffrey S. Roman, Vice President, Technology and New Business Development, General Instrument Corporation

Doug Dunn, Chairman and CEO, Philips Semiconductors

Ichiro Fujita, Vice President, Systems Application Engineering, and General Manager, Microcomputer Semiconductor Business Unit, NEC Electronics Inc.

Robert Luff, Chief Technical Officer, Broadband Communications Group, Scientific-Atlanta, Inc.

Larry Thorpe, Vice President of Advanced Dev., Sony Electronics

Theodore M. Hoff, Senior Vice President and General Manager, Fox Interactive

The PC vs. TV “battle for interactivity” promises to be one of the most explosive new market dramas as we head into the 21st century. Which will drive and control television’s future interactivity functions—the PC or the TV? In short, does your semiconductor company sell to a Compaq or a Sony? Do not miss this forum!

- What’s happening with content providers and content deliverers?
- Which standards will emerge—and why?
- Will PCs and cable boxes merge into a hybrid?
- Price, ease of use, and the consumer’s comfort zone—how vital will these be to your future success?
CELEBRITY GOLF

Designed by Ted Robinson, Marriott's sweeping Desert Springs Golf Course is the host of the annual Frank Sinatra Celebrity Golf Tournament. It's also the site of our Semiconductor Celebrity Golf Tournament on Saturday, October 8, featuring PGA pro and ABC golf commentator, Bob Rosburg. Join us for a day of relaxation on one of Palm Springs' most prestigious courses!

Help your game with tips from a pro and you'll help foster international relations, too!

We're happy to announce that a portion of the proceeds from the Semiconductor Celebrity Golf Tournament will be donated to the Institute of International Education on behalf of Dataquest and Marriott's Desert Springs Resort & Spa. Based in New York City, the Institute is the United States' largest nonprofit educational and cultural exchange agency.

Saturday, October 8:
6:45 am – Clinic with Bob Rosburg
7:30 am – Tee off

Green fees, shared cart, luncheon, and prizes – $245

Plus....

Your opportunity to shoot a hole-in-one and drive away in a brand new Mazda Miata Convertible!

Spouse Programs for Sight-Seeing and Star-Gazing!

Celebrate our 20th Annual Semiconductor Conference by bringing your spouse for some fun in the sun. Each day offers an exciting, action-filled program for those not attending the conference!

Aerial Tramway and Desert Star Search

Includes tram ascent with breathtaking views from 8,500-foot Mt. San Jacinto. You'll also "star gaze" by the homes of Bob Hope, Marilyn Monroe, Elvis Presley, and many more!
October 6, 9:00 am—1:00 pm, $38 (Program A)

Palm Springs Desert Museum and Shopping

Includes tour of an exquisite museum highlighting the best in visual arts, performing arts, and natural sciences. And wait until you try the shopping along Palm Canyon Drive!
October 7, 9:30 am—1:00 pm, $32 (Program B)
Registration by FAX: please complete this form and fax to (805) 298-4388 or mail it to the address below. Your confirmation will be sent to you by mail. (For additional conference registrations, please copy this form.)

Please print or type clearly to ensure correct spelling on conference materials.

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<th>Last Name</th>
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### Registration Fees:

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<tr>
<td>Conference Early Bird Rate</td>
<td>$1,075</td>
<td>$1,255</td>
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<td>After Sept. 9, 1994</td>
<td>$1,195</td>
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<th>Transcripts</th>
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<td>Non-Attendee</td>
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### Optional Programs

- Semiconductor Celebrity Golf Tournament: $245
- Spouse Program A: $38
- Spouse Program B: $32
- Spouse Dinner: $70

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<th>Group Rate</th>
<th>Register three and receive a fourth registration free — compliments of Dataquest.</th>
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<td>Note:</td>
<td>Payment must be received by September 9, 1994 to qualify for the Early Bird Discount.</td>
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<td>All payments must be received prior to conference.</td>
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<td>Call us at (714) 476-9117 to find out how your tournament fee may be tax deductible.</td>
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<td>If minimum of 25 is not met on each spouse program, program may be cancelled.</td>
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**Method of Payment:**

- Purchase Order #
- Check by mail
- MasterCard | American Express | Visa

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### Cancellation Policy:

Cancellations received up to two weeks prior to the conference date are subject to a $100.00 cancellation fee. Cancellations received within two weeks of the conference date are subject to payment in full. Substitutions may be made in writing up to one week prior to the conference. Nonattendance is subject to full payment.

### Hotel Information:

Marriott's Desert Springs Resort & Spa, 74855 Country Club Drive, Palm Desert, CA 92260

For accommodations, contact reservations at: Tel: (619) 341-2211 or (800) 228-9290

Rooms are limited, so please call or fax the hotel reservations desk as soon you register for the conference. Mention that you are with the Dataquest Conference for special rate.

### Conference Registration Desk:

Toll Free (U.S.): 800 • 457 • 8233 Fax: 805 • 298 • 4388 Tel: 805 • 298 • 3262

Make checks payable to Market Makers and send to: Dataquest Incorporated 26524 Golden Valley Road, Suite 401, Santa Clarita, CA 91350
Worldwide Offices

1290 Ridder Park Drive
San Jose, California  95131-2398
Tel: (408) 437 8000
Fax: (408) 437 0292

3990 Westerly Place, Suite 100
Newport Beach, California  92660
Tel: (714) 476 9117
Fax: (714) 476 9969

550 Cochituate Road
P.O. Box 9324
Framingham, Massachusetts  01701-9324
Tel: (508) 370 5555
Fax: (508) 370 6262

Holmers Farm Way
High Wycombe
Bucks County HP12 4XH England
Tel: (44494) 422722
Fax: (44494) 422742

Shinkawa Sanko Building 6th Floor
1-3-17 Shinkawa
Chuo-ku, Tokyo  104, Japan
Tel: (81) 3 5566 0411
Fax: (81) 3 5566 0425

Kronstadter Strasse 9
8000 München 80, Germany
Tel: (4989) 930 9090
Fax: (4989) 930 3277

Tour Franklin
Cedex 11
92042 Paris la Défense, France
Tel: (33141) 25 1800
Fax: (33141) 25 1818

Suite 3806, Trade Tower
159 Samsung-dong
Kangnam-gu, Seoul  135-729, Korea
Tel: (822) 551 1331
Fax: (822) 551 1330

Dataquest
a company of
The Dun & Bradstreet Corporation
SEMICON/West Seminar—Status 1994

Dataquest Seminar
July 20, 1994
San Francisco Marriott
San Francisco, California
TABLE OF CONTENTS

Agenda
Conference Evaluation
Attendees
Presentations
SEMICON/West Seminar—Status 1994
San Francisco Marriott, 55 Fourth Street
San Francisco, California
July 20, 1994

7:30-8:00 a.m. Registration and Continental Breakfast ........................................ Foyer

8:00 a.m. Welcome ........................................................................................................ Buena Vista Room
Joseph Grenier
Vice President, Semiconductor Manufacturing and Applications Service
Semiconductors Group
Dataquest Incorporated

8:10 a.m. Wafer Fab Equipment Forecast: How Long Will the Boom Last? ....... Buena Vista Room
Clark Fuhs
Senior Industry Analyst, Semiconductor Equipment, Manufacturing, and Materials Service
Semiconductors Group
Dataquest Incorporated

8:40 a.m. The Interplay between IC Process Trends and Advanced Equipment .... Buena Vista Room
Calvin Chang, Ph.D.
Industry Analyst, Semiconductor Equipment, Manufacturing, and Materials Service
Semiconductors Group
Dataquest Incorporated

9:10 a.m. Semiconductor Fabs: Why, Where, and What? ......................................... Buena Vista Room
Nader Pakdaman
Senior Industry Analyst, Semiconductor Equipment, Manufacturing, and Materials Service
Semiconductors Group
Dataquest Incorporated

9:40-10:00 a.m. Break ........................................................................................................ Foyer

10:00 a.m. Chips, Chips, and More Chips—Toward a $200 Billion IC Market ...... Buena Vista Room
Ron Bohn
Senior Industry Analyst, Memories Worldwide
Semiconductors Group
Dataquest Incorporated

10:30 a.m. PC and Mobile Computing: What’s Hot for the Desktop? ................. Buena Vista Room
Philippe de Marcillac
Director and Principal Analyst, Personal Computers Worldwide
Computer Systems and Peripherals Group
Dataquest Incorporated

11:00 a.m. Semiconductor Market Opportunities in China—Will China Become the Next Asian Semiconductor Power? .......... Buena Vista Room
Jingsheng Huang
Market Research Analyst
Research Operations Group
Dataquest Incorporated

11:30 a.m. Seminar Concludes
Thank you for attending SEMICON/West 1994. Your thoughts and comments regarding this event are an important part of our process to continually improve the value provided through our seminar program. Please help us by taking a few moments to complete this questionnaire.

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Where did you originally hear about this seminar?  ○ Brochure  ○ Fax  ○ Telephone  ○ Other ________

How satisfied are you overall that the seminar met these objectives:

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<th>not very satisfied</th>
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What topics/issues would you like to see addressed at future seminars? Please list.

General Comments:

...
Please evaluate the sessions by circling your rating:

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<tr>
<td>Jingsheng Huang</td>
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</table>
Attendees

ABN AMRO Bank, N.V.
Bob Hartinger
Group Vice President
Case Lebbeus
Vice President

ACSI, Inc.
Richard Brewer
President, CEO

AG Associates/CVD
Donald Yoshikawa
Marketing Manager

Analog Devices, Inc.
Cate Thomas
Director, Strategic Programs

Anderson DeBartolo Pan
Stewart Startt
Marketing Director

Applied Materials
Cheryl Blalock
Purchasing Manager
Dana Ditmore
President, North America
Steve Lindsay
President, Applied Materials Europe
Michael Musson
Director, Investor Relations
Edith Ong
Technology Program Director
Katherine Pilewskie
Senior Industry Analyst
Deborah Robinson
Market Analyst
Richard Tauber

ASM Lithography
Jim Greeneich
Vice President, Strategic Marketing
Franki D’Hoore
Strategic Marketing Manager

Bank of America
Steve Parry
Vice President

Bank of Boston
Mary Frances Galligan
Director
Lee Merkle
Assistant Vice President
Debra Staiger
Assistant Vice President

Bank of California
Bill Bloore
Assistant Vice President

Canon, Inc.
Ogiso Mitsuoshi
General Manager

Cisco Systems, Inc.
Robert Vellios
Commodity Specialist

Comdisco Electronics Group
Steven Grundon
Executive Vice President
Paul Edstrom
Director of Technology
Douglas Fritch
Assistant Credit Manager
Michael Herman
President
Michael Mardesich
Director of Technology

Computer Reseller News
Greg Quick
Sr. Editor

Concept Systems Design, Inc.
Alan Carbonaro
Vice President
Jim Mezey
President
Chuck Smith

Cupertino National Bank
Tom Jorgensen

Daifuku U.S.A., Inc.
Ron Smith
Assistant Manager

Dataquest Incorporated
Ron Bohn
Senior Industry Analyst, Memories
Worldwide, Semiconductors Group
Calvin Chang, Ph.D.
Industry Analyst, Semiconductor
Equipment, Manufacturing, and
Materials Service, Semiconductor
Group
Philippe de Marcillac
Director and Principal Analyst,
Personal Computers Worldwide,
Computer Systems and Peripherals
Group
Clark Fuhs
Senior Industry Analyst, Semicon-
ductor Equipment, Manufacturing,
and Materials Service, Semiconduc-
tors Group
Joseph Grenier
Vice President, Semiconductor
Manufacturing and Applications
Service, Semiconductors Group
Jingsheng Huang
Market Research Analyst, Research
Operations Group
Nader Pakdaman
Senior Industry Analyst, Semi-
 conductor Equipment, Manufacturing,
and Materials Service, Semiconduc-
tors Group

Daymarc
Kevin Brennan
Product Manager

Demer IR Counsel
Robin Mechlowitz
Consultant

Disco Hi-Tec America
Marc Caltabiano
Product Specialist
Tommy Weiss
Marketing Manager

Dow Corning Corporation
Keith Michael
Manager, Electronics Business

SEMICON/West Seminar—Status 1994
Attendees

Dupont Polymers
Greg Pfister
Industry Manager

E.T. Systems, Inc.
Dale Scott
Vice President/General Manager

Eaton Corporation
Robert Klimm
General Manager

Edwards High Vacuum Intl.
Robert Adams
Vice President of Marketing

EKC Technology Inc.
Gene Goebel
Vice President

Electronic Business Asia
Tom McHale

Empak International
Bob Hays
Vice President, Sales and Marketing

ESI
Russell Schlager
Product Marketing Manager

ESTEK Corp.
Gene Bates
Director Marketing

Etec Systems, Inc.
Gary VanNice
Product Marketing Manager

FSI International
 Roxanne Johnson
Sales Forecast Analyst
Laureen Walker
Marketing Manager

Fusion Semiconductor
John Matthews
Vice President

Gasonics, Inc.
Lou Perrone

GE Capital
Brian Comay
Account Executive
Carmen Gellineau
Market Analyst
Richard Gumbrecht
Jane Holland
Manager-High Tech Assets
Keith Kaseta
Portfolio Administration Rep.
Benjamin Lu
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Prior to joining Dataquest, Mr. Grenier was Product Marketing Manager at GCA Corporation where he managed marketing activities for the reactive ion etch program. He was also International Marketing Manager at GCA and was responsible for the overseas marketing of wafer-processing equipment. Previously, he worked as a Product Manager at Varian Associates/Instrument Division, as a Systems Engineer at the USAF Satellite Test Center, and as a Test Engineer at General Motors’ Noise Vibration Laboratory.

Mr. Grenier received a B.S.E.E. degree from the University of Detroit and an M.B.A. degree from the University of Santa Clara.
Mr. Fuhs is a Senior Industry Analyst for Dataquest's Semiconductor Equipment, Manufacturing, and Materials service in the Semiconductors group. He is responsible for research and analysis of semiconductor materials and trends in IC manufacturing techniques along with forecasting capital spending and the wafer fab equipment market.

Prior to joining Dataquest, Mr. Fuhs was Strategic Marketing Manager for Genus Inc., a manufacturer of advanced chemical vapor deposition (CVD) and high energy ion implantation equipment. During his 10 years at Genus, he held positions of Product Manager, several responsibilities in Product Marketing, and Process Engineer in the metal CVD group. In his most recent position, Mr. Fuhs was responsible for correlating process techniques with demand for equipment and materials. He has been involved with the Modular Equipment Standards Committee of SEMI, a trade organization, as chairman of a task force, authoring a standard. His experience also includes Chevron Oil, where he was a Process Engineer in the Richmond, California, refinery responsible for the hydrogen manufacturing plant.

Mr. Fuhs earned a B.S. degree in Chemical Engineering from Purdue University in West Lafayette, Indiana, and received an M.B.A. degree from the University of California at Berkeley.
Wafer Fab Equipment Forecast: How Long Will the Boom Last?

**Agenda**
- Semiconductor production
- Capital spending trends and drivers
- Wafer fab equipment forecast
- Has underinvestment been corrected?
- Enter the 200mm wafer era

**Estimated Semiconductor Production Worldwide**

<table>
<thead>
<tr>
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<td>160</td>
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</table>

Source: Dataquest
Wafer Fab Equipment Forecast: How Long Will the Boom Last?

Regional Semiconductor Production Trend

<table>
<thead>
<tr>
<th>Region</th>
<th>1993 Production</th>
<th>1998 Production</th>
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<tbody>
<tr>
<td>Asia-Pacific/ROW</td>
<td>$87.7 Billion</td>
<td></td>
</tr>
<tr>
<td>Europe</td>
<td>11%</td>
<td>11%</td>
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<tr>
<td>North America</td>
<td>41%</td>
<td>42%</td>
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<tr>
<td>Japan</td>
<td>39%</td>
<td>36%</td>
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</tbody>
</table>

Source: Dataquest

Capital Spending Summary

- Worldwide growth of 36.6 percent
- Asia/Pacific and Japan leading the way
- Japanese companies
  - Investing heavily despite the domestic economy
  - Filling the empty buildings with equipment
- North American investment sustained
- Second-tier companies participating in every region
Wafer Fab Equipment Forecast: How Long Will the Boom Last?

Capital Spending Drivers

- DRAMs, DRAMs, and DRAMs
  - Korean spending up 75 percent
  - Incremental Japanese spending concentrated on 16Mb DRAM
- Foundry capacity
  - Evolution of dedicated contract manufacturing
  - Taiwan and Singapore spending triples to $1.2 billion
- Logic/ASIC demand spurring North American strength
- Second-tier company profitability

Top 10 Capital Spenders in 1994

<table>
<thead>
<tr>
<th>1994 Rank</th>
<th>1993 Rank</th>
<th>1994 Projected Spending ($M)</th>
<th>Percentage Change from 1993</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>1</td>
<td>2,300</td>
<td>35</td>
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<tr>
<td>2</td>
<td>2</td>
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<td>9</td>
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<td>780</td>
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<td>10</td>
<td>9</td>
<td>750</td>
<td>56</td>
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</table>

Source: Dataquest
Wafer Fab Equipment Forecast: How Long Will the Boom Last?

Regional Capital Spending Summary

1994 Regional Capital Spending

By Base of Company

By Region of Spending

Source: Dataquest

SEMICON/West Seminar—Status 1994
1994 Wafer Fab Equipment Market Summary

- Completed a strong year 1993—up 35%
- This year will be stronger
- Forecasting growth of 37 percent in a range of 35 to 45
- DRAM-sensitive segments will be favored
  - Steppers and track
  - Tube CVD
  - High voltage and high current implant
  - Polysilicon etch
  - Diffusion

Source: Dataquest

Regional Wafer Fab Equipment Summary

Percentage Growth

Source: Dataquest
Wafer Fab Equipment Forecast: How Long Will the Boom Last?

Fastest-Growing Equipment Segments in 1994

<table>
<thead>
<tr>
<th>Equipment Type</th>
<th>Percentage Growth</th>
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<tbody>
<tr>
<td>High-Voltage Implant</td>
<td>80%</td>
</tr>
<tr>
<td>CMP</td>
<td>70%</td>
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<tr>
<td>High-Current Implant</td>
<td>60%</td>
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<tr>
<td>Steppers</td>
<td>50%</td>
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<tr>
<td>Wafer Inspection</td>
<td>40%</td>
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</table>

Source: Dataquest

Worldwide Wafer Fab Equipment Forecast

<table>
<thead>
<tr>
<th>Year</th>
<th>Billions of Dollars</th>
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<tbody>
<tr>
<td>1988</td>
<td>4.5</td>
</tr>
<tr>
<td>1989</td>
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<td>1998</td>
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Source: Dataquest
Wafer Fab Equipment Forecast: How Long Will the Boom Last?

Wafer Fab Equipment: Year-to-Year Percentage Changes

Percentage Year-to-Year Growth

<table>
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<tr>
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<td>-20</td>
<td>-10</td>
<td>-20</td>
<td>-30</td>
</tr>
</tbody>
</table>

Source: Dataquest

Wafer Fab Equipment Market by Region

Percentage of Equipment Market

<table>
<thead>
<tr>
<th></th>
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<tr>
<td>Japan</td>
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<td>60</td>
<td>50</td>
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<td>North America</td>
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<td>-50</td>
<td>-60</td>
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<td>-80</td>
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<tr>
<td>Asia/Pacific-ROW</td>
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Source: Dataquest

SEMICON/West Seminar—Status 1994
Wafer Fab Equipment Forecast: How Long Will the Boom Last?

Equipment Segment Trends and Forecast

<table>
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<td>Deposition</td>
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<td>20</td>
<td>20</td>
<td>20</td>
<td>20</td>
<td>20</td>
<td>20</td>
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<td>Process Control</td>
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</tbody>
</table>

Source: Dataquest

Wafer Fab Equipment Forecast: Summary

<table>
<thead>
<tr>
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<tbody>
<tr>
<td>Wafer Fab Equipment ($M)</td>
<td>9,463</td>
<td>10,660</td>
<td>10,132</td>
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<tr>
<td>Growth (Percent)</td>
<td>37</td>
<td>13</td>
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<tr>
<td>Regional Growth (Percent)</td>
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</tr>
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<td>29</td>
<td>8</td>
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<tr>
<td>Japan</td>
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<td>Europe</td>
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<td>-4</td>
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<tr>
<td>Asia/Pacific-ROW</td>
<td>72</td>
<td>18</td>
<td>-10</td>
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</tbody>
</table>

Source: Dataquest
Overinvestment versus Underinvestment: Methodology

- Objective: quantify degree of capacity constraint/excess
- Long-term growth rates for semiconductors and wafer fab equipment are correlated
- Industry cycles through over- and underinvestment
- Net cumulative investment equals zero over time
- Model developed correlating historical information
  - Results presented are calculations from established forecast
  - No predictive component from this methodology included in forecast model

Dollar Value Over- and Underinvestment in Equipment

<table>
<thead>
<tr>
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<td>500</td>
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<td>1,500</td>
</tr>
</tbody>
</table>

Source: Dataquest

SEMICON/West Seminar—Status 1994
Wafer Fab Equipment Forecast: How Long Will the Boom Last?

**Over- and Underinvestment as a Percentage of Equipment Market**

Source: Dataquest

**Net Dollar Value Investment: 37% versus 45% Equipment Growth in 1994**

Source: Dataquest
Wafer Fab Equipment Forecast: How Long Will the Boom Last?

**Wafer Size Distribution Forecast:**
200mm Ramp Becomes Reality

- **1993 Wafer Area**
  - 200mm: 4%
  - 150mm: 49%
  - <125mm: 17%

- **1998 Wafer Area**
  - 200mm: 25%
  - 150mm: 46%
  - <125mm: 8%

Source: Dataquest

Test/Monitor Wafers Seeing Higher Use as 200mm Diameter Increases

- Percentage Silicon Area

Source: Dataquest

SEMICON/West Seminar—Status 1994
Summary

- 1994 will be the peak growth year for equipment
- DRAM expansion frenzy is in full swing
- Asia/Pacific and Japan are leading the way
- Momentum will mean growth in 1995
- By the end of the year, semiconductor manufacturers will be at least $1.1 billion overinvested in equipment
- Look for a modest decline in 1996 with a flat 1997
- Next spending cycle starts in late 1997 into 1998

Acknowledgments

- Kunio Achiwa
- Terrance A. Birkholz
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- Joe Grenier
- Dan Heyler
- Sarah Jacob
- Mario Morales
- Nader Pakdaman
- Yoshihiro Shimada
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Mr. Chang earned B.S. degrees, with distinction, in Physics, Mathematics, and Computer Science from the University of Washington and a Ph.D. in Materials Science and Engineering with a minor in Electrical Engineering from Stanford University (Summer 1994).
The Interplay between IC Process Trends and Advanced Equipment

IC Process Trends...

- Common technology drivers
  - Lithography
  - High-density etch
  - Wafer size
  - Mix-and-match manufacturing
- Technology roadmap divergence
  - Microprocessors
  - DRAM

...and Equipment Trends

- Performance
  - Process specifications
- Cost of ownership
  - Equipment cost
  - Productivity: throughput and yield
  - Reliability
  - Maintenance
  - User-friendliness: software
The Interplay between IC Process Trends and Advanced Equipment

Lithography

Feature Size (Microns)

- Research
- Prototype
- Early Production
- First Shrink
- Main Production
- Late Cycle
- Small-Volume
- High End

Source: Dataquest

Lithography Will Be I-Line and Some Deep-UV

Units

G-Line

I-Line

Excimer/Deep-UV

Source: Dataquest

SEMICON/West Seminar—Status 1994
The Interplay between IC Process Trends and Advanced Equipment

High-Density Plasma Is the Way of the Future for Dry Etch

- High-density plasma reactors
  - Low-pressure, high ion density
  - ECR, Helicon, TCP, ICP, HRe
  - Selectivity and microloading
  - Poly etch: DRAM applications
  - Oxide and metal etch: logic applications

- System issues
  - Higher equipment cost
  - Software sells equipment

Mix-and-Match Manufacturing Is a Viable Cost-Control Solution

- Realistic solution to abating escalating equipment costs
  - Lithography: a key strategy with growing implementation
  - Etch: high-density and low-density etch

- Mix:
  - High-end equipment for critical processes
  - A combination of high-end and lower-cost equipment
**The Interplay between IC Process Trends and Advanced Equipment**

**Match Is Essential to Mix-and-Match**
- Match: equipment compatibility
  - Lithography: alignment and field size
  - Etch: environmental
  - User-specific "matchability" information

**Next Wafer Size Is Critical for the Future of the Equipment Industry**
- Wafer sizes
  - 300mm (+ 125%) → 400mm (+ 300%)?
  - 350mm (+ 200%)?
- There is no consensus
  - Consensus among equipment, materials suppliers, and device manufacturers a must
The Interplay between IC Process Trends and Advanced Equipment

Next Wafer Size? Who's Going to Pay for It?

- Costs/risks/benefits analysis
  - Wafer costs, process uniformity, equipment development
  - Benefits: larger die and more units per wafer
- Equipment development
  - Development will be long and costly
  - Multinational organization of industry consortia taking leadership
  - Cost sharing

Microprocessor and DRAM Have Different Technology Requirements

- Microprocessor/logic
  - Multilevel interconnection
  - Planarization, metallization material and processes
- DRAM
  - Capacitor structure and dielectric materials
The Interplay between IC Process Trends and Advanced Equipment

**Microprocessor Roadmap**

- Multilevel interconnection
  - Driving forces
    - Increasing device packing density
    - Signal routing: performance
- Planarization
  - Limited by lithography depth of focus
  - Decoupling local from global planarization

**Local Planarization Is Filling Gaps**

- Local planarization: gap fill
  - Dep/etch/dep
  - SOG and new SOG
  - HDP oxide (simultaneous dep/etch)
  - APCVD/SACVD oxide
- New materials
  - Material properties
    - Moisture resistance, breakdown voltage, low dielectric constant
The Interplay between IC Process Trends and Advanced Equipment

Global Planarization Is by CMP... and Some SOG?

- Chemical mechanical polishing (CMP)
  - Critical technology enabler
  - Explosive growth potential
    - Equipment sales grew by 160% in 1993
    - Few vendors
  - In production but technical problems abound
    - Process characterization and calibration
    - End-point detection, pad conditioning, slurries
    - Process ownership currently resides with device manufacturers

- SOG beyond 0.5-micron?

Metallization Will Likely Be PVD with CVD Gaining Greater Interest...

- Interconnect deposition
  - Hot or reflow PVD Al/Si/Cu metallization
- Barrier and adhesion layer
  - Step coverage at 0.35-micron and below
    - CVD TiN and Ti
- Contact/via plugs
  - CVD W
... and Some Using Copper?

- Copper
  - Still in research stage
  - Complex processing issues
    - Diffusion barrier
    - No dry etch
  - Process development cost

Intermetal Dielectric—Will It Still Be Oxide?

- Oxide is robust except dielectric constant
  - Other materials?
    - Parylene, polyimide, teflon
- Damascene process
  - More oxide etch and less metal etch
  - Less metal patterning, less ARC
  - Oxide etch becomes more critical
    - Selectivity, etch stop required?
    - Microloading, pattern sensitivity
Besides CD, DRAM Roadmap Is Mostly about Capacitor Material and Structure

- Dielectric materials
  - High dielectric constant is a must at 256Mb
  - Process feasibility
- Capacitor cell structure
  - Stacked capacitor is primary design for 16Mb and beyond

Other DRAM-Sensitive Technologies

- Vapor phase cleaning
- WSiₓ CVD
  - DCS replaces silane
    - Step coverage and lower fluorine content
- High-voltage implant at 0.5-micron and beyond
  - Retrograde wells
  - Buried layer
Dataquest Conclusions

- Equipment trends today and the future
  - Performance and cost-of-ownership
- Cost control: mix-and-match moves beyond lithography
- Wafer size: looking for leadership
- Roadmap divergence: MPU/DRAM
- MPU/logic/ASIC: planarization and metallization
- DRAM: capacitor structure and dielectric materials
Mr. Pakdaman is a Senior Industry Analyst for Dataquest's Semiconductor Equipment, Manufacturing, and Materials service in the Semiconductors group. He is responsible for research and analysis of semiconductor equipment and trends in IC manufacturing techniques with a specific focus on the lithography segment.

Prior to joining Dataquest, Mr. Pakdaman was at IBM T.J. Watson Research Center and IBM East Fishkill. His responsibilities included fast optoelectronic testing and qualification of advanced optical lithography systems.

Mr. Pakdaman has B.S. degrees in Mathematics and Physics and an M.S. degree in Electrical Engineering from Purdue University. He was a doctoral candidate at Columbia University in Applied Physics prior to joining Dataquest.
Semiconductor Fabs: Why, Where, and What?

**Why All the New Fabs?**

- Worldwide electronic market
- MPU production
- PCs
- DRAM
- Capital spending
  - Patterns of spending
  - Fabless/foundry influence

---

**Worldwide Electronic Equipment Production Revenue Forecast**

![Graph showing revenue forecast for different sectors from 1988 to 1998.](source: Dataquest)

---

Source: Dataquest

---

SEMICON/West Seminar—Status 1994
Semiconductor Fabs: Why, Where, and What?

**MPU Product Forecast**

Thousands of Units

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<thead>
<tr>
<th></th>
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</thead>
<tbody>
<tr>
<td>Units</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

- ESF
- LEA
- OSR
- 68K
- x86

Source: Dataquest

**Digital Microcomponent**

- **Microprocessor (MPU)**
  - Market controlled by Intel, other players are supply constrained
  - 8-inch wafer driver in logic
  - High-end geometries will be <0.5μm in 1995

- **Microcontroller (MCU)**
  - Market controlled by Motorola, and is supply constrained
  - 1.2- to 1.6μm geometries, some will go to 0.9μm
  - Migration from 8-bit to 16-bit

- **Microperipheral (MPR)**
  - Market is fragmented, demand-constrained
  - High-volume gate arrays
  - 0.8- to 1μm geometries
Semiconductor Fabs: Why, Where, and What?

PC Unit Forecast

Thousands of Units

Q1/95  Q2/95  Q3/95  Q4/95  Q1/96  Q2/96  Q3/96  Q4/96

Source: Dataquest

DRAM Supply versus Demand: The Scenario Six Months Ago

Supply as a Percentage of Demand

Q2/94  Q3/94  Q4/94  Q1/95  Q2/95  Q3/95

Source: Dataquest
Semiconductor Fabs: Why, Where, and What?

Capital: What Did the Top 10 Spenders Do?

<table>
<thead>
<tr>
<th>1994</th>
<th>1993</th>
</tr>
</thead>
<tbody>
<tr>
<td>U.S.$10.7 Billion</td>
<td>U.S.$7.8 Billion</td>
</tr>
<tr>
<td>3 North America, 5 Japan, 1 Europe, 1 ROW</td>
<td>3 North America, 4 Japan, 1 Europe, 2 ROW</td>
</tr>
</tbody>
</table>

- 54% Computer Equipment
- 27% Property and Plant
- 7% Test and Assembly
- 7% Wafer Fab

Source: Dataquest

Ramp-Up Patterns

- North America
  - Start with pilot and gradual ramp-up
- Japan
  - A commodity manufacturer in transition
  - Recently has built massive empty shells and ramp-up as demand dictates
- Europe
  - Many expansions as capital spending has increased
- ROW
  - Massive spending in all areas, new facilities
  - Dynamic, could fluctuate with demand shifts
Semiconductor Fabs: Why, Where, and What?

A Rising Star: Fabless/Foundry

- Fabless companies' share of worldwide semiconductor revenue:
  - 3.7% (1993) to 5.0% (1998)
- Approximately 30% of this revenue will go to foundries
- ROW is the most foundry-sensitive region
- Taiwan and Singapore capital spending:
  - U.S.$400 million (1993) to U.S.$1.2 billion (1994)
  - Higher percentile in nonwafer fab equipment

Where Are the 8-Inch and 6-Inch?

- 6-inch planned fabs
- 8-inch past, present, and future
- 6-inch and 8-inch capacity comparison
Notes on 6-Inch and 8-Inch Fabs

- 6-inch fabs
  - There will be more capacity expansions than new fabs
  - Most activity is in the low end
  - Expect ROW activity to be much higher
- 8-inch fabs
  - Our window is more clear through 1995
  - Today's scenario shows ROW highly active beyond 1995
  - Expect upgrades as 8-inch matures

Fab Capacity by Wafer Size

Source: Dataquest
Semiconductor Fabs: Why, Where, and What?

What Are the 8-Inch Product Lines?

Number of Lines per Year

- Others
- Logic
- DRAM
- 256Mb
- 64Mb
- 16Mb
- 4Mb

Source: Dataquest

All in One... Pattern Recognition

Billions of U.S. Dollars

- Wafer Fab Equipment Market
- 8-Inch/Total Silicon Consumption
- 8-Inch/Total Silicon Capacity

Source: Dataquest
A Glimpse of the Future

- End-user market is strong
- 8-inch will be gaining ground on 6-inch after 1994
- Expansions of 8-inch fabs have begun
- North American logic driving 8-inch fabs
- Japan is clearly on the upswing for 16Mb and...
- Asia/Pacific is a region to watch for equipment purchase in 1995
- Capital spending/capacity/consumption comparison show tight capacity developing in 1997

Contributors

- Kunio Achiwa
- Jerry Banks
- Terry Birkholz
- Calvin Chang
- Dale Ford
- Clark Fuhs
- Mark Giudici
- Ken Lowe
- Mario Morales
- Nhat Pham
Mr. Bohn is a Senior Industry Analyst for Dataquest's Semiconductor Memories Worldwide service. He is responsible for research and analysis in semiconductor memory pricing, supplier, and product technology trends including DRAMs and flash ICs. His responsibility includes strategic planning, competitive analysis, and consulting projects. He works with securities companies, banks, and other members of the financial community on semiconductor trends and also tracks world trade, intellectual property, and related legal trends for their impact on the electronics industry. At Dataquest he has forecast pricing of more than 100 semiconductor products.

Mr. Bohn has written a series of reports on benchmarking and has assessed semiconductor life cycles from a component engineering perspective. This research served as a basis for Dataquest's PC "teardown" cost analysis. At Dataquest, he has also served as the analyst tracking semiconductor trends in the interactive CD-ROM player and PCMCIA markets.

Prior to joining Dataquest in the mid-1980s, Mr. Bohn assessed worldwide electronic markets on a macro- and microeconomic basis for a market research company. He served as International Market Research Manager for the Korea Trade Center in the United States and has financial, legal, and government experience.

Mr. Bohn received a B.A. degree from Cornell University, an M.B.A. degree from the University of California at Berkeley, and a J.D. degree from the Hastings College of Law.
Chips, Chips, and More Chips—Toward a $200 Billion IC Market

Agenda

- The 1993 semiconductor market
- A look ahead to 1998-2000
- Road maps

Three Main Points

- 20% semiconductor content
- $200 billion dollars in revenue for semiconductors
- By the year 2000
Chips, Chips, and More Chips—Toward a $200 Billion IC Market

Highlights of 1993 Semiconductor Market

- 27.4% worldwide growth over 1992
- Memory and micro ICs account for 50% of semiconductors
- North American market grew by 31%
- Asia/Pacific-ROW market grew by 43%

Source: Dataquest

1993 Worldwide Semiconductor Market Shares

<table>
<thead>
<tr>
<th></th>
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<th></th>
<th></th>
<th></th>
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</tr>
</thead>
<tbody>
<tr>
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<td>Intel</td>
<td>9.3</td>
<td>7,970</td>
<td>5,091</td>
<td>57</td>
</tr>
<tr>
<td>2</td>
<td>NEC</td>
<td>7.2</td>
<td>6,141</td>
<td>4,869</td>
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<tr>
<td>3</td>
<td>Motorola</td>
<td>7.0</td>
<td>5,957</td>
<td>4,694</td>
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<tr>
<td>4</td>
<td>Toshiba</td>
<td>6.7</td>
<td>5,727</td>
<td>4,675</td>
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<td>5</td>
<td>Hitachi</td>
<td>5.9</td>
<td>5,015</td>
<td>3,851</td>
<td>30</td>
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<tr>
<td>6</td>
<td>TI</td>
<td>4.8</td>
<td>4,893</td>
<td>3,087</td>
<td>32</td>
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<tr>
<td>7</td>
<td>Samsung</td>
<td>3.6</td>
<td>3,044</td>
<td>1,900</td>
<td>60</td>
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<tr>
<td>8</td>
<td>Fujitsu</td>
<td>3.4</td>
<td>2,926</td>
<td>2,533</td>
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<tr>
<td>9</td>
<td>Mitsubishi</td>
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<td>2,823</td>
<td>2,213</td>
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<tr>
<td>10</td>
<td>IBM</td>
<td>2.9</td>
<td>2,510</td>
<td>-</td>
<td>-</td>
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<tr>
<td>Others</td>
<td></td>
<td>24.8</td>
<td>39,263</td>
<td>32,407</td>
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<td>Total with IBM</td>
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<td>100.0</td>
<td>85,461</td>
<td>65,260</td>
<td>31.2</td>
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<tr>
<td>Total without IBM</td>
<td></td>
<td>83,311</td>
<td>65,260</td>
<td>27.4</td>
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</tr>
</tbody>
</table>

Source: Dataquest
Chips, Chips, and More Chips—Toward a $200 Billion IC Market

Agenda

- The 1993 market
- A look ahead to 1998-2000

What About the Silicon Cycle?

- Demand will stay strong through 1995
- Undercapacity for the foreseeable future
- Favorable economic outlook
Chips, Chips, and More Chips—Toward a $200 Billion IC Market

**Semiconductor Engines**

- Computers
- Data Storage
- Input/Output
- Dedicated Systems
- Other Data Processing
- Premise Telecom
- Public Telecom
- Mobile Communications
- Broadcast and Studio
- Other Communications
- Audio
- Video
- Personal Electronics
- Appliances
- Other Consumer
- Industrial
- Transportation
- Mil/Civil Aerospace

![Worldwide Revenue Chart](chart1.png)

Source: Dataquest

**Worldwide Semiconductor Forecast**

![Revenue Chart](chart2.png)

- 1991
- 1992
- 1993
- 1994
- 1995
- 1996
- 1997
- 1998

Billions of Dollars

Source: Dataquest
Forecast Assumptions

- Worldwide PC market growth (15%) drives market
- Japan will lose 4% of market per year to Asia/Pacific
- MPUs and memory SIMMs are increasingly added in local market (consumption spread among all 4 regions)
- MPR and MOS logic used on motherboard increasingly consumed in Asia/Pacific market

Semiconductors by Region History/Forecast
Chips, Chips, and More Chips—Toward a $200 Billion IC Market

Highlights of Forecast
- Asia/Pacific market passes Japan in 1995
- Microcomponents pass memory ICs in 1995
- Micros and memory ICs together will account for 60% of semiconductor market by 1998 (50% in 1993)

Agenda
- Product road maps
- Microcomponents
- Memory
Chips, Chips, and More Chips—Toward a $200 Billion IC Market

**Worldwide Forecast by Product**

<table>
<thead>
<tr>
<th>Year</th>
<th>Microcomponents</th>
<th>Memory</th>
<th>Logic/ASIC</th>
<th>Analog/Mixed</th>
<th>Hybrid ICs</th>
<th>Discrete</th>
<th>Optical Semiconductors</th>
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<tbody>
<tr>
<td>1993</td>
<td>27.6%</td>
<td>14.4%</td>
<td>10.6%</td>
<td>-3.5%</td>
<td>18.9%</td>
<td>1.7%</td>
<td>1.0%</td>
</tr>
<tr>
<td>1998</td>
<td>23.3%</td>
<td>16.5%</td>
<td>29.8%</td>
<td>-2.5%</td>
<td>26.9%</td>
<td>14.3%</td>
<td>3.0%</td>
</tr>
</tbody>
</table>

Total = $85.6 Billion  
Total = $163.1 Billion

- Microcomponents  
- Memory  
- Logic/ASIC  
- Analog/Mixed  
- Hybrid ICs  
- Discrete  
- Optical Semiconductors

Source: Dataquest

**Microcomponents Five-Year Forecast**

<table>
<thead>
<tr>
<th>Year</th>
<th>MPU</th>
<th>MCU</th>
<th>MPR</th>
<th>pDSP</th>
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<td>8,000</td>
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<tr>
<td>1992</td>
<td>6,000</td>
<td>7,000</td>
<td>8,000</td>
<td>9,000</td>
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<tr>
<td>1993</td>
<td>7,000</td>
<td>8,000</td>
<td>9,000</td>
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<tr>
<td>1994</td>
<td>8,000</td>
<td>9,000</td>
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<td>1995</td>
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<td>1996</td>
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<tr>
<td>1998</td>
<td>12,000</td>
<td>13,000</td>
<td>14,000</td>
<td>15,000</td>
</tr>
</tbody>
</table>

Source: Dataquest
Chips, Chips, and More Chips—Toward a $200 Billion IC Market

**Microperipheral Product Forecast**

- Others
- Mass Storage
- Communication
- Graphics/Video
- Math Coprocessors
- System Logic

Source: Datasheet

---

**Intel's on Top of the Hill**

- Moore's law still applies
  - Except for DRAM
- Walk financial margin "tight rope"

Source: Datasheet
Chips, Chips, and More Chips—Toward a $200 Billion IC Market

The DRAM Outlook
- PC market-driven
  - Strong through 1994—and 1995?
  - 70 million PCs by 1997
- New technologies
  - Extended Data Out (EDO)
  - Synchronous, Rambus, VRAM-replacement

MOS Memory Market, 1993-1998

<table>
<thead>
<tr>
<th>Year</th>
<th>ROM</th>
<th>EPROM</th>
<th>Flash</th>
<th>SRAM</th>
<th>Others</th>
<th>DRAM</th>
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</thead>
<tbody>
<tr>
<td>1993</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>1998</td>
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</tbody>
</table>
Chips, Chips, and More Chips—Toward a $200 Billion IC Market

Flash Memory Outlook
- Technology standard battles
  - NOR versus NAND
  - Single versus multiple voltages
- Exploding market
  - 1993-1998: 47% annual growth rate
  - Applications profusion
  - Handheld system technology of choice

Agenda
- The 1993 semiconductor market
- A look ahead to 1998-2000
- Road maps
Dataquest Conclusion

Semiconductor Industry—Megatrends 2000
- Total semiconductor market size: $200 billion; total electronics industry: $1 trillion
- $5 billion to get into top 10 suppliers
- Asia/Pacific second largest market ($50 billion), with China No. 1, followed by Taiwan and Korea
- Personal conferencing, personal communications, speech recognition appliances, virtual reality, home entertainment systems dominate the applications market

Source: Dataquest
PC and Mobile Computing: What's Hot for the Desktop?

Philippe de Marcillac
Director and Principal Analyst
Personal Computers Worldwide
Dataquest Incorporated

Mr. de Marcillac is the Director and Principal Analyst of Dataquest's PC Worldwide group. Prior to this he spent six years in Europe as Director and Principal Analyst for Dataquest's PC Europe and Dataquest's European Computer Systems and Peripherals group. He is responsible for the content and quality of Dataquest's PC services in North America, Europe, and Asia. He has managed projects involving extensive research into the European personal computer market and the vertical markets in Europe and also carried out detailed analysis of IBM 370 and UNIX environments. Mr. de Marcillac is also responsible for Dataquest's electronic delivery strategy and for the electronic data management system, MarketView.

Prior to joining Dataquest, Mr. de Marcillac was European Research Director for International Data Corporation (IDC), where he spent six years.

Mr. de Marcillac received an honors degree in Natural Sciences at Cambridge University, United Kingdom.
The World Is Becoming a More Global Market

- Free-trade zones are becoming established
- Regions, rather than countries, will dominate global thinking in the next 20 years
- Companies, too, are becoming much more global
- These trends affect all industries: high technology with its high rate of change will move fast
- Competition will become tougher

Worldwide Economies of Scale
A Million Units per Annum Is the Level to Aim for... for Now

Economies of Scale Are Increasing in Importance in the PC Business Model

- In a return to earlier days, manufacturing economies of scale are sought after
- The million unit threshold will likely move up to 3 million quite fast
- Component pricing and availability are major factors at play here
- OEMs will continue to put pricing pressure on suppliers of materials
Some Key Points for Our Industry

- The economy affects both the demand side (investments and spending) and the supply side
- The recession in Japan will have a strong effect on our industry
- U.S. vendors are increasing their dominance as suppliers of finished goods
- Manufacturing locations and trends will modify to take best advantage of:
  - NAFTA and the EU
  - Logistics and supply of components/materials
  - Educated workforce vs. low wages

Moving On to the PC Industry...
PC and Mobile Computing: What’s Hot for the Desktop?

What’s Hot for the PC Market in 1994—and Beyond?

- PC Vendors
- "ProLinea"
- "ValuePoint"
- "PowerBook"
- "ThinkPad"
- "Brands"
- Channels (VAR, Fax/Phone, Consumer Electronics)
- Market Concentration
- MPU Technology
- The Pace Will Accelerate

- Intel's reaction against PowerPC will intensify in 1994
  - Agreement with HP for late 1990s
- Migration to Pentium will likely exceed even some of the recent optimistic forecasts
- But RISC architectures will make significant inroads
- PowerPC with Apple in 1994
- More vendors in 1994/1995
Apple Is a Key Factor in Determining the Pace of Success of RISC

- Apple has launched its highly anticipated PowerPC products
- These products run Windows under emulation
- It appears that Apple will license its Mac OS—but when and how?
- Nevertheless, it is clear that Apple alone cannot break Intel's stranglehold on MPU technology
- By the late 1990s, even Intel will be using RISC technology extensively

A Number of Factors Are Necessary for RISC to Take Off in the Short Term

- A leading vendor must adopt the architecture
- A viable OS must be available
- One or two further leading companies must follow
- What OS ?????
**Within the RISC PC Environment**

**PowerPC Will Dominate in the Mid-1990s**

- Apple "will ship up to 1 million units within one year of announcement"
- IBM and clones will accelerate at year-end into 1995
- Alpha will be a good technological alternative—but will not match PowerPC's volumes
- Other processors will be niche players
- However, outside of Apple, all RISC PCs will be affected by the slow pace of Windows NT
- Can RISC PCs break out of the server environment?

---

**Overall, Intel Is Likely to Remain Dominant—But...**

- **In 1998, 77.0 Million PCs Shipped Worldwide**

  - 87%
  - 13%

  - **All x86- Compatible PCs**
  - **All Other PCs**

  *Source: Datquest*
Looking at Formats and the Portable Market...

Portable PCs Are Starting to Look Very Attractive Again—At Last!

- Despite much media hype...
- Portables have made little progress against desktop/deskside PCs over the last two years!
  - Massive reductions in desktop prices
  - Color active matrix screen shortages
  - Performance vs. size/weight for portables
- Portable PCs have proved very popular in Japan but because of their form factor, not their portability!
- PCMCIA will help, but demand will be affected by high prices in 1994
Portable Average Selling Prices Have Increased Sharply...

![Graph showing the increase in portable average selling prices from 1991 to 1996.](Source: Dataquest)

Nevertheless, Demand for Portable PCs Is Set to Grow Fast

![Bar chart showing the growth in millions of units shipped worldwide from 1993 to 1998.](CAGR 26.0%)

Note: Includes laptops, notebooks, and subnotebooks only

![Source: Dataquest](Dataquest)
PC and Mobile Computing: What's Hot for the Desktop?

**Improved Notebooks/Subnotebooks Will Drive Portable Demand**

- With improved performance, notebooks will start to approach the capabilities of the desktop
- Subnotebooks have been disappointing so far... A standard is needed
- But a new set of products in 1994/1995 will remedy the low user perception
- The PDA debate/hype affects the notebook/subnotebook market

**Overall, Desktop PCs Will Remain the Largest Portion of the Industry**

- Despite hype, desktop/deskside PCs still have a bright future
- They remain the lowest cost performance PC for the foreseeable future
- Performance issues vs. size/weight for portables
- Many users do not need mobility at the moment!
Portable PCs Grow Fast; But Desktop/Deskside PCs Still Dominate

Millions of Units Shipped Worldwide

<table>
<thead>
<tr>
<th>Year</th>
<th>Desktop/side</th>
<th>Portables*</th>
</tr>
</thead>
<tbody>
<tr>
<td>1993</td>
<td>20</td>
<td>15</td>
</tr>
<tr>
<td>1994</td>
<td>22</td>
<td>16</td>
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<td>1995</td>
<td>24</td>
<td>17</td>
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<td>1996</td>
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<td>18</td>
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<td>1997</td>
<td>28</td>
<td>19</td>
</tr>
<tr>
<td>1998</td>
<td>30</td>
<td>20</td>
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</tbody>
</table>

* Include laptops, notebooks, and subnotebooks only

Source: Dataquest

Portable PCs Grow Fast; But Desktop/Deskside PCs Still Dominate

Percentage of Worldwide Shipments

<table>
<thead>
<tr>
<th>Year</th>
<th>Desktop/side</th>
<th>Portables*</th>
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</thead>
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<tr>
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<td>1994</td>
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<td>1995</td>
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</tr>
<tr>
<td>1996</td>
<td>10%</td>
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</tr>
<tr>
<td>1997</td>
<td>10%</td>
<td>90%</td>
</tr>
<tr>
<td>1998</td>
<td>10%</td>
<td>90%</td>
</tr>
</tbody>
</table>

* Include laptops, notebooks, and subnotebooks only

Source: Dataquest
A New Opportunity: Consumer Markets

- The consumer market is exploding, particularly within the United States
- Other regions will follow this trend
- This market is largely unpenetrated
- Consumers look for different price points and different levels of support
- Usage of PC brands and selected channels of distribution help vendors address these markets

In Addition, New Markets Are Opening Up and Driving Demand

Asia, Latin America, eastern Europe ... are starting to drive the worldwide market
PC and Mobile Computing: What's Hot for the Desktop?

Marketing Issues: PC Brands

Branding of PC Products Will Intensify in Search of Market Share

Branding is a natural part of the maturation of our market
- It permits better channel control
- It provides for a variety of price points
- It is useful both in developed markets and in emerging markets
- It allows a vendor to reach multiple user groups

"PS/2, ValuePoint, PS/1, ThinkPad, ProLinea, DeskPro/M, DeskPro/i"
Branding Will Evolve in 1994

- Branding will increase in both desktop and portable markets
- More vendors will use this approach—and for more ranges of products
- But how many brands should be used?
- The usage of branding will become more sophisticated
- Our industry will learn from other industries’ experience in this field

How Do Users Buy?
And What Is the Future for Channels of Distribution?
In 1994, Users to Shift Buying Patterns

Traditional PC Channels

VARs
Sales Force
Dealers

Face-to-Face Meetings

Walk-In

Face-to-Face Meetings

Fax/Phone/Mail
New Channels Opened Up New Customer Groups

Direct Sellers Influenced Buying Patterns
The "Superstore" Concept: Well Placed to Increase Market Share in 1994 and 1995

- VARs
- Sales Force
- Dealers
- Superstores ("Direct Sellers")
- Consumer Electronics
- Mass Merchants
- Walk-In
- Face-to-Face Meetings
- Fax/Phone/Mail

New Channels of Distribution Are Gaining in Importance

- The distribution model is becoming more complex
- Distribution strategies must vary by region and even country in the world
- Expect retailing channels to become more sophisticated
- Superstore format accepted and progressing well in the United States, yet experimental in Europe
- Direct fax/phone/mail may have peaked in developed markets
PC and Mobile Computing: What's Hot for the Desktop?

Some of the Latest Data...

U.S. PC Market Quarterly Growth

Source: Dataquest
**PC and Mobile Computing: What's Hot for the Desktop?**

**Conclusions**

- Technology will remain a major driving force—but there are many others
- Leading players will grab increased share, and the market will consolidate further
- Branding will be a key success factor
- The war will be won within the channels of distribution
- Price pressures will not abate
- There are many untapped markets and opportunities
Semiconductor Market Opportunities in China—Will China Become the Next Asian Semiconductor Power?

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Market Research Analyst
Research Operations Group
Dataquest Incorporated

Mr. Huang is a Market Research Analyst in the Research Operations group at Dataquest. His primary responsibility is the research on PC and workgroup business applications software and semiconductor equipment and materials. He is instrumental in Asia-related research, answering inquiries, consulting projects, and business development. He was also a member of the Dataquest team that regularly appears on KNTV in San Jose to comment on industry trends in the Silicon Valley.

Prior to joining Dataquest, he was a project manager at Freeman, Sullivan & Company in San Francisco, where he managed data analysis/processing for research projects on the power and medical industries. He also did a feasibility study on used-equipment market in China. While studying at Stanford University, Mr. Huang worked on projects on global economic development at the Hoover Institute. He also worked as a research associate at SRI International on a project on the economic competitiveness of Hong Kong by year 2000. Before Mr. Huang came to the United States in 1985, he taught English at Beijing Broadcasting Institute. In 1983, he co-led a study on value changes of Chinese young people for the Youth Research Institute of the Chinese Academy of Social Sciences. He was also a freelance reporter for China Daily.

Mr. Huang received an M.A. degree in Sociology/Organization Studies from Stanford University and a B.A. degree in English from the Beijing Foreign Studies University.
Semiconductor Market Opportunities in China—Will China Become the Next Asian Semiconductor Power?

**Agenda**

- Dataquest's China research
- The big picture
- Hot markets for products with ICs
- China's domestic semiconductor industry
- China strategies for device and equipment makers
- Dataquest conclusions

**Dataquest's China Research: The Team**

**Country Overview**

- Telecommunications (Jing Huang, Patty Chang, and Nancy Jamison)
- Computers and Peripherals (Patty Chang)
- Services (Cynthia Moore)
- Software (Jing Huang)
- Semiconductors (Dan Heyler)
- User Wants and Needs (Patty Chang)

Team Leader: Patty Chang
Semiconductor Market Opportunities in China—Will China Become the Next Asian Semiconductor Power?

Dataquest's China Research: Seven Reports

Source: Dataquest

The Big Picture: Some Basics

Population: 1.2 billion
Geographic size: As large as the United States
Civilization: 5,000 years old
1993 GDP: $549.1 billion
1993 total trade: $195.8 billion
1993 savings: $200.0 billion

Source: Dataquest
Semiconductor Market Opportunities in China—Will China Become the Next Asian Semiconductor Power?

The Big Picture: China GDP Growth

The Big Picture: Retail Sales in China
Semiconductor Market Opportunities in China—Will China Become the Next Asian Semiconductor Power?

The Big Picture: Economic Growth

- Economic reforms
- Economic cycles
- Inflation
- GATT
- A greater China

The Big Picture: Political Stability

- Post-Deng Xiaoping China
- Ruling elite
- Decentralization
- Social unrest
Semiconductor Market Opportunities in China—Will China Become the Next Asian Semiconductor Power?

**Hot Markets: 1989 to 1997 Asia/Pacific Semiconductor Consumption within Region**

<table>
<thead>
<tr>
<th>Year</th>
<th>ASEAN/Others</th>
<th>China</th>
</tr>
</thead>
<tbody>
<tr>
<td>1989</td>
<td>(6%)</td>
<td>(7%)</td>
</tr>
<tr>
<td>1993</td>
<td>(21%)</td>
<td>(12%)</td>
</tr>
<tr>
<td>1997</td>
<td>(21%)</td>
<td></td>
</tr>
</tbody>
</table>

Total = U.S.$6.0 Billion
Total = U.S.$14.5 Billion
Total = U.S.$26.2 Billion

Source: Datasquest

**Hot Markets for Products with ICs**

- Consumer Electronics
- Data Processing
- Telecom
- Transportation

Source: Datasquest
China’s 1993 IT Market by Segment

- **Consumer** $8.5 billion (46%)
- **Computers** $1.8 billion (10%)
- **Software** $250.0 million (1%)
- **Telecom** $7.0 billion (37%)

Total = $18.7 Billion

Source: Dataquest

China’s 1997 IT Market by Segment

- **Consumer** $17.8 billion (37%)
- **Computers** $3.3 billion (7%)
- **Software** $766.0 million (2%)
- **Telecom** $23.8 billion (49%)

Total = $48.03 Billion

Source: Dataquest
Semiconductor Market Opportunities in China—Will China Become the Next Asian Semiconductor Power?

**Consumer Durables: Top Three**
- 1970s: Bike, sewing machine, electric fan
- 1980s: TV, washing machine, refrigerator
- Early 1990s: VCR, motorcycle, telephone
- Late 1990s: AC, camcorder, PC

**Consumer Appliances: Household Penetration in Shanghai, 1993**

<table>
<thead>
<tr>
<th>Appliance</th>
<th>Percent</th>
</tr>
</thead>
<tbody>
<tr>
<td>Camcorder</td>
<td>90</td>
</tr>
<tr>
<td>CD Player</td>
<td>80</td>
</tr>
<tr>
<td>Microwave</td>
<td>70</td>
</tr>
<tr>
<td>Hi-Fi System</td>
<td>60</td>
</tr>
<tr>
<td>VCR</td>
<td>50</td>
</tr>
<tr>
<td>Rice Cooker</td>
<td>40</td>
</tr>
<tr>
<td>Tape Recorder</td>
<td>30</td>
</tr>
<tr>
<td>Color TV</td>
<td>20</td>
</tr>
</tbody>
</table>

Source: Dataquest
Semiconductor Market Opportunities in China—Will China Become the Next Asian Semiconductor Power?

Telecom Growth Rates—China's GNP versus Post and Telecom Services, 1983 to 1993

Percent

- Post and Telecom Services
- GNP

Source: PRC, Dataquest

Telecom: Capacity of China's National Telephone Exchange, 1990 to 2000

Millions of Lines

Source: PRC, Dataquest
Semiconductor Market Opportunities in China—Will China Become the Next Asian Semiconductor Power?

Telecom: Number of Paging Subscribers in China, 1990 to 1994

Thousand

16,000
14,000
12,000
10,000
8,000
6,000
4,000
2,000


Source: PRC, Dataquest


Millions of Dollars

PC
WS
Mini
MF/MR


Source: Dataquest
Semiconductor Market Opportunities in China—Will China Become the Next Asian Semiconductor Power?

**Hot Markets: Vendor Profiles**
- Foreign vendors: dominant in market share
  - Consumer electronics: Japanese
  - Telecom: European, North American, Japanese
  - Computers: United States, Taiwan/Hong Kong
- Sino-foreign joint ventures to get market access
- Weak Chinese domestic manufacturers

**China Semiconductor Industry: Production Can't Meet Consumption**

![Graph showing the comparison between semiconductor production and consumption in millions of U.S. dollars from 1992 to 1997.](image)
China Semiconductor Industry: Foreign Companies

- Shanghai Belling
- Shanghai Philips
- Shougang NEC
- Motorola in Tianjin
- Test/assembly plants

China Semiconductor Industry: Domestic Fabs

- About 70 fab lines: small, low-end
- Low yield
- Most losing money
- Looking for way out
- A tale of two IC makers
  - Huajing
  - Huayue
Semiconductor Market Opportunities in China—Will China Become the Next Asian Semiconductor Power?

China Semiconductor Industry: Government Resolve?
- National goals
- Getting short on capital
- Becoming short-sighted
- Government and university as businesses

China's Play for Device Makers
- Fabs for internal use for finished products for China
- Look outside China for chip sales
- Look inside China for test/assembly sites
- Donate old equipment to universities for training
- Make use of cheap software design engineers
Semiconductor Market Opportunities in China—Will China Become the Next Asian Semiconductor Power?

**China's Play for Equipment Vendors**
- Look outside China for equipment sales
- Look inside China for software development contract
- Educate Chinese officials
- Don't get excited at "$2 billion"
- Wait

**Dataquest Conclusions for the Next Five Years**
- Will China be a huge market for IC consumption? Yes.
- Will more test/assembly plants move to China? Yes.
- Will the Chinese government invest billions in fabs? No.
- Will China become the next Asian semiconductor power? No.
- China and Taiwan: A comparison