Dataquest
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The Dun & Bradstreet Corporation

１９８６日本半導体産業会議

「超ＬＳＩ、その将来と応用」

参加者リスト

１９８６年４月１３日～４月１５日

箱根プリンスホテル

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＊＊＊ 日本半導体国際会議出席者リスト ＊＊＊

ｱﾙﾌｧﾍﾞｯﾄ順 敬称省略

A	株式会社アド・ビューロー	取締役 営業部部長 折原 隆
A	株式会社アドバンテスト 営業本部 ATE営業部	取締役部長 南 勝明
A	AG Associates Sales & Marketing	Director Richard Seaman
A	アルプス電気株式会社 特機事業部 開発部	部長・技術士 彌永 真
A	ｱﾄﾞﾊﾞﾝｽﾄ･ﾏｲｸﾛ･ﾃﾞﾊﾞｲｽ 株式会社	代表取締役 ｼﾞｪｲﾑｽﾞ･ｼﾝ
A	ｱﾌﾟﾗｲﾄﾞ ﾏﾃﾘｱﾙｽﾞ ｼﾞｬﾊﾟﾝ 株式会社	取締役社長 岩崎 哲夫
A	ｱﾌﾟﾗｲﾄﾞ ﾏﾃﾘｱﾙｽﾞ ｼﾞｬﾊﾟﾝ 株式会社	取締役・第二製品事業部長 砂金 養一
A	Applied Materials, Inc.	President & CEO James Morgan
A	朝日新聞社 経済部	記者 長谷川 智
A	旭化成工業株式会社 電子事業推進本部	副部長 永里 善彦
A	旭化成工業株式会社 LSI事業推進室	部長 小森 良三
A	旭化成工業株式会社 電子事業推進本部	LSI営業部長 徳永 哲男
A	旭化成工業株式会社 電子事業推進本部	取締役本部長 東 誠司
A	旭マイクロシステム株式会社	取締役副社長 宮内 浩次
A	ｱｼﾞｱ ｳｫｰﾙ ｽﾄﾘｰﾄ ｼﾞｬｰﾅﾙ 東京支局特派員	ｽﾃｨｰﾌﾞﾝ･K・ﾖｰﾀﾞ
A	AT&T International Components	Market Development Manager David Hytha
A	AT&T Technology Systems	Manager Intl. Strategic Planning Paul Mostek
B	Belmont Computer Inc.	John William Poduska
B	Belmont Computer Inc.	Mrs. Poduska
B	ビジネス・ウイーク	東京支局長 ﾗﾘｰ･ｱｰﾑｽﾄﾛﾝｸﾞ
C	キヤノン株式会社 光学機器事業部長	専務取締役 西岡 茂
C	Capital Research Company	Investment Analyst Abe, Masaaki
C	カシオ計算機株式会社 開発本部 管理部 総合企画室	室長 折居 正晴
C	カシオ計算機株式会社	常務取締役 志村 則彰
C	CNEDSC IC Design Center	Chief Engineer Wang Zhenghua
C	CNEDSC Electronic Device	Deputy Manager He Mingzhang
C	クレストロニクス株式会社	代表取締役 小原 克彦
D	大日本印刷株式会社 ミクロ製品事業部企画課	課長 松嶋 欽爾

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D	Data General Corporation	Vice President Vahe Sarkissian
D	データ・アイ・オー・ジャパン株式会社	代表取締役社長 河南 公宣
D	Delco Electronics Corporation Engineering	Director Robert McMillin
D	Department of State	International Economist Ross Riley
D	Department of State	International Economist Steve Lemons
D	Department of State	Tom D'Elia
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D	データクエスト社	副社長 ﾌﾚﾄﾞﾘｯｸ･ｼﾞｰﾊﾞｰ
D	データクエスト社 JSIS	副社長 ｼﾞｰﾝ･ﾉﾚｯﾄ
D	データクエスト社 SIS	副社長 ｼﾞﾑ･ﾗｲﾘｰ
D	データクエスト社 JSIS	ｲﾝﾀﾞｽﾄﾘ･ｱﾅﾘｽﾄ ｼｪﾘﾀﾞﾝ･ﾀﾂﾉ
D	データクエスト社	ｼﾆｱ･ｲﾝﾀﾞｽﾄﾘ･ｱﾅﾘｽﾄ ﾚｰﾝ･ﾒｲｿﾝ
D	データクエスト社 JSIS	ﾘｻｰﾁ･ｱﾅﾘｽﾄ ﾊﾟﾄﾘｼｱ･ｺｯｸｽ
D	データクエスト社 JSIS	ﾓﾘｰﾝ･ﾃﾞｲﾋﾞｽ
D	日本データクエスト株式会社	取締役副社長 森下 茂
D	日本データクエスト株式会社 日本半導体産業ｻｰﾋﾞｽ	ｱｿｼｴｲﾂ･ﾃﾞｨﾚｸﾀｰ 大竹 修
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D	日本データクエスト株式会社 日本半導体産業ｻｰﾋﾞｽ	山根 ナナ子
D	日本データクエスト株式会社 ﾏｰｹﾃｨﾝｸﾞ	ｼﾆｱ･ﾏｰｹﾃｨﾝｸﾞ･ﾏﾈｰｼﾞｬｰ 南石 正和
D	日本データクエスト株式会社 ﾏｰｹﾃｨﾝｸﾞ	ﾏｰｹﾃｨﾝｸﾞ ﾏﾈｰｼﾞｬｰ 関 悟司
D	日本データクエスト株式会社 ﾏｰｹﾃｨﾝｸﾞ	山田島 玲子
D	日本データクエスト株式会社 ﾏｰｹﾃｨﾝｸﾞ	星崎 里子
D	日本データクエスト株式会社	柳沢 淳子
E	Electric Engineering Times CMP Publications	Bureau Chief David Lammers
E	ERSO/ITRI	Vice President & General Manager Chintay Shih
E	イー・エス・アイ・ジャパン	ｾｰﾙｽ･ﾏﾈｰｼﾞｬｰ 祝前 英一郎
E	Exar Corporation	Hatta, Nobuo
F	Faichild Camera & Instrument Co.,	President & Chief Exe. Officer Donald Brooks

F	日本フェアチャイルド株式会社	専務取締役 堀 義和
F	ﾌｪｱﾁｬｲﾙﾄﾞｾﾐｺﾝﾀﾞｸﾀｰｱｼﾞｱｲﾝｺｰﾎﾟﾚｰﾃｯﾄ	取締役副社長 ﾛﾅﾙﾄﾞ･C･ﾉﾘｽ
F	Fairﾌｪｱﾁｬｲﾙﾄﾞ ｾﾐｺﾝﾀﾞｸﾀｰ ｺｰﾎﾟﾚｲｼｮﾝ	ﾍﾟｲﾄﾝ･ｺｰﾙ
F	Ferranti Interdesign, Inc. Marketing & Sales	Vice President Michael Kannett
F	フォード・モーターカンパニー 電気電子事業部	ｱｼﾞｱ ﾊﾟｼﾌｨｯｸ ﾘｴｿﾞﾝ ｴﾝｼﾞﾆｱ ｼﾞｪｲﾑｽﾞ A. ﾁｬｱﾝ
F	富士電機株式会社 電子)IC事業部 IC営業技術部	部長 星野 利雄
F	富士エレクトロニクス株式会社	取締役社長 息栖 国夫
F	富士通株式会社 半導体ﾃﾞﾊﾞｲｽ営業推進部販売推進部	部長 栗林 伸吉
F	富士通株式会社 半導体ﾃﾞﾊﾞｲｽ海外営業推進部販推部	部長代理 高山 攻
F	富士通部商株式会社 技術部	部長 本間 明
G	General Datacomm, Inc. Technology	Vice President Fred Cronin
G	General Datacomm Industries, Inc. Engineering	Vice Presidebt Arthur Braun
G	GE(USA)ｾﾐｺﾝﾀﾞｸﾀｰ 株式会社	取締役社長 三村 拓生
G	ｾﾞﾈﾗﾙｴﾚｸﾄﾘｯｸ ﾃｸﾆｶﾙｻｰﾋﾞｽ ｶﾝﾊﾟﾆｰ 極東石英製品事業部	事業部長 吉田 稔
G	General Datacomm Industries Inc.	James Linnell
G	金星半導体株式会社 半導体事業部	白 光善
G	GT Capital Management, Inc.	Director Sano, Itsuki
H	ハリス株式会社	代表取締役社長 ﾘﾁｬｰﾄﾞ F. ﾒｲ
H	株式会社日立製作所 電子部品営業本部	副本部長 金丸 久雄
H	株式会社日立製作所 電子部品営業本部ﾏｰｹﾃｨﾝｸﾞ部	部長代理 浦上 清
H	株式会社日立製作所 半導体事業部	技術本部長 初鹿野 凱一
H	株式会社日立製作所 電子部品営業本部 ﾏｰｹﾃｨﾝｸﾞ部	部長 竹川 正之
H	株式会社日立製作所 電子部品営業本部マーケティング部	主任 周藤 仁吉
H	株式会社日立製作所	取締役副社長 浅野 弘
H	株式会社日立製作所	武蔵工場長 牧本 次生
H	日立金属株式会社 営業本部	主席調査役 江上 種一
H	株式会社日立製作所 総研 経済ｸﾞﾙｰﾌﾟ	研究員 蓮沼 利建
H	ＨＯＹＡ株式会社 電子事業部海外部	取締役部長 打矢 文俊

H	ＨＯＹＡ株式会社	専務取締役 奥津　小一郎
I	日本アイ・ビー・エム株式会社 野洲工場　電子部品生産	部長 橋本　孝久
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I	IBM Corporation Business Analysis	Manager Ed Boerger
I	IBM World Trade Asia Corporation	CCP Int'l Business Manager Carlton Mitchell
I	IBM World Trade Asia Corporation	 Merlene Mitchell
I	ICI Americas, Inc.	Project Manager Richard LaFrance
I	INMOS Corporation Marketing	Vice President A. C. D'Augustine
I	Inoue Consulting	 Inoue, Toru
I	インテル・ジャパン株式会社	営業本部長 傳田　信行
I	インテルジャパン株式会社	社長 加茂　剛弘
I	Intel Japan K.K Office of Development	Director T.W. Kang
I	泉シーアール・ボックス株式会社	副社長 菊地　富雄
J	J.H. Whiteny & Company	General Partner Russell Planitzer
J	ｼﾞｬｰﾃﾞｨﾝ･ﾌﾚﾐﾝｸﾞ 証券会社 調査部	ｱﾅﾘｽﾄ ﾆｺﾗｽ･ｴﾄﾞﾜｰﾄﾞ
K	兼松江商株式会社 産業電子機器部	部長 習田　高弘
K	兼松電子部品株式会社	常務取締役営業本部長 竹内　政明
K	川崎製鐵株式会社 LSI 事業推進部	部長 平井　信恒
K	株式会社小糸製作所 研究部	副部長 斉田　富三
L	Lex Electronics Business Development	Vice President Robert Newton
L	Lex Electronics Business Development	Vice President Malcolm Packer
L	ＬＳＩロジック株式会社 営業本部	本部長 知名　定清
L	ＬＳＩロジック株式会社	社長 八幡　恵介
L	LSI Logic Inc., Marketing	Vice President William O'Meara
L	エルティーエクス株式会社	代表取締役社長 木佐貫　寛
M	ジャパン マクニクス株式会社	社長 神山　治貴
M	ジャパン マクニクス株式会社 コンポーネント営業部	部長 小宮　千秋
M	Marco Group	Consultant Michael Bae

M	Marco Group		Euni Bae
M	丸紅電子エンジニアリング株式会社 企画室	室長	川合　重美
M	丸紅ハイテック株式会社 半導体装置事業部	取締役事業部長	安藤　孔一
M	丸紅ハイテック株式会社	取締役社長	木村　市太郎
M	松下電器産業株式会社 電子部品営業本部 商品一部	部長	楢田　善治
M	松下電器産業株式会社 開発本部製品開発推進ｾﾝﾀｰ	副参事	正田　耕一郎
M	松下電子工業株式会社 半導体事業本部経営企画部	部長	下村　宏
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M	MIPS Computer Systems Development Programs	Vice President	Skip Stritter
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M	三菱化成工業株式会社 電子材料部	次長	徳光　文穂
M	三菱電機株式会社 半導体製品企画部	主幹	釜原　紘一
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M	三菱金属株式会社 シリコン事業部	常務取締役	川田　洋一
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M	Monolithic Memories, Inc.		Retina Rae Donovan
M	Monolithic Memories, Inc. Marketing	Vice President	Timothy Propeck
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M	Monsanto Electronic Materials Co.	President	Jim Springgate
M	Motorola, Inc.	Regional Analyst	Bob Gonzalez
M	日本モトローラ株式会社 ﾏｰｹﾃｨﾝｸﾞ	Vice President & Director	Ted Jaros

*** 日本半導体国際会議出席者リスト ***

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M	日本モトローラ株式会社 営業推進本部企画部	次長 上中 誠男
M	Motorola, Inc.	 Carolee Jenkins
M	Motorola, Inc.	Vice President Bob Jenkins
M	Motorola, Inc.	Executive VP & General Manager Gary Tooker
M	Motorola, Inc.	Vice President & G.Manager, Asia C.D. Tam
M	Motorola, Inc. Ken Phillips	Director Communications
M	日本モトローラ株式会社 半導体事業部	取締役副社長 ﾘｯｸ･ﾔﾝﾂ
N	ナノメトリクスジャパン	代表取締役社長 四ヶ所 稔
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N	日本電気株式会社 資材第二部国際購買部	購買課長 川崎 雄二郎
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N	日本光学工業株式会社 精機事業部企画部第一企画課	次長 中村 信雄
N	日本光学工業株式会社 精機事業部	副事業部長 倉本 豊壽
N	日本光学工業株式会社	取締役・精機事業部長 吉田 庄一郎
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N	新日本製鐵株式会社 経営企画部	部長代理 台 文彦
N	新日本製鐵株式会社 第一技術研究所	主任研究員 谷 誠一郎
N	日産自動車株式会社 電子研究所	主任研究員 廣田 幸嗣
N	日製産業株式会社 電子営業本部 開発部	部長 松隈 毅

N	日本鋼管株式会社 総合企画部	主任部長 井戸　禎光
N	日本精工株式会社 電子研究所	副所長 野村　勉
N	日本電信電話株式会社	代表取締役副社長 北原　安定
N	NTT ｴﾚｸﾄﾛﾆｸｽ ﾃｸﾉﾛｼﾞｰ 株式会社	社長 豊田　博夫
N	日本電信電話株式会社 NTT技術開発部　通信網部門	通信網計画担当部長 久米　祐介
O	沖電気工業株式会社 電子デバイス事業本部	取締役IC事業部長 東　忠男
O	沖電気工業株式会社 電子ﾃﾞﾊﾞｲｽ事業本部IC事業部	IC事業企画部長 山川　正明
O	沖電気工業株式会社 電子ﾃﾞﾊﾞｲｽ営業本部営業企画部	計画課長 九里　泰朗
O	大倉商事株式会社 電子機械部	次長 柳沢　一夫
O	大倉商事株式会社 電子機械部	部長 市川　恵三
O	Ing. C. Olivetti & C., S.p.A.	Director of Quality, Corp. Staff Tito Conti
O	立石電機株式会社 制御機器事業本部　SC事業部	業務室長 浜口　邦憲
P	特許庁 第5部半導体機器	特許庁審判官・審査官 馬場　玄式
P	Prudential-Bache Securities	Vice President Richard Whittington
P	ベーチェ証券会社 調査部	ﾌｧｲﾅﾝｼｬﾙ・ｱﾅﾘｽﾄ ﾋﾟｰﾀｰ G. ｳﾙﾌ
P	Perkin-Elmer Corporation Semiconductor Equipment Group	Senior Marketing Specialist Thomas H. Lewis
P	Philips I.D.C.C. Sales & Mktg, Philips IC Products	Far East Manager Peter W. Bacon
P	日本ﾌﾟﾚｼｼﾞｮﾝ・ｻｰｷｯﾂ 株式会社 営業部	取締役・営業部長 太田　章
R	RCA Sales & Marketing -Asia Pacific	Director Charles Hanchett
R	株式会社リコー 電子ﾃﾞﾊﾞｲｽ事業部事業部長室企画課	課長 中山　春夫
R	Robert Bosch GmbH Technology Planning	Manager Gunter Matthai
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M	Mitsui High-Tec. Inc	Oumi, Isamu	No.118
M	MMI Japan K.K	Yamashita, Takao	No.053
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M	Monolithic Memories, Inc.	Mrs. Donovan	No.151
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M	Monsanto Japan Ltd.	Charles W. Cook	No.077

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Japanese Semiconductor Industry Conference

April 13–15, 1986
Hakone Prince Hotel
Hakone, Japan

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1986 JAPANESE SEMICONDUCTOR INDUSTRY CONFERENCE
Future VLSI and Applications

April 13-15, 1986
Hakone Prince Hotel
Hakone, Japan

SUNDAY, April 13

5:00 p.m. to 8:00 p.m.	**Registration**	*Main Lobby*
8:00 p.m. to 9:30 p.m.	**Cocktails**	*Congress Hall*

MONDAY, April 14

7:30 a.m.	**Buffet Breakfast**	*Restaurant Sakura* *Restaurant Potomac* *Restaurant Nanakamado*
7:30 a.m.	**Registration Continues**	*Hakone-en Hall*
8:30 a.m.	**Welcome** Gene Norrett Vice President and Associate Director Semiconductor Industry Group Dataquest Incorporated Manny Fernandez President Dataquest Incorporated	*Hakone-en Hall*
9:00 a.m.	**World Semiconductor Outlook** Osamu Ohtake Associate Director Japanese Semiconductor Industry Service Dataquest Japan Ltd.	*Hakone-en Hall*
9:30 a.m.	**Does it Make Sense to Make Memories?** Lane Mason Senior Industry Analyst Semiconductor Industry Service Dataquest Incorporated	*Hakone-en Hall*
10:00 a.m.	**Break**	*Garden*
10:30 a.m.	**High-Performance VLSI—Implications for Management** Donald W. Brooks President and Chief Executive Officer Fairchild Semiconductor Corporation	*Hakone-en Hall*
11:00 a.m.	**Future VLSI and Consumer Electronics** Fumio Kohno Director Senior General Manager Semiconductor Group Sony Corporation	*Hakone-en Hall*
11:30 a.m.	**Lunch**	*Restaurant Sakura*
1:00 p.m.	**Applications: Present and Future** Nagayoshi Nakano Research Analyst Japanese Semiconductor Industry Service Dataquest Japan Ltd.	*Hakone-en Hall*
1:30 p.m.	**Future VLSI Applications for the Automobile** Robert J. McMillin Director of Engineering Delco Electronics Corporation	*Hakone-en Hall*
~~2:00~~ p.m. 2^{30}	**Break**	*Garden*

(over)

1290 Ridder Park Drive, San Jose, CA 95131-2398, (408) 971-9000 Telex 171973

2:30 p.m. **Design Solutions with ASICs** .... *Hakone-en Hall*
Al Stein
Chairman and CEO
VLSI Technology, Incorporated

3:00 p.m. **The Impact of VLSI on Automatic Testing** .... *Hakone-en Hall*
Alex d'Arbeloff
President and CEO
Teradyne Incorporated

3:30 p.m. **Toward User-Friendly Integrated Circuits** .... *Hakone-en Hall*
Dr. Tsugio Makimoto
General Manager
Musashi Works
Hitachi, Limited

4:00 p.m. **Forming International Partnerships** .... *Hakone-en Hall*
James Riley Dr. Shih
Senior Vice President
Dataquest Incorporated

6:00 p.m. **Cocktails** .... *On the ship* Ashinoko Maru

7:00 p.m. **Dinner** .... *Restaurant Sakura*

8:00 p.m. **Dinner Speakers** .... *Hakone-en Hall*
Gary L. Tooker
Executive Vice President and General Manager
Motorola, Incorporated

Hiroshi Asano
Executive Vice President
Hitachi, Limited

TUESDAY, April 15

7:30 a.m. **Buffet Breakfast** .... *Restaurant Sakura*
Restaurant Potomac
Restaurant Nanakamado

9:00 a.m. **ULSI, INS, and the Future** .... *Hakone-en Hall*
Dr. Yasusada Kitahara
Senior Executive Vice President
Nippon Telegraph and Telephone Corporation

9:30 a.m. **Japanese Initiative and Cooperation in High-Tech Industry** .... *Hakone-en Hall*
Minoru Yoshida
President
Tokyo Electron Limited

10:00 a.m. **Application Strategies for Success** .... *Hakone-en Hall*
Noriaki Shimura
Managing Director
Casio Computer Company, Limited

10:30 a.m. **Break** .... *Garden*

11:00 a.m. **Supporting the Transition to VLSI Fabrication** .... *Hakone-en Hall*
James C. Morgan
President and CEO
Applied Materials Incorporated

11:30 a.m. **Silicon and Semiconductors—Partners in the '80s** .... *Hakone-en Hall*
Jim Springgate
President
Monsanto Electronic Materials Company

12:00 Noon **Corporate Alliances** .... *Hakone-en Hall*
Keiske Yawata
Chief Executive Officer
LSI Logic K.K.

12:30 p.m. **Lunch** .... *Restaurant Nanakamado*

2:15 p.m. **Perspective for the 1990s** .... *Hakone-en Hall*
Kimio Sato
Senior Managing Director
Mitsubishi Electric Corporation

2:45 p.m. **Status and Future—China Semiconductor Industry** .... *Hakone-en Hall*
Zhang Kai
Vice President
China National Electronic Devices Corporation

3:15 p.m.	**The Asia-Pacific Electronics Industry—An Industry in Transition** C.D. Tam Vice President and General Manager (Asia) Motorola, Incorporated	*Hakone-en Hall*
3:45 p.m.	**Break**	*Garden*
4:15 p.m.	**The Technology Challenge—Case of the Automobile** Masao Murayama Executive Managing Director Nippondenso Company Limited	*Hakone-en Hall*
4:45 p.m.	**The Taiwan VLSI Industry: 1986 and Beyond** Dr. ~~Chintay Shih~~ ~~Vice~~ President and ERSO General Manager Jim Riley ITRI	*Hakone-en Hall*
5:15 p.m.	**Closing Remarks** Frederick L. Zieber Executive Vice President Dataquest Incorporated	*Hakone-en Hall*
5:45 p.m.	**Cocktails**	*Congress Hall*
7:30 p.m.	**Buses depart for Tokyo**	

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Japanese Semiconductor Industry Conference
April 14 through 15, 1986
Hakone, Japan

List of Attendees

Masaaki Abe	Capital Research Company
Taizo Abe	Shinko Electric Company, Ltd.
Koichi Ando	Marubeni Hytech Co., Ltd.
Hiroshi Asano	Hitachi America, Ltd.
Alexander Au	Vitelic Corporation
Seiji Azuma	Asahi Chemical Industry Company, Ltd.
Peter Bacon	Philips I.D.C.C.
Michael Bae Euni Bae	Macro Group
K.S. Baek	Goldstar Semiconductor, Ltd.
Rene Berterottiere	Thomson-CSF Communications, Inc.
Ed Boerger	IBM Corporation
Donald Brooks	Fairchild Camera & Instrument Corp.
Bob Chamberlain	Megatest Corporation
James Chiang	Ford Motor Company
Sadakiyo China	LSI Logic K K
Peyton Cole	Fairchild Camera & Instrument Corp.
Tito Conti	Ing. C. Olivetti & C., S p A
Charles Cook	Monsanto Japan Ltd.
Patricia Cox	Dataquest Incorporated
Alexander D'Arbeloff	Teradyne, Inc.
A. C. D'Augustine	INMOS Corporation

Tom D'Elia	Department of State
Fumihiko Dai	Nippon Steel Corporation
Maureen Davies	Dataquest Incorporated
Nobuyuki Denda	Intel Japan, K.K.
Stephen Donovan Retina Rae Donovan	Monolithic Memories, Inc.
Richard Dyck	Teradyne K.K., Ltd.
Tanekazu Egami	Hitachi Metals, Ltd.
Manny Fernandez	Dataquest Incorporated
Eugene Flath	Intel International
Ichiro Fujitaka	NEC Corporation
Yasuhiko Fukuda	Mitsubishi Electric Corporation
Yasuyuki Fukuda	Tomen Electronics Corporation
L. R. Gibson	VLSI Technology, Inc.
Bob Gonzalez	Motorola, Inc.
Kuninori Hamaguchi	Omron Tateisi Electronics Co.
Charles Hanchett	RCA Corporation
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Yoshikazu Hatsukano	Hitachi, Ltd.
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Tadao Higashi	Oki Electric Industry Co., Ltd.
Nobuyuki Hirai	Kawasaki Steel Corporation
Yukitsugu Hirota	Nissan Motor Co., Ltd
Akira Honma	Fujitsu Busho Company

Yoshikazu Hori	Nippon Fairchild K.K.
Harry Horie	Tokyo Electron, Ltd.
Toshio Hoshino	Fuji Electric Company, Ltd.
Satoko Hoshizaki	Dataquest Japan, Ltd.
Diechard Huber	Wacker Chemitronic GmbH
David Hytha	AT&T International
Keizo Ichikawa	Okura & Co., Ltd.
Yoshimitsu Ido	Nippon Kokan K.K.
Noboru Iino	Rockwell International Corporation
Shunroku Ijichi	Wacker Chemicals East Asia, Ltd.
Yoshinori Inoi	Seiko Epson Corporation
Toru Inouye	Inouye Consultanting
Kazuto Irie	Toshiba Corporation
Yoichi Isago	Applied Materials, Inc.
Masataka Isobe	ESI Japan Company
Takio Itoh	Tokyo Electron, Ltd.
Eiichiro Iwaisaki	ESI Japan Company
Shigenori Iwakuma	Victor Company of Japan
Tetsuo Iwasaki	Applied Materials, Inc.
Ted Jaros	Nippon Motorola, Ltd.
Bob Jenkins	Motorola, Inc.
Carolee Jenkins	
Zhang Kai	China National Electronic Devices Corp.
Koichi Kamahara	Mitsubishi Chemical Industries
Nobuo Kamata	Soliton Systems K.K.
Haruki Kamiyama	Japan Macnics Corporation

Takahiro Kamo	Intel Japan, K.K.
Setsufumi Kamuro	Sharp Electronics Corporation
Hisao Kanamaru	Hitachi, Ltd.
Zen-ichi Kato	Sumitomo Metal Industries, Ltd.
Yoichi Kawada	Mitsubishi Metal Corporation
Shigemi Kawai	Marubeni Denshi Engineering Co.
Yujiro Kawasaki	NEC Corporation
Anthony Keig	Union Carbide Corporation
Michael Kennett	Ferranti Interdesign, Inc.
Tomio Kikuchi	Izumi CR Box Corporation
H. K. Kim	Samsung Semiconductor & Telecommunications Co., Ltd
S. H. Kim	Samsung Semiconductor & Telecommunications Co., Ltd.
Ichitaro Kimura	Marubeni Hytech Co., Ltd.
Yutaka Kisanuki	LTX Japan, Co., Ltd.
Yasusada Kitahara	Nippon Telegraph & Telephone Corporation
Fumio Kohno	Sony Corporation
Chiaki Komiya	Japan Macnics Corporation
Hiroshi Konno	Tokyo Systems Laboratories Ltd.
Masaichi Kubo	Matsushita Electronics Co., Ltd.
Yasuro Kunori	Oki Electric Industry Co., Ltd.
Toyohisa Kuramoto	Nippon Kogaku K.K.
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Shinkichi Kuribayashi	Fujitsu, Ltd.
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Steve Lemons	Department of State
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Bernard Levi	Thomson-CSF Communications, Inc.
Thomas Lewis	Perkin-Elmer Corporation
Chin-Tien Lin	Tatung Company
Yukihiko Machida	Sony Corporation
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Kinji Matsushima	Dai Nippon Printing Company
Yuji Matsushita	Tokyo Musen Kizai Co.
Dr. Gunter Matthai	Robert Bosch GmbH
Richard May	Harris K.K.
Robert McMillin	Delco Electronics Corporation
Takuo Mimura	General Electric (USA) Semiconductor, KK
Katsuaki Minami	Advantest Corporation
Carlton Mitchell Merlene Mitchell	IBM Word Trade Asia Corporation
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Tatsuo Morotomi	Idemitsu Petrochemical Company
Paul Mostek	AT&T

Masao Murayana	Nippondenso Company Limited
Saburo Nagae	New Japan Radio Co., Ltd.
Yoshihiko Nagasato	Asahi Chemical Industry Company, Ltd.
Akira Nakamura	Sumitomo Eaton Nova Corporation
Hidetaka Nakamura	Nihon Digital Equipment Corporation
Hiromichi Nakamura	Japan Silicon Co., Ltd.
Nobuo Nakamura	Nippon Kogaku K.K.
Nagayoshi Nakano	Dataquest Japan, Ltd.
Mamoru Nakao	Toshiba Corporation
Haruo Nakayama	Ricoh Company, Ltd.
Max Nanseki	Dataquest Japan, Ltd.
Robert Newton	Lex Electronics
Yoshio Nishimura	Nikkei McGraw-Hill, Inc.
Shigeru Nishioka	Canon Inc.
Tsutomu Nomura	Nippon Seiko K.K.
Gene Norrett	Dataquest Incorporated
Ronald Norris	Fairchild Semiconductor Asaia Inc.
Jun Numata	Sony Corporation
Bill O'Meara	LSI Logic Corporation
Akira Ohta	Nippon Procision Circuits Ltd.
Kazuo Ohta	Narumi China Corporation
Osamu Ohtake	Dataquest Japan, Ltd.
Koichiro Okutsu	Hoya Corporation
Isamu Oumi	Mitsui High-Tec, Inc.
Malcolm Packer	Lex Electronics

Ken Phillips	Motorola, Inc.
Russell Planitzer	J. H. Whitney & Company
John William Poduska Susan Poduska	Belmont Computer Inc.
James Prestridge	Teradyne, Inc.
Timothy Propeck	Monolithic Memories Corporation
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Ross Riley	Department of State
Martin Roth	Jardine Fleming Securities, Ltd.
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Kunishiro Saito	NEC Corporation
Keiko Sakimura	Dataquest Japan, Ltd.
Fernando Salgado	Westinghouse Elec/VenWest, Inc.
Itsuki Sano	GT Capital Management, Inc.
Vahe Sarkissian	Data General Corporation
Kimio Sato	Mitsubishi Electric Corporation
Richard Seaman	AG Associates
Masanobu Seiki	Sony Corporation
Satoshi Seki	Dataquest Japan, Ltd.
Chintay Shih	ERSO/ITRI
Minoru Shikasho	Nanometrics Japan Co.
Takashi Shima	Toshiba Corporation
Hiroshi Shimomura	Matsushita Electronics Co., Ltd.
Noriaki Shimura	Casio Computer Company, Ltd.

James Shinn	Advanced Micro Devices, Inc.
Koichiro Shoda	Matsushita Electric Industry, Co., Ltd.
Takahiro Shuda	Kanematsu-Gosho Co., Ltd.
Jim Springgate	Monsanto Electronic Materials Company
Al Stein	VLSI Technology, Inc.
Skip Stritter	MIPS Computer Systems
Taro Sugawara	Shin-etsu Chemical Co., Ltd.
Jinkichi Suto	Hitachi, Ltd.
Fumio Suzuki	Mitsubishi Corporation
Saburo Szuki	Sumitomo Eaton Nova Corporation
Kenneth Tai	Sertek International Inc.
Minoru Takagi	Nippon Megatest K.K.
Masahiro Takahashi	Sony Corporation
C. Takehara	Union Carbide Corporation
Yoichiro Takekuro	Vacuum Metallurgical Co., Ltd.
Toshimasa Takekusa	IBM Japan, Ltd.
Masaaki Takeuchi	Kanematsu Electronic Components Corp.
C.D. Tam	Motorola, Inc.
Yuan-Sun Tang	Tatung Company
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Kenichi Tohyama	Tokyo Electron Ltd.
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Gary Tooker	Motorola, Inc.
Robert Tsao	United Microelectronics Corporation

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Fumitoshi Uchiya	Hoya Corporation
Nobuo Uenaka	Nippon Motorola, Ltd.
Kiyoshi Uragami	Hitachi, Ltd.
John Wagner	Union Carbide Corporation
Hideya Wakamatsu	Nippon Motorola, Ltd.
Sumio Washino	Shin-etsu Handotai Co., Ltd.
William Watson	National Semiconductor Japan, Ltd.
Richard Whittington	Prudential-Bache Securities
Peter Wolff	Prudential-Bache Securities
Reiko Yamadashima	Dataquest Japan, Ltd.
Nobuaki Yamaguchi	NEC Corporation
Seiichi Yamaguchi	Koito Manufacturing Company, Ltd.
Koki Yamakawa	Sumitomo Metal Industries, Ltd.
Masaaki Yamakawa	Oki Electric Industry Co., Ltd.
Nanako Yamane	Dataquest Japan, Ltd.
Kanehiro Yamashita	Alps Electric Company, Ltd.
Takao Yamashita	MMI Japan K.K.
Mitsuhiro Yamazaki	Soliton Systems K.K.
Atsuko Yanagisawa	Dataquest Japan, Ltd.
Kazuo Yanagisawa	Okura & Co., Ltd.
Keiske Yawata	Nihon LSI Logic Corporation
Stephen Yoder	Asian Wall Street Journal
Minoru Yoshida	General Electric Japan, Ltd.

Minoru Yoshida	Tokyo Electron Limited
Hideo Yoshizaki	Texas Instruments Japan, Ltd.
Rick Younts	Nippon Motorola, Ltd.
Frederick Zieber	Dataquest Incorporated

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Japanese Semiconductor Industry Conference
April 14 through 15, 1986
Hakone, Japan

List of Attendees

AG Associates	Richard Seaman, Director, Sales & Marketing
AT&T	Paul Mostek, Manager International Strategic Planning, Technology Systems
AT&T International	David Hytha, Market Development Manager, Components
Advanced Micro Devices, Inc.	James Shinn, General Manager
Advantest Corporation	Katsuaki Minami, General Manager
Alps Electric Company, Ltd.	Kanehiro Yamashita, Division Manager, Yokohama Division
Applied Materials, Inc.	Yoichi Isago, Managing Director Tetsuo Iwasaki, President James Morgan, President & CEO Gary Robertson, Managing Director
Asahi Chemical Industry Company, Ltd.	Seiji Azuma, Director, General Manager, Electronic Business Administration Hirotsugu Miyauchi, Executive Vice President Yoshihiko Nagasato, Electronics Administration, Assistant General Manager
Asahi Microsystems, Inc.	Kyoji Kurata, Manager
Asian Wall Street Journal	Stephen Yoder

Belmont Computer Inc.	John William Poduska, Chairman of the Board & CEO Susan Poduska
Canon Inc.	Shigeru Nishioka. Senior Managing Director, Group Executive
Capital Research Company	Masaaki Abe, Investment Analyst
Casio Computer Company, Ltd.	Noriaki Shimura, Managing Driector
China National Electronic Devices Corporation	Zhang Kai, Vice President
Dai Nippon Printing Company	Kinji Matsushima, Manager, Micro Products Division Overseas
Data General Corporation	Vahe Sarkissian. Vice President
Dataquest Incorporated	Patricia Cox, Research Analyst Maureen Davies, Conference Assistant Manny Fernandez, President Lane Mason, Senior Industry Analyst Gene Norrett, Vice President & Director, Japanese Semiconductor Industry Service Jim Riley, Senior Vice President, Semiconductor Industry Service Sheridan Tatsuno, Industry Analyst Frederick Zieber. Executive Vice President & General Manager, Technology Operations
Dataquest Japan, Ltd.	Satoko Hoshizaki. Conference Assistant Shigeru Morishita. Senior Vice President & General Manager Nagayoshi Nakano. Research Analyst Max Nanseki. Marketing Manager Keiko Sakimura Osamu Ohtake, Associate Director Satoshi Seki Marketing Manager Nanako Yamane, Conference Assistant Reiko Yamadashima. Conference Assistant Atsuko Yanagisawa

Delco Electronics Corporation	Robert McMillin, Director, Engineering
Department of State	Tom E'Elia, International Economist Steve Lemons, International Economist Ross Riley, International Economist
ERSO/ITRI	Chintay Shih, Vice President & General Director
ESI Japan Company	Masataka Isobe, General Manager Eiichiro Iwaisaki, Sales Manager
Exar Corporation	Nobuo Hatta, President
Fairchild Camera & Instrument Corporation	Donald Brooks, President & Chief Executive Officer
Fairchild Semiconductor Asaia Inc.	Ronald Norris, Executive Vice President
Ferranti Interdesign, Inc.	Michael Kennett, Vice President, Marketing & Sales
Ford Motor Company	James Chiang, Asia-Pacific Liason Engineer
Fuji Electric Company, Ltd.	Toshio Hoshino, General Manager, Electronic Group IC
Fujitsu Busho Company	Akira Honma, General Manager
Fujitsu, Ltd.	Shinkichi Kuribayashi, Manager, Domestic Marketing, S/D Devices
GT Capital Management, Inc.	Itsuki Sano, Director
General Electric (USA) Semiconductor, KK	Takuo Mimura

General Electric Japan, Ltd.	Minoru Yoshida, Manager
Harris K K.	Richard May, President
Hitachi America, Ltd.	Hiroshi Asano, Executive Vice President
Hitachi Metals, Ltd.	Tanekazu Egami, General Manager, Corporate Sales Administration
Hitachi, Ltd.	Toshitake Hasunuma, Researcher Yoshikazu Hatsukano, Deputy General Manager Hisao Kanamaru, Deputy Group Manager, Electronics Device Sales Office Tsugio Makimoto, Deputy General Manager, Musahi Works Jinkichi Suto, Assistant Manager, Market & Planning Department Kiyoshi Uragami, Manager, Marketing & Planning Department
HOYA Corporation	Koichiro Okutsu, Executive Managing Director Fumitoshi Uchiya, Deputy General Manager
IBM Corporation	Ed Boerger, Manager, Business Analysis
IBM Japan, Ltd.	Takahisa Hashimoto, Manager of Component Operations, Yasu Plant Toshimasa Takekusa, Technology Evolution Manager
IBM Word Trade Asia Corporation	Carlton Mitchell, CCP International Business Manager Merlene Mitchell
ICI Americas, Inc.	Richard LaFrance, Project Manager
INMOS Corporation	A. C D'Augustine, Vice President, Marketing

Idemitsu Petrochemical Company	Tatsuo Morotomi, Manager, Commercial Development
Ing. C. Olivetti & C., S.p.A.	Tito Conti, Director of Quality, Corporate Staff
Inouye Consultanting	Toru Inouye, Consultant
Intel Corporation	Eugene Flath, Executive Vice President
Intel Japan, K.K.	Nobuyuki Denda, General Sales Manager Takahiro Kamo, President
Izumi CR Box Corporation	Tomio Kikuchi, Vice President
J. H. Whitney & Company	Russell Planitzer, General Partner
Japan Macnics Corporation	Haruki Kamiyama, President Chiaki Komiya, Director
Japan Silicon Co., Ltd.	Hiromichi Nakamura, Executive Vice President
Jardine Fleming Securities, Ltd.	Martin Roth, Analyst, Research Department
Kanematsu Electronic Components Corporation	Masaaki Takeuchi, Managing Director
Kanematsu-Gosho Co., Ltd.	Takahiro Shuda, Manager
Kawasaki Steel Corporation	Nobuyuki Hirai, General Manager, LSI Department
Koito Manufacturing Company, Ltd.	Tomizo Saita, Manager, Research & Development Division Seiichi Yamaguchi, Executive Managing Director

LSI Logic K.K.	Sadakiyo China, General Manager
LTX Japan, Co., Ltd.	Yutaka Kisanuki, President
Lex Electronics	Robert Newton, Vice President, Business Development Malcolm Packer, Vice President, Business Development
MIPS Computer Systems	Skip Stritter, Vice President, Engineering
MMI Japan K.K.	Takao Yamashita, Marketing Manager
Macro Group	Michael Bae, Consultant Euni Bae
Marubeni Denshi Engineering Co.	Shigemi Kawai, Consultant, Marketing
Marubeni Hytech Co., Ltd.	Koichi Ando, Director, General Manager Ichitaro Kimura, President
Matsushita Electric Industry Co., Ltd.	Yoshiharu Kusuda, General Manager Jim Miyamoto, Senior Coordinator Koichiro Shoda, Manager, Corporat Product Development Center
Matsushita Electronics Co., Ltd.	Masaichi Kubo, Director, Semicon Division Engineering Center Hiroshi Shimomura, General Manager
Megatest Corporation	Bob Chamberlain, Vice President, Sales
Mitsubishi Chemical Industries	Koichi Kamahara, Assistant Manager Fumio Tokumitsu, Senior Manager

Mitsubishi Corporation	Fumio Suzuki, Assistant General Manager Newer Metals & Products Department
Mitsubishi Electric Corporation	Yasuhiko Fukuda, Group Manager, Electronic Devices Group Kimio Sato, Senior Managing Director
Mitsubishi Metal Corporation	Yoichi Kawada, Managing Director, Silicon Division
Mitsubushi Electric Corporation	Yasuhiko Fukuda, Group Manager, Electronic Devices Group
Mitsui High-Tec, Inc.	Isamu Oumi, Operating Officer
Monolithic Memories, Inc.	Stephen Donovan, Marketing Manager Retina Rae Donovan Timothy Propeck, Vice President, Marketing
Monsanto Electronic Materials Company	Jim Springgate, President
Monsanto Japan Ltd.	Charles Cook, Vice President, Electronic Materials Division Robert Lerch, Director Silicon Operations, Electronic Materials Division
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NEC Corporation	Ichiro Fujitaka, Microcomputer Engineering Department Manager Yujiro Kawasaki, Purchasing Manager Kunishiro Saito, General Manager Akitake Tsuda, Assistant General Manager Nobuaki Yamaguchi, Marketing Promotion Division General Manager
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Narumi China Corporation	Kazuo Ohta, Director & General Manager
National Semiconductor Japan, Ltd.	William Watson, President
New Japan Radio Co., Ltd.	Saburo Nagae, General Manager
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Nihon LSI Logic Corporation	Keiske Yawata, President
Nikkei McGraw-Hill, Inc.	Yoshio Nishimura, Editor in Chief
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Nippon Kogaku K.K.	Toyohisa Kuramoto, Deputy General Manager Nobuo Nakamura, Manager, 1st Planning
Nippon Kokan K.K.	Yoshimitsu Ido, Manager
Nippon Megatest K.K.	Minoru Takagi, President
Nippon Motorola, Ltd.	Obie Hasty, Operations Manager Ted Jaros, Vice President & Director Nobuo Uenaka, Assistant Manager, Planning Department Hideya Wakamatsu, Manager Rick Younts, Executive Vice President & General Manager Semiconductor Products Operation

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Nippon Seiko K.K.	Tsutomu Nomura, Senior Manager
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Oki Electric Industry Co., Ltd.	Tadao Higashi, Corporate Director Yasuro Kunori, Manager, Marketing & Sales Division, Electronic Development Group Masaaki Yamakawa, Manager, Integrated Circuit Division
Okura & Co , Ltd.	Keizo Ichikawa, GM, Electronic Machinery Department Kazuo Yanagisawa, Deputy General Manager Electronic Machinery Department
Omron Tateisi Electronics Co.	Kuninori Hamaguchi, Administration Section Manager
Perkin-Elmer Corporation	Mir Ali, Manager, International Marketing Thomas Lewis, Senior Marketing Specialist

Philips I.D.C.C.	Peter Bacon, Philips IC Sales/Marketing Manager Far East
Prudential-Bache Securities	Richard Whittington, Vice President Peter Wolff
RCA Corporation	Charles Hanchett, Director, Sales & Marketing, Asian Pacific
Ricoh Company, Ltd.	Haruo Nakayama, Manager
Robert Bosch GmbH	Gunter Matthai, Manager, Technology Planning
Rockwell International Corporation	Noboru Iino, Regional Manager
Samsung Semiconductor & Telecommunications Co., Ltd.	H.K. Kim, Director S.H. Kim, General Manager, Planning Department
Seiko Epson Corporation	Yoshinori Inoi, Director, Semiconductor Operation Division
Sertek International Inc.	Kenneth Tai, General Manager
Sharp Electronics Corporation	Setsufumi Kamuro, Manager, Integrated Circuit Group
Shin-etsu Chemical Co., Ltd.	Taro Sugawara, Managing Director & General Manager, Materials Division
Shin-etsu Handotai Co., Ltd.	Sumio Washino, Section Chief, Corporate Planning Department
Shinko Electric Company, Ltd.	Taizo Abe, Director & GM, Hermetic Package Division

Soliton Systems K.K.	Nobuo Kamata, President Mitsuhiro Yamazaki, Vice President, Marketing
Sony Corporation	Fumio Kohno, Director, Senior General Manager Yukihiko Machida, Manager, Consumer Video Jun Numata, General Manager, Semicon Group Application Department Masanobu Seiki, General Manager, Semicon Group Masahiro Takahashi, Deputy Senior General Manager Semiconductor Group Katsuaki Tsurushima, General Manager
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Sumitomo Metal Industries, Ltd.	Zen-ichi Kato, Assistant Sales Manager Koki Yamakawa, Assistant Staff Manager
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Tokyo Electron, Ltd.	Harry Horie, Manager, Semiconductor Sales Department Takio Itoh, Manager, EC Marketing Department Kenichi Tohyama, Section Manager Minoru Yoshida, President
Tokyo Musen Kizai Co.	Yuji Matsushita, Staff Engineer
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Vacuum Metallurgical Co., Ltd.	Yoichiro Takekuro, Senior Managing Director
Victor Company of Japan	Shigenori Iwakuma, Manager, R&D Division
Vitelic Corporation	Alexander Au, President

Wacker Chemicals East Asia, Ltd.	Shunroku Ijichi, Manager, Technical Service Center
Wacker Chemitronic GmbH	Diechard Huber, Director, Diplom-Physiker, Materials & Application Research
Westinghouse Elec/VenWest, Inc.	Dennis Richardson, Associate Director, Energy & Advanced Technology Group Fernando Salgado, Principal Engineer, Energy & Advanced Technology Group
Zilog, Inc.	Wayne Ricciardi, Vice President, Marketing & Sales Computer Division

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JAPANESE SEMICONDUCTOR INDUSTRY CONFERENCE
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Lane Mason
Senior Industry Analyst
Dataquest Incorporated

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President and CEO
Fairchild Semiconductor Corporation

Fumio Kohno
Director, Senior General Manager
Semiconductor Group
Sony Corporation

Nagayoshi Nakano
Research Analyst
Dataquest Japan Limited

Robert J. McMillin
Director of Engineering
Delco Electronics Corporation

Al Stein
Chairman and CEO
VLSI Technology, Incorporated

Alex d'Arbeloff
President and CEO
Teradyne Incorporated

James Riley
Senior Vice President
Dataquest Incorporated

Gary Tooker
Executive Vice President and General Manager
Motorola, Incorporated

Hiroshi Asano
Executive Vice President
Hitachi, Limited

Keiske Yawata
Chief Executive Officer
LSI Logic K.K.

Dr. Yasusada Kitahara
Senior Executive Vice President
Nippon Telegraph and Telephone Corporation

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President and CEO
Applied Materials Incorporated

Noriaki Shimura
Managing Director
Casio Computer Company, Limited

Minoru Yoshida
President
Tokyo Electron Limited

Dr. Chintay Shih
Vice President and ERSO General Director
ITRI

Dr. Tsugio Makimoto
Deputy General Manager
Hitachi, Limited

Jim Springgate
President
Monsanto Electronic Materials Company

C.D. Tam
Vice President and General Manager
Motorola, Incorporated

Zhang Kai
Vice President
China National Electronic Devices Corporation

Masao Murayana
Executive Managing Director
Nippondenso Company Limited

Kimio Sato
Senior Managing Director
Mitsubishi Electric Corporation

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The Dun & Bradstreet Corporation

WORLD SEMICONDUCTOR OUTLOOK

Osamu Ohtake
Associate Director
Japanese Semiconductor Industry Service
Dataquest Incorporated

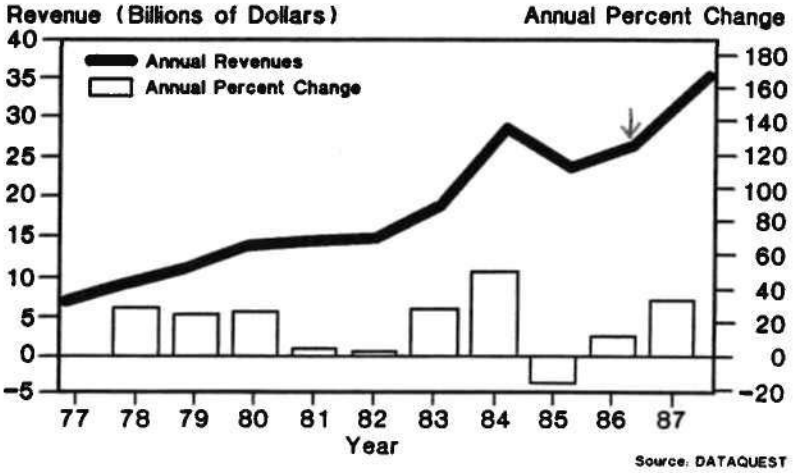
Mr. Ohtake is the Tokyo-based Associate Director of Dataquest's Japanese Semiconductor Industry Service and is responsible for strategic research on technologies, markets, products, and manufacturers. In addition, he manages the Japanese Semiconductor Industry Service capacity data base. Prior to joining Dataquest, Mr. Ohtake worked for 10 years as a reporter and most recently as Components Group Manager, for Dempa Shimbun, a daily electronics industry newspaper published in Japan. He has also authored reports on the Japanese VLSI project and on semiconductor materials and equipment markets. Mr. Ohtake is a graduate of Tokyo Denki University, specializing in communications.

Dataquest Incorporated
JAPANESE SEMICONDUCTOR INDUSTRY CONFERENCE
April 13-15, 1986
Hakone, Japan

WORLD SEMICONDUCTOR OUTLOOK

OSAMU OHTAKE
Associate Director
Dataquest Japan

ESTIMATED WORLDWIDE SEMICONDUCTOR INDUSTRY



Source: DATAQUEST

THE WORST SEMICONDUCTOR RECESSION

Semiconductor Consumption
(Billions of Dollars)

	1984	1985	Percent Growth
United States	13.3	9.7	(27%)
Japan	8.7	8.5	(2%)
Europe	4.8	4.6	(4%)
ROW	2.1	1.7	(19%)
Total	28.9	24.5	(15%)

Source: DATAQUEST

THE WORST SEMICONDUCTOR RECESSION

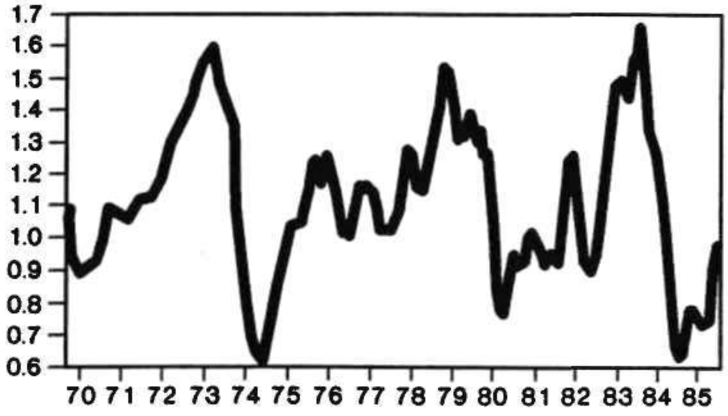
Top 10 Manufacturers

	1984		1985		
	No.	Millions of Dollars	No.	Millions of Dollars	Percent Change
NEC	3	2,251	1	1,984	(11.9%)
Motorola	2	2,320	2	1,850	(20.3%)
Texas Instruments	1	2,480	3	1,766	(28.8%)
Hitachi	4	2,052	4	1,671	(18.6%)
Toshiba	5	1,561	5	1,459	(6.5%)
Philips/Signetics	6	1,325	6	1,068	(19.4%)
Fujitsu	9	1,190	7	1,020	(14.3%)
Intel	8	1,201	8	1,020	(15.1%)
National	7	1,263	9	940	(25.6%)
Matsushita	12	928	10	906	(2.4%)

Source: DATAQUEST

THE WORST SEMICONDUCTOR RECESSION
BOOK-TO-BILL RATIO

U.S. IC Consumption



Source: DATAQUEST

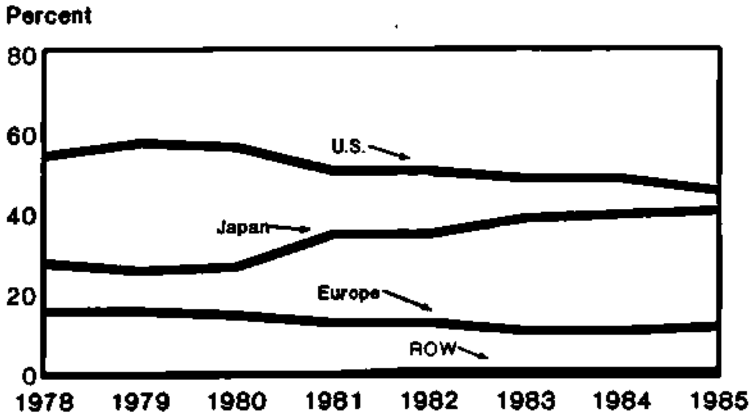
JAPANESE SEMICONDUCTOR INDUSTRY STATUS

1985/1986

- WORST REVENUE AND PROFITABILITY DECLINE
- EXCESS CAPACITY IN 1985
- INCREASING WORLD MARKET SHARE
- TRADE FRICTION/LAWSUITS
- REVOLUTION IN TECHNOLOGY ALLIANCES

REGIONAL MARKET SHIFTS

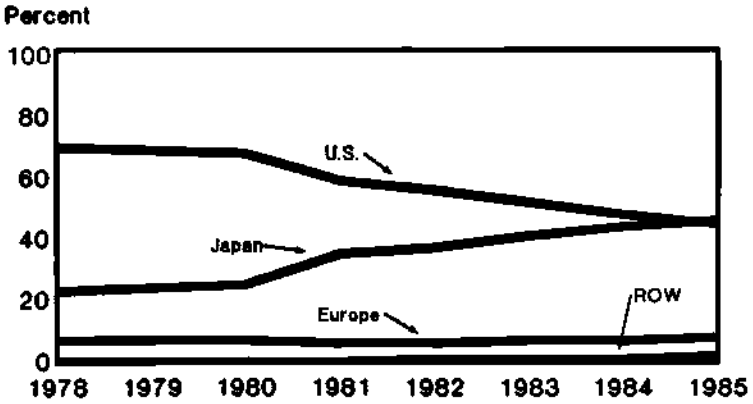
Total Semiconductors



Source: DATAQUEST

PRODUCT MARKET SHIFTS

Total MOS



Source: DATAQUEST

PRODUCT MARKET SHIFTS

REGIONAL MANUFACTURERS' SHARES OF TOTAL MOS

(Percent)

	1978	1980	1983	1985
UNITED STATES	70.0	67.8	51.6	45.0
JAPAN	23.0	25.4	40.8	45.9
EUROPE	7.0	6.7	6.6	7.6
OTHER	0	0.1	1.0	1.5

Source: DATAQUEST

MOS MEMORY RANKINGS--1985

1984 RANK	1985 RANK	COMPANY	1984 REVENUES ($M)	1985 REVENUE ($M)	PERCENT CHANGE
1	1	• HITACHI	971	662	(31.8)
2	2	• NEC	713	470	(34.1)
3	4	TI	693	345	(50.2)
4	3	• FUJITSU	527	412	(21.8)
5	5	• TOSHIBA	396	288	(27.3)
6	6	INTEL	380	280	(26.3)
8	16	MOSTEK	350	75	(87.1)
9	9	MOTOROLA	349	125	(64.2)
7	8	• MITSUBISHI	370	169	(54.3)
10	7	AMD	259	183	(29.3)
		TOTAL OF ABOVE	5,008	3,009	(35.9)

Source: DATAQUEST

CAPITAL SPENDING BY JAPANESE SEMICONDUCTOR COMPANIES

(Millions of Dollars)

	CAPITAL EXPENDITURES			% OF SEMI SALES		
	1983	1984	1985E	1983	1984	1985E
NEC	285	591	420	20	20	21
HITACHI	294	548	297	25	24	18
TOSHIBA	413	624	480	42	32	33
FUJITSU	234	527	280	37	36	28
MATSUSHITA	98	401	340	16	49	38
MITSUBISHI	149	295	224	34	26	32
SHARP	98	118	160	35	31	49
SANYO	55	148	184	17	28	40
OKI	67	118	100	29	37	33
TOTAL	1,693	3,370	2,485	27	31	28

E - Estimated

Source: DATAQUEST

CAPITAL SPENDING BY U.S. SEMICONDUCTOR COMPANIES

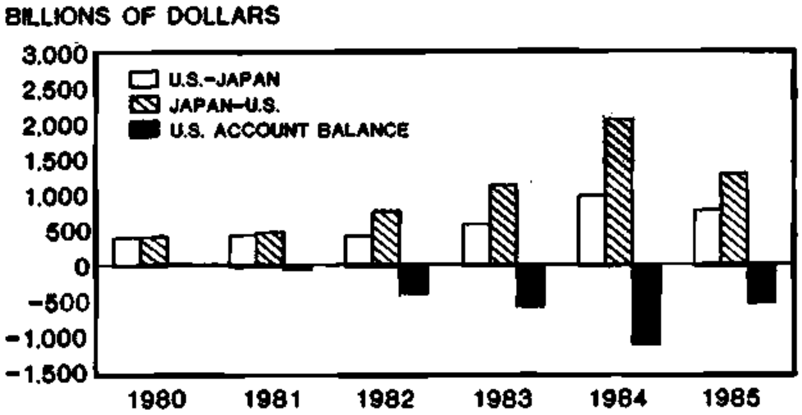
(Millions of Dollars)

	CAPITAL EXPENDITURES			% OF SEMI SALES		
	1983	1984	1985E	1983	1984	1985E
MOTOROLA	175	412	330	11	17	18
TI	232	472	348	14	19	20
NATIONAL	120	300	169	13	24	18
INTEL	145	388	194	19	32	19
AMD	111	237	120	22	25	20
FAIRCHILD	125	195	100	27	29	20
MOSTEK	78	123	27	25	26	21
SIGNETICS	58	133	65	13	17	16
MONOLITHIC MEM.	16	50	25	15	27	13
ANALOG DEVICES	14	40	20	10	20	10
TOTAL	1,074	2,350	1,398	14	21	17

E - Estimated

Source: DATAQUEST

ESTIMATED U.S.-JAPAN TRADE IN SEMICONDUCTORS



Source: DATAQUEST

RESULTS OF THE MEMORY WAR

1985

- RED INK FOR EVERYONE--U.S., EUROPE, JAPAN
- DYNAMIC RAM DEFECTIONS:
  - NSC--ALL
  - MOTOROLA--NMOS
  - INTEL--ALL
  - MOSTEK--ALL (?)
  - INMOS--WILL USE FOUNDRY

RESULTS OF THE MEMORY WAR

1985

- LAWSUITS--MICRON, INTEL/AMD/NSC
- TOTAL JAPANESE DOMINANCE IN HIGH-DENSITY SRAMs/DRAMs, COMING ON STRONG IN EPROMs
- NO STRONG U.S. RAM SUPPLIER
- CAN TOSHIBA PUSH 1Mb DRAM MARKET AS FAST AS IT CLAIMS?

ASIAN CONNECTION

- WHAT TRENDS ARE EMERGING?
- WHO IS TEAMING UP?
- WHY ARE THEY TEAMING UP?
- WHEN ARE PARTNERSHIPS CRUCIAL?
- HOW ARE PARTNERSHIPS BEING ORGANIZED?
- WHERE IS MANUFACTURING LOCATED?

SOUTH KOREANS--
THE REAL STORY

	($ Millions) 1984	1985
PRODUCTION	1,259	994
CONSUMPTION	304	255
NATIVE PRODUCTION		
SAMSUNG – Mr. Kim	60	95
GOLDSTAR	15	35
KEC	26	38
HYUNDAI	0	0

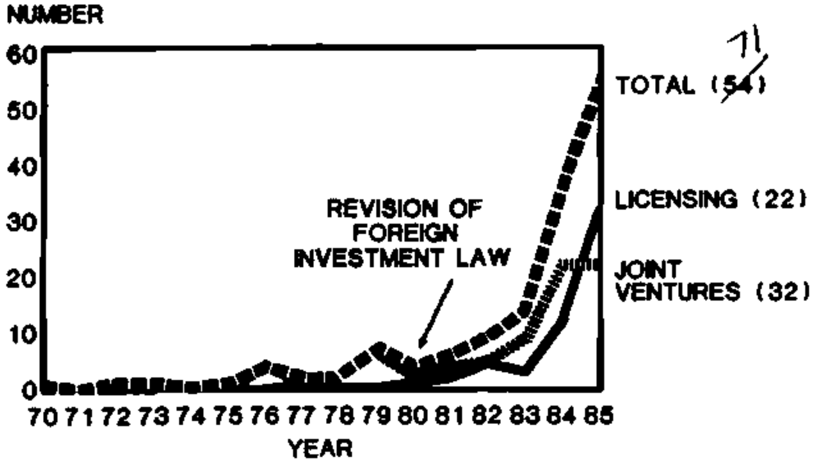
Source: DATAQUEST

ASIAN PARTNERSHIP STRATEGIES

SALES AND MARKETING	TECHNICAL TIES	MANUFACTURING
SALES AGENCY	ONE-WAY LICENSING	SILICON FOUNDRY
SALES OFFICE	TECHNOLOGY EXCHANGE	ASSEMBLY AND TEST
DISTRIBUTOR	JOINT DEVELOPMENT	WAFER FAB
MARKET INTELLIGENCE		ALL PRODUCTION

Source: DATAQUEST

TRENDS IN JOINT VENTURES AND LICENSING

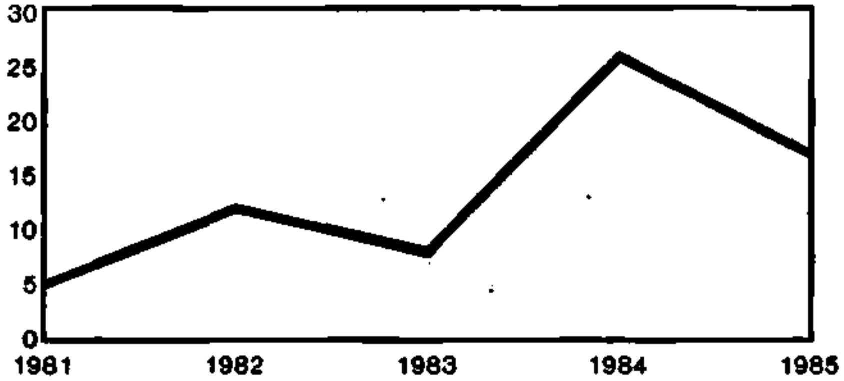


MEMORY--THE SHIFT TO CMOS PARTNERSHIPS (1984-1985)

JAPANESE COMPANY	FOREIGN COMPANY	PRODUCT LINE
FUJITSU	INTEL	EPROMs (ON MPUs)
NMB SEMI.	INMOS	256K CMOS DRAMs
OKI ELECTRIC	EXEL	16K EEPROMs/16K SRAMs/ASM
RICOH	PANATEC R&D MODULAR SEMI.	256K DRAMs
RICOH	ROCKWELL	64K CMOS EPROMs
RICOH	VLSI TECHNOLOGY	64K/128K/256K MASK ROMs
SHARP	RCA	256K CMOS DRAMs
SHARP	WAFER SCALE INTEGRATION	64K/256K CMOS EPROMs
SONY	VITELIC	64K CMOS DRAMs
SUWA SEIKOSHA	SMOS SYSTEMS	16K/64K CMOS SRAMs 64K/256K CMOS MASK ROMs

Source DATAQUEST

SEMICONDUCTOR EQUIPMENT AND MATERIALS JOINT VENTURES



Source: DATAQUEST

WHY STRATEGIC PARTNERSHIPS?

DEFENSE

- WORK WITH POTENTIAL RIVALS
- KEEP OUT COMPETITORS
- AVOID "BOOMERANG EFFECT"
- MONITOR TECHNOLOGY AND MARKET TRENDS

OFFENSE

- SECURE TECHNOLOGIES
- GAIN ACCESS TO MARKETS
- FILL IN PRODUCT PORTFOLIOS
- USE SILICON FOUNDRIES
- CUT PRODUCTION COSTS

Source: DATAQUEST

ASICs--APPLICATION-SPECIFIC PARTNERSHIPS
(1983-1985)

AMERICAN COMPANY	ASIAN COMPANY	PRODUCT LINE
AMI	ASAHI CHEMICAL	CMOS CUSTOM AND GATE ARRAYS
CUSTOM MOS ARRAYS	RICOH	CMOS GATE ARRAYS
INT'L COMPUTER	FUJITSU	GATE ARRAYS
LSI LOGIC	SHARP	CMOS WAFERS
	MITSUBISHI	CMOS WAFERS (NOT TOSHIBA)
	TOSHIBA	1K TO 10K GATE ARRAYS
MICRO-CIRCUIT	KANEMATSU SEMI.	IMPORT GATE ARRAYS
MICRO LINEAR	NIHON TEKSEL	SALES AGENCY
MMI	FUJITSU	TTL GATE ARRAYS
RCA	SHARP	JOINT DESIGN CENTER AND FAB
SMOS SYSTEMS	SUWA SEIKOSHA	CMOS GATE ARRAYS
SPERRY	MITSUBISHI	GATE ARRAYS
TEXAS INSTRUMENTS	FUJITSU	H-CMOS AND STTL GATE ARRAYS

Source: DATAQUEST

ESTIMATED JAPAN QUARTERLY SEMICONDUCTOR CONSUMPTION

(Millions of Dollars)

1985

	Q1	Q2	Q3	Q4	TOTAL
DISCRETE	$ 475	$ 474	$ 492	$ 591	$2,032
IC	1,584	1,579	1,583	1,821	6,567
TOTAL	$2,059	$2,053	$2,075	$2,412	$8,599
% CHANGE		(0.3%)	1.1%	16.2%	(2.8%)

1986

	Q1	Q2	Q3	Q4	TOTAL
DISCRETE	$ 610	$ 625	$ 639	$ 664	$ 2,538
IC	1,909	2,045	2,184	2,363	8,501
TOTAL	$2,519	$2,670	$2,823	$3,027	$11,039
% CHANGE	4.4%	6.0%	5.7%	7.2%	(28.4%) -- ?

Source: DATAQUEST

only 10% up in ~~units~~ yen

ESTIMATED U.S. QUARTERLY SEMICONDUCTOR CONSUMPTION

(Millions of Dollars)

	1985				
	Q1	Q2	Q3	Q4	TOTAL
DISCRETE	$ 494	$ 480	$ 451	$ 472	$1,897
IC	2,210	1,960	1,788	1,736	7,693
TOTAL	$2,704	$2,440	$2,239	$2,207	$9,590
% CHANGE		(9.8%)	(8.2%)	(1.4%)	(27.0%)

	1986				
	Q1	Q2	Q3	Q4	TOTAL
DISCRETE	$ 486	$ 526	$ 550	$ 597	$ 2,158
IC	1,807	2,008	2,181	2,470	8,466
TOTAL	$2,293	$2,533	$2,731	$3,067	$10,624
% CHANGE	3.9%	10.5%	7.8%	12.3%	10.8%

Source: DATAQUEST

ESTIMATED WORLDWIDE SEMICONDUCTOR CONSUMPTION

(Billions of Dollars)

	1986	1991	1996
U.S.	$10.6	$26.0	$ 66.9
JAPAN	11.0	28.0	78.0
EUROPE	4.9	12.0	32.2
ROW	2.2	5.5	14.1
WORLDWIDE	$28.7	$71.5	$191.2

Source: DATAQUEST

LONG-TERM RESULTS OF REGION AND PRODUCT SHIFTS

- INFRASTRUCTURE CHANGING TO MORE AND LARGER JAPANESE PLAYERS
- WALL STREET'S VIEW CHANGING
- EMPLOYMENT PATTERN SHIFTING To Asia
- HEAVY GOVERNMENT AND LEGAL INVOLVEMENT
- PURCHASING CENTERS CHANGING TO FAR EAST

ESTIMATED EUROPE QUARTERLY SEMICONDUCTOR CONSUMPTION

(Millions of Dollars)

	1985				
	Q1	Q2	Q3	Q4	TOTAL
DISCRETE	$ 316	$ 303	$ 285	$ 285	$1,189
IC	985	886	793	779	3,443
TOTAL	$1,301	$1,189	$1,078	$1,064	$4,632
% CHANGE		(8.6%)	(9.3%)	(1.3%)	(3.6%)

	1986				
	Q1	Q2	Q3	Q4	TOTAL
DISCRETE	$ 283	$ 305	$ 320	$ 336	$1,244
IC	759	825	955	$1,140	3,679
TOTAL	$1,042	$1,130	$1,275	$1,476	$4,923
% CHANGE	(2.1%)	8.4%	12.8%	15.8%	6.3%

Source: DATAQUEST

ESTIMATED ROW QUARTERLY SEMICONDUCTOR CONSUMPTION

(Millions of Dollars)

1985

	Q1	Q2	Q3	Q4	TOTAL
DISCRETE	$180	$178	$183	$220	$ 761
IC	312	294	277	272	1,155
TOTAL	$492	$472	$460	$492	$1,916
% CHANGE		(4.1%)	(2.5%)	7.0%	(16.6%)

1986

	Q1	Q2	Q3	Q4	TOTAL
DISCRETE	$224	$231	$238	$247	$ 940
IC	276	298	322	361	1,257
TOTAL	$500	$529	$560	$608	$2,197
% CHANGE	1.6%	5.8%	5.9%	8.6%	14.7%

Source: DATAQUEST

CONCLUSIONS

THE NEXT FIVE YEARS

- EXCESS CAPACITY
- BUSINESS CYCLES WILL CONTINUE
- INTENSE COMPETITION
- CONTINUING SHIFT IN MARKET SHARE
- MODERATION IN PRICES

Q & A

1. Will Japanese capital spending rate continue?
2. Change in Japanese end base (1984-85)?

Dataquest
a company of
The Dun & Bradstreet Corporation

DOES IT MAKE SENSE TO MAKE MEMORIES?

Lane Mason
Senior Industry Analyst
Semiconductor Industry Service
Dataquest Incorporated

Mr. Mason is a Senior Industry Analyst for Dataquest's Semiconductor Industry Service. He has been with Dataquest for eight years, during which he has gained increased responsibility for coverage of the MOS memory and bipolar markets, as well as general research support. Previously, Mr. Mason worked for Hughes Aircraft Company and Raychem Corporation. He has a B.S. degree in Physics from the California Institute of Technology and has done graduate work at the University of California at Los Angeles in the Department of Economics.

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DOES IT MAKE SENSE TO MAKE MEMORIES?

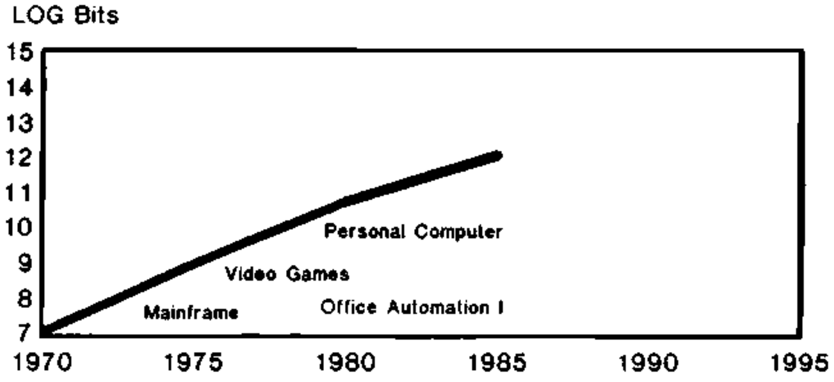
LANE MASON
Senior Industry Analyst
Dataquest Incorporated

PROGRAM

- Outlook: Yesterday and Tomorrow
- Profit and Loss
- Memory Producers' Problems
- Issues and Choices

MARKET OUTLOOK: YESTERDAY AND TOMORROW

MOS Memory Bits Shipped



Source DATAQUEST

Average 100% CAGR bit growth rate

145×10^{12} bits shipped (1985)

⇒ 145 trillion bits

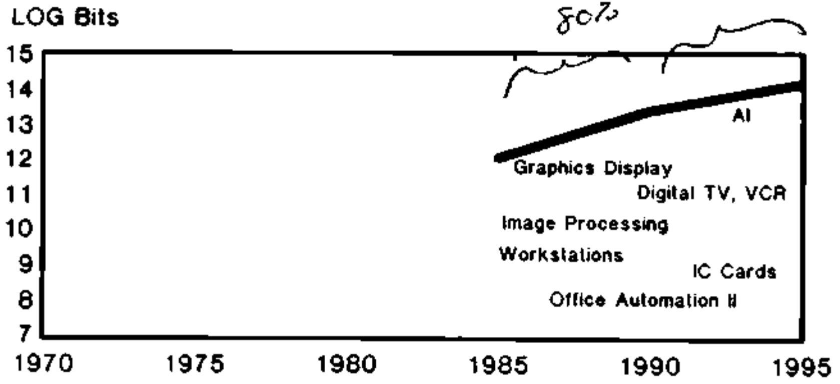
bit-mapped processing

Digital TV

MARKET OUTLOOK: YESTERDAY AND TOMORROW

MOS Memory Bits Shipped

80% 50% CAGR bit growth



Source DATAQUEST

Lower bit-cost

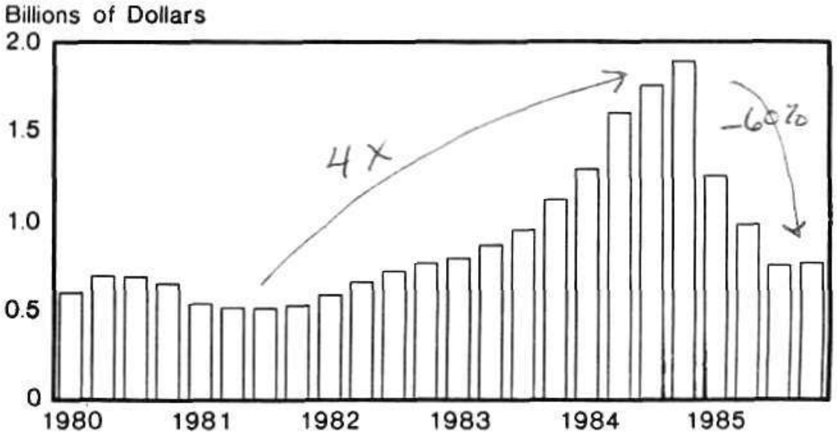
↓

compete with FD storage media

Slowing bit ~~ga~~ growth → lower margins

PROFIT AND LOSS

Quarterly MOS Memory Revenue

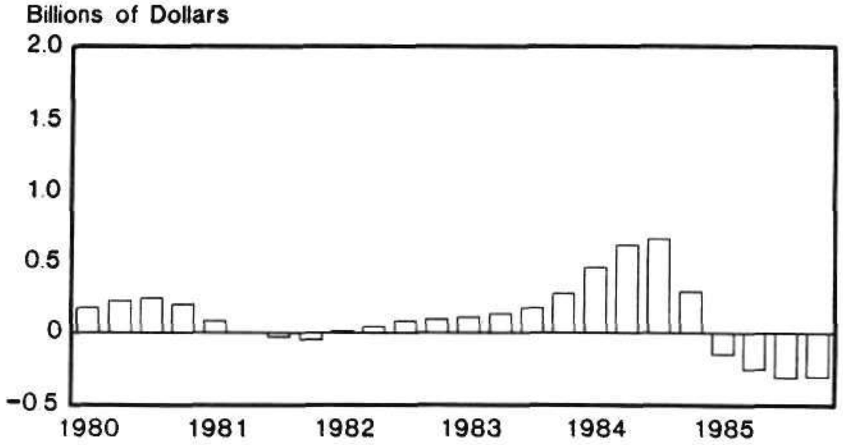


Source DATAQUEST

bit growth
100% (1980-84)
35% (1985)

PROFIT AND LOSS

Estimated Pretax Profit



Source: DATAQUEST

PROFIT AND LOSS

1985 Estimated Pretax Losses
Memory Products

U.S. Companies	Revenues ($M)	Pretax Loss ($M)
AMD	$ 193	$ 35
Texas Instruments	330	90
Mostek (now Thomson)	77	250
Micron Technology	39	40
Intel	283	45
Motorola	93	40
Seeq	29	19
Xicor	32	19
National Semiconductor	64	14
Other U.S.	313	107
Total U.S.	$1,453	$609

Source: DATAQUEST

PROFIT AND LOSS

1985 Estimated Pretax Losses
Memory Products

	Revenues ($M)	Pretax Loss ($M)
U.S.	$1453	$ 609
Europe	190	60
Japan	2285	400
ROW	39	100
Total	$3967	$1169 conservative

Source: DATAQUEST

no profits till Q3/86

PROFIT AND LOSS

- Inventory write-downs
- Asset write-downs (Mostek, Exel)
- Fixed charges (depreciation)
- Variable charges (prices)

PROFIT AND LOSS

U.S. Companies' Layoffs - 1985

Mostek	10,000
Texas Instruments	5,000
Intel	3,000
Motorola	6,000
National Semiconductor	7,000
Others	23,000
Total	54,000

Source: DATAQUEST

PROFIT AND LOSS

Casualties of RAM wars . . .

- Mostek – DRAMs
- Inmos – DRAMs
- NSC – DRAMs
- Motorola – NMOS DRAMs
- Intel – DRAMs
- (Mostek Corporation)

PROFIT AND LOSS

E Pluribus Unum
Integrated Device Technology

Memory Sales	$45M
Est. Memory Pretax Profit	$ 4M

Source: DATAQUEST

MEMORY PRODUCERS' PROBLEMS

Industry problems facing all
memory manufacturers:

- Characteristics of the industry
- Ignorance of market mechanisms
- Varying motives for participation
- Market information failures
- Market features

Little companies can do; few unassailable positions.
Fast, unpredictable, capital-intensive; "foundation
for other products"

MEMORY PRODUCERS' PROBLEMS

Characteristics of the industry:

- Free competition
- Cyclical nature
- High fixed cost
- Users: wait for more price decline

MEMORY PRODUCERS' PROBLEMS

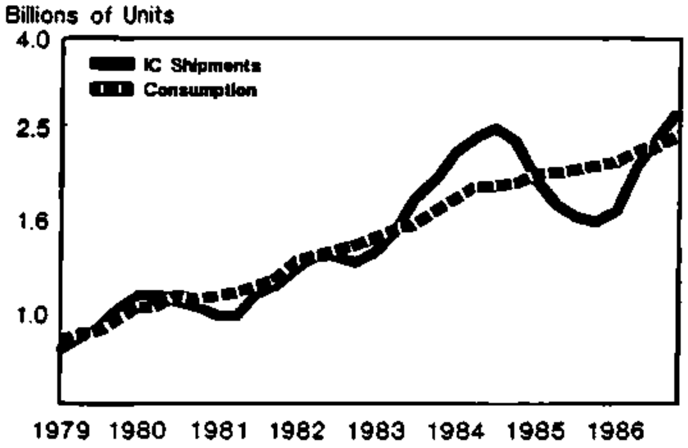
MOS Memory Manufacturers – 1985
(Millions of Dollars)

Revenues	Number of Companies
$200+	6
$100-200	2
$50-100	9
$25-50	10
$<25	26
	53

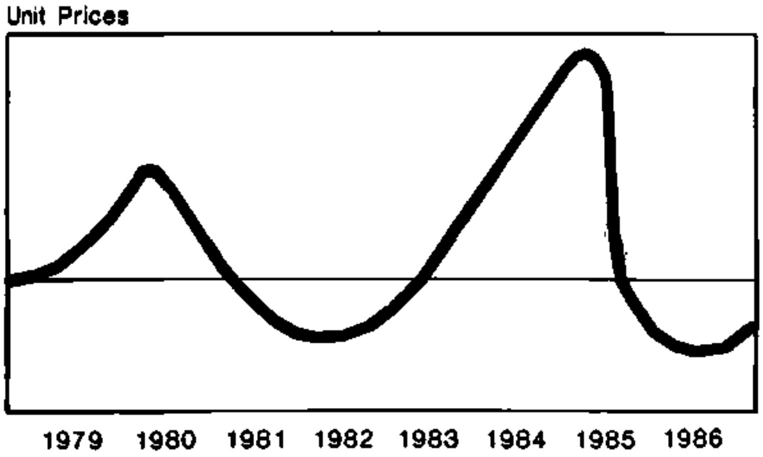
Source DATAQUEST

MEMORY PRODUCERS' PROBLEMS

U.S. IC Units

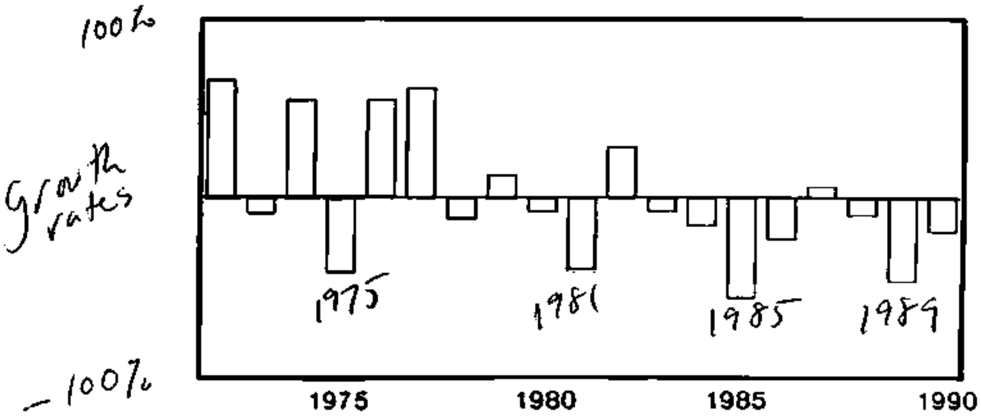


MEMORY PRODUCERS' PROBLEMS



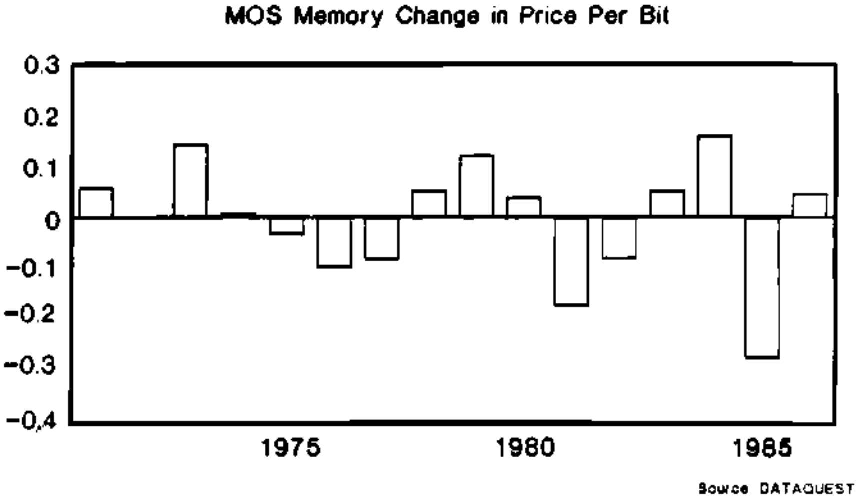
MEMORY PRODUCERS' PROBLEMS

MOS Memory Bits Shipped



Source DATAQUEST

MEMORY PRODUCERS' PROBLEMS



MEMORY PRODUCERS' PROBLEMS

Ignorance of market mechanisms

- Short- and long-term price elasticity
- Response of price to supply-demand imbalance

MEMORY PRODUCERS' PROBLEMS

Different motives for participation:

- Profitability — low-profit makers are drivers
- Fill fab
- Process driver for the other LSI products
- VLSI (Vault into Large Sales Imperative)
- Product line synergy
- Historical relic

MEMORY PRODUCERS' PROBLEMS

Market information failures:

- Inventory excesses not fully appreciated
- Demand outlook overly optimistic for 1985
- Production capacity not monitored
- Slow response to weakness in late 1984/early 1985

MEMORY PRODUCERS' PROBLEMS

Market features:

- Commodity product
- High degree of substitutability
- Driven by new demand
- Steep learning curve

ISSUES AND CHOICES

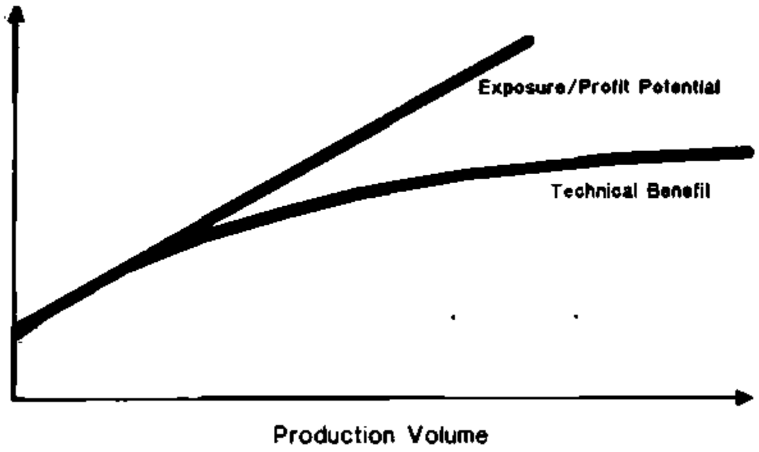
"In the long run, to be a significant competitor in the IC business, you need to produce MOS memory to drive your process."

ISSUES AND CHOICES

Company Decisions

- MOS memory?
- What are our motives?
- Can it be done with several niches?
- Long-term strategy/short term tactics . . . Can the cycle be countered?
- Make for yourself or use foundry?
- Naked memory product line?
- What synergy?
- Risk and rewards - how much is enough?
- What technology is transferred to other products?
- Are there alternatives to high exposure?
- How far will competition drag the price down?
- Is demand true or fluff?
- Can engineers substitute for high volume?
- What are competitor's costs?
- How much of market is dominated by manufacturing? . . .and what places are not?
- How much can our company afford?

ISSUES AND CHOICES



Source DATAQUEST

ISSUES AND CHOICES

Industry Decisions

- User-vendor communication
- Rational corporate decision-making
- Better market intelligence
  - Demand
  - Inventory levels
  - Capacity
  - Early warning
  - Investment, costs and profits
- Improved understanding of market mechanics

ISSUES AND CHOICES

Year	Market Decline
1981	(17%)
1985	(39%)
1989	?

Source DATAQUEST

Q & A

1. How do you view silicon foundry alliance strategy?

Must be well-managed; less control. Process/design compatibility required. Diverse interests. Other vendors' prodn

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HIGH-PERFORMANCE VLSI--IMPLICATIONS FOR MANAGEMENT

Donald W. Brooks
President and Chief Executive Officer
Fairchild Semiconductor Corporation

Mr. Brooks is President and Chief Executive Officer of Fairchild Semiconductor Corporation and Executive Vice President of Schlumberger Limited. He came to Fairchild from Texas Instruments where he was Senior Vice President, Digital and Military Group. Prior to that assignment, Mr. Brooks was Senior Vice President of TI's MOS Memory Division. He spent 25 years at Texas Instruments, where he also held several other key management positions. Mr. Brooks received a Bachelor of Science degree in Electronic Engineering from Southern Methodist University in Texas.

Dataquest Incorporated
JAPANESE SEMICONDUCTOR INDUSTRY CONFERENCE
April 13-15, 1986
Hakone, Japan

FAIRCHILD
A Schlumberger Company

HIGH PERFORMANCE VLSI

IMPLICATIONS FOR MANAGEMENT

BY

DONALD W. BROOKS
PRESIDENT AND CEO

FAIRCHILD SEMICONDUCTOR CORPORATION

FAIRCHILD
A Schlumberger Company

AGENDA

I. APPLICATIONS DRIVERS
II. TECHNOLOGIES
III. EXAMPLES
IV. CAPABILITIES
V. LOCAL PRESENCE

1) advanced processing – VLSI densities
2)
3)
4) use of mixed technologies – chip-level – bipolar/mos
– board – GaAs/Si

HIGH PERFORMANCE APPLICATIONS

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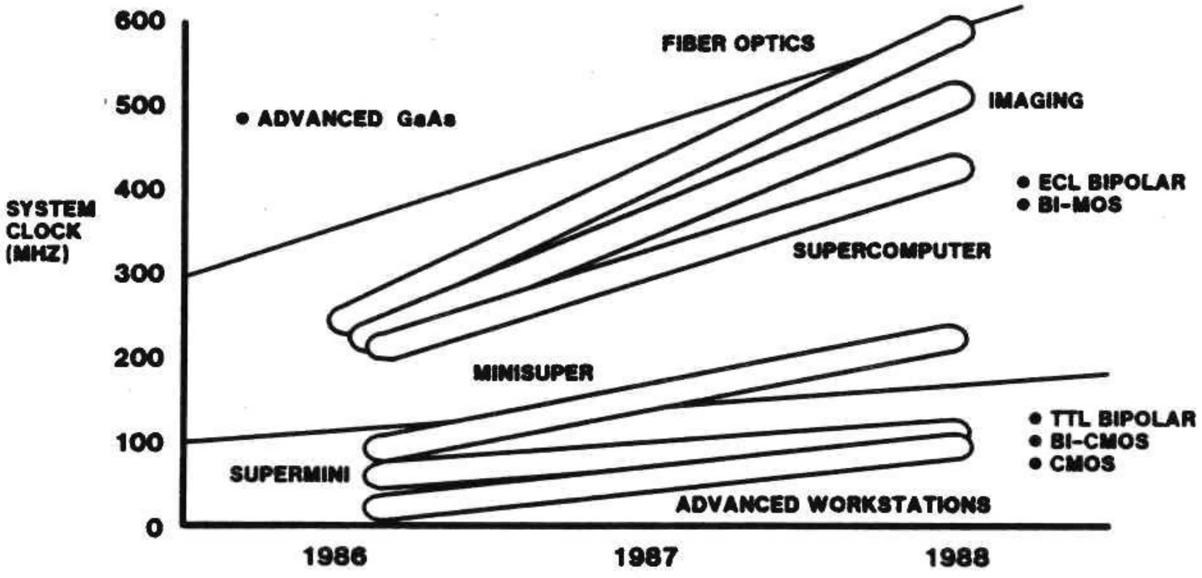

SUPER COMPUTER PRICE AND PERFORMANCE

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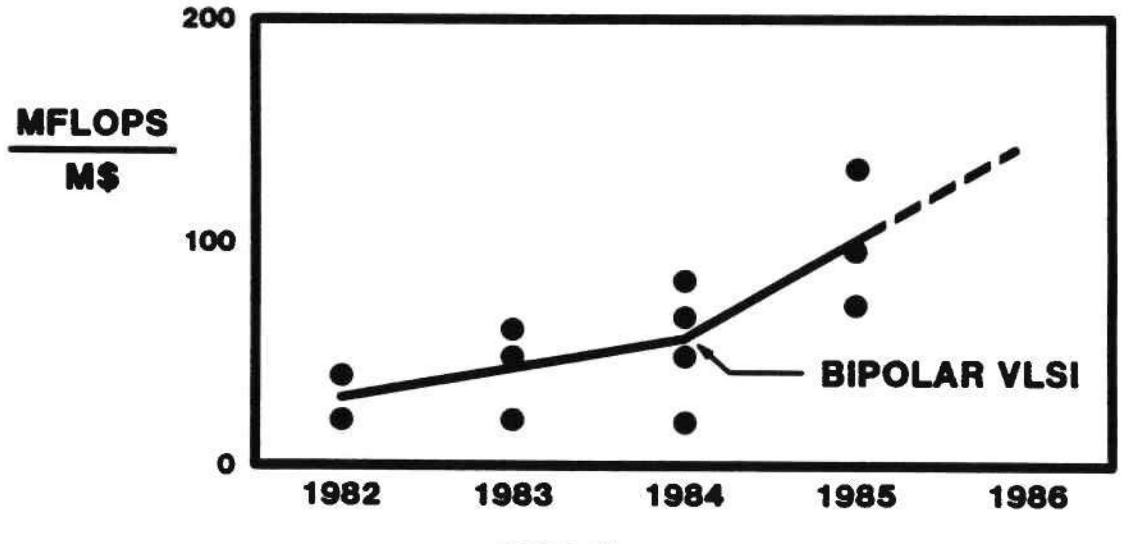

● MODELS INTRODUCED

SYSTEM PERFORMANCE TRENDS

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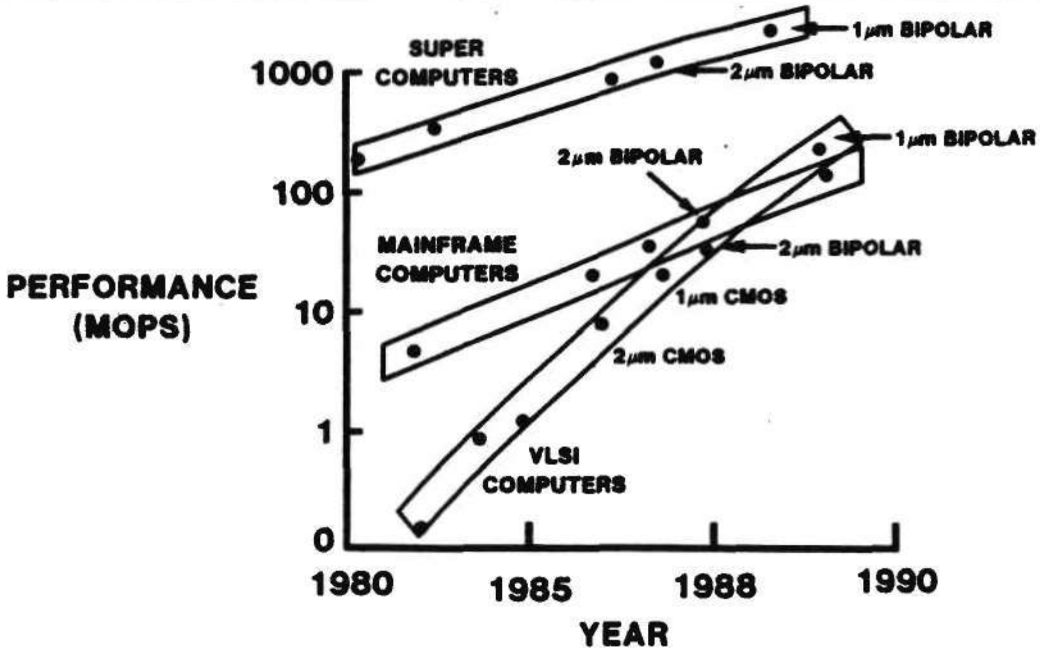

SEMICONDUCTOR TECHNOLOGY PROJECTION

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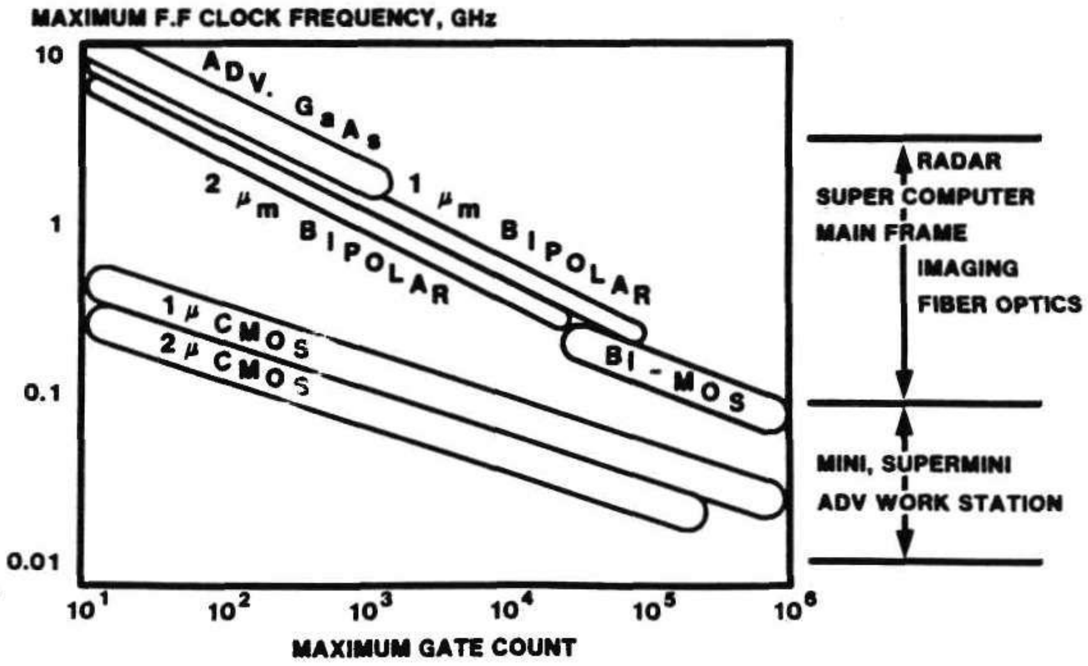

Bimos — speed, power, density

CLIPPER

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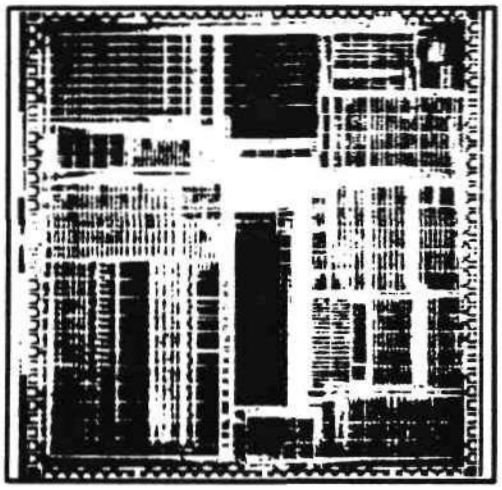

Major challenge:
- appropriate architecture
- fully automated CAD system
- new packaging design

- ARCHITECTURE
  - SPEED
  - SOFTWARE
- CAD

CLIPPER 32 BIT CPU

- EQUIVALENT THROUGHPUT OF VAX 8600 OR 5 VAX 11/780s
- 33 MHZ, 33 MIP PEAK PERFORMANCE
- 1.2 MICRON CMOS
- UNIX, C, FORTRAN, PASCAL

32 BIT CLIPPER MICROPROCESSOR MODULE

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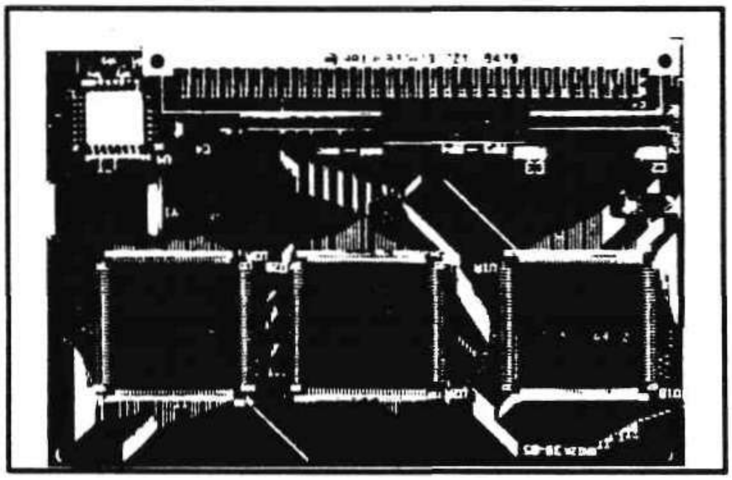

- HIGH LAYOUT DENSITY
- REDUCE SYSTEM INTERCONNECT DELAY

- COMPLETE SYSTEM ON ONE 3.0"x4.5" CARD WITH 96 PIN CONNECTOR
- SURFACE MOUNTED, 132 PINS

μA212A

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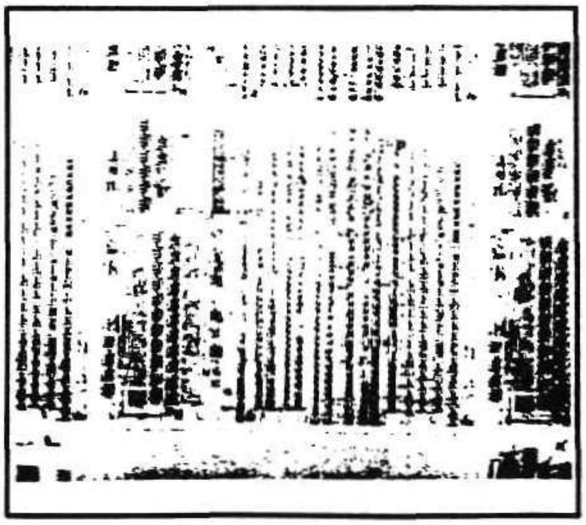

- MIXED SIGNAL CAD TOOLS
- RECONFIGURABLE FOR SPECIFIC USERS OR STANDARDS

- Complete cell library

BELL 212A COMPATIBLE CMOS SINGLE CHIP MODEM

- ADVANCED ANALOG AND DIGITAL CMOS TECHNOLOGY

F 9450

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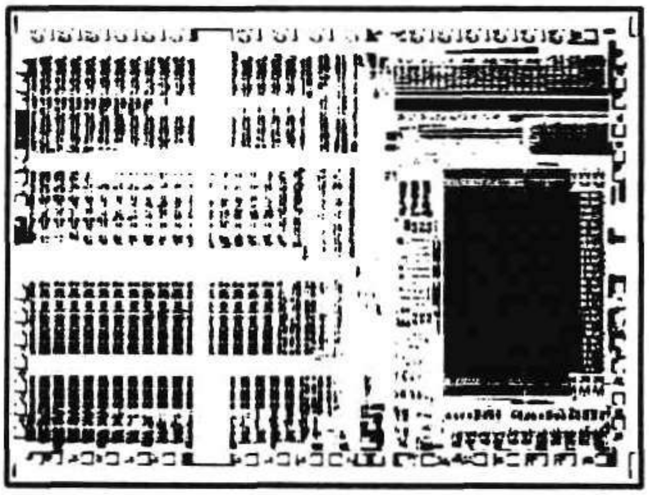

- HIGH PERFORMANCE OVER FULL TEMPERATURE RANGE
- HIGH DISSAPATION PACKAGE

15 MHZ 16 BIT MICROCONTROLLER

- 1750A ISA
- I^3L TECHNOLOGY

FGE 2500

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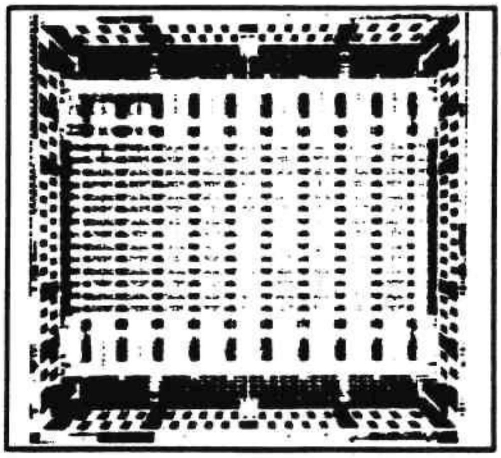

- INTEGRATED CUSTOMER DESIGN TOOLS
- TURNAROUND TIME
- PACKAGING
- TEST

2500 GATE ECL GATE ARRAY

- 225 PS
- MIXABLE ECL/TTL I/Os
- THREE SPEED/POWER OPTIONS

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MANAGEMENT
OF
CAPABILITIES

SILICON CAPABILITIES

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Achieved by makers.

- PHOTOLITHOGRAPHY
- MULTILEVEL INTERCONNECT
- ETCH
- DEFECT DENSITY
- PLANARIZATION

Real challenge to vendors

NON-SILICON CAPABILITIES

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- ARCHITECTURAL DEFINITION – modem, Chipper, etc.
    - USERS NEEDS
    - STANDARDS
    - WORLDWIDE MARKETS
- CIRCUIT DESIGN METHODOLOGIES
    - HIERARCHICAL
    - AUTOMATIC TEST VECTOR GENERATION
    - CELL LIBRARIES
- CIRCUIT DESIGN TOOLS
    - FLOOR PLANNING
    - ROUTING
    - SIMULATION
    - TEST GENERATION
- TEST
    - AUTOMATIC TEST EQUIPMENT
    - ON-CHIP SCAN PATH AND DIAGNOSTICS
- PACKAGING
    - SPEED
    - THERMAL DISSIPATION
    - PIN COUNT
    - COST

Closer

CUSTOMER-VENDOR RELATIONSHIP

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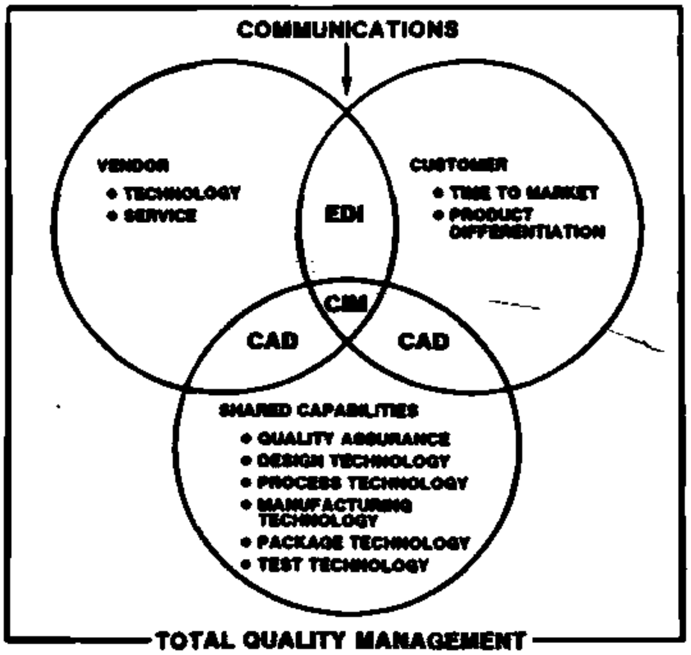

Needed
Integrated data mgt system employing computer

Computer integrated mfg
— Quality assurance
— Process,
— Scheduling
— Product mix

SERVICE FACTORS — 30 clients

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Locally
preference
impact/10

1. ACHIEVEMENT OF DELIVERY PROMISES
2. COMPETITIVE PRICING
3. PRODUCT PERFORMANCE
4. LEAD TIME
5. AVAILABILITY OF SECOND SOURCE
6. INCOMING REJECT RATE
7. RESPONSE TO INQUIRIES
8. PRODUCT PERFORMANCE DATA
9. MTBF IN OPERATION
10. PRODUCT APPLICATIONS DATA
11. UP-TO-DATE PRODUCTS
12. RESPONSE TO COMPLAINTS
13. PRODUCT KNOWLEDGE OF SALESMAN
14. STRENGTH OF DISTRIBUTOR NETWORK
15. APPLICATION SUPPORT OF SUPPLIER
16. PRODUCT KNOWLEDGE OF DISTRIBUTOR
17. TECHNICAL ABILITY OF SALESMAN
18. COMPANY STABILITY
19. WIDTH OF PRODUCT RANGE
20. EFFICIENCY OF ORDER PROCESSING
21. APPLICATION SUPPORT OF DISTRIBUTOR
22. PACKAGE OPTIONS
23. SALESMEN PERSONAL VISIT TO USER
24. RESPONSE TO FEEDBACK FROM USERS
25. ACCESS TO TOP MANAGEMENT
26. TECHNICAL ABILITY OF DISTRIBUTOR
27. STABILITY OF SALES FORCE
28. LOCAL MANUFACTURING
29. COMMERCIAL ABILITY OF DISTRIBUTOR
30. REPUTATION WITH OTHER USERS
31. COMMERCIAL ABILITY OF SALESMEN

SERVICE FACTORS

areas directly impacted by local presence

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1. ACHIEVEMENT OF DELIVERY PROMISES
2. **COMPETITIVE PRICING**
3. **PRODUCT PERFORMANCE**
4. LEAD TIME
5. **AVAILABILITY OF SECOND SOURCE**
6. INCOMING REJECT RATE
7. RESPONSE TO INQUIRIES
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30. **REPUTATION WITH OTHER USERS**
31. COMMERCIAL ABILITY OF SALESMEN

LOCAL PRESENCE

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A Schlumberger Company

- **SALES - 18 COUNTRIES**
- **DESIGN CENTERS - 3 COUNTRIES**
- **MANUFACTURING - 6 COUNTRIES**

- VLSI COMMERCIALIZATION IS A SHARED MANAGEMENT EXPERIENCE BETWEEN VENDOR AND CUSTOMER
- DOMINATED BY NON-SILICON CAPABILITIES AND TOTAL QUALITY MANAGEMENT
- REQUIRING LOCAL DESIGN, MANUFACTURING AND CUSTOMER SERVICE

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VLSI, THE FUTURE AND THE APPLICATION

Fumio Kohno
Director and Senior General Manager
Semiconductor Group
Sony Corporation

Mr. Kohno is Director and Senior General Manager of the Semiconductor Group at Sony Corporation. He is in charge of the semiconductor business, which encompasses all phases from development and production to worldwide sales activities. Previously, he was Senior General Manager of the Video Group at Sony. Mr. Kohno graduated from Waseda University and majored in Electronics and Communication Engineering.

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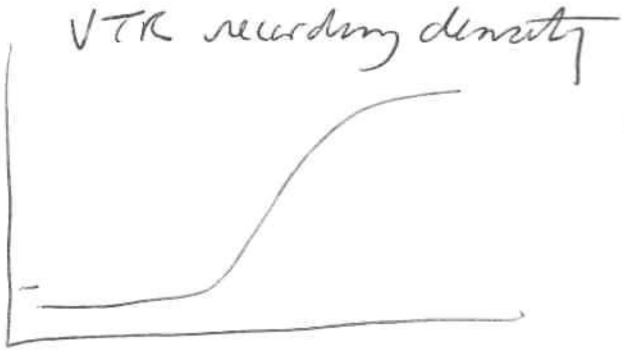
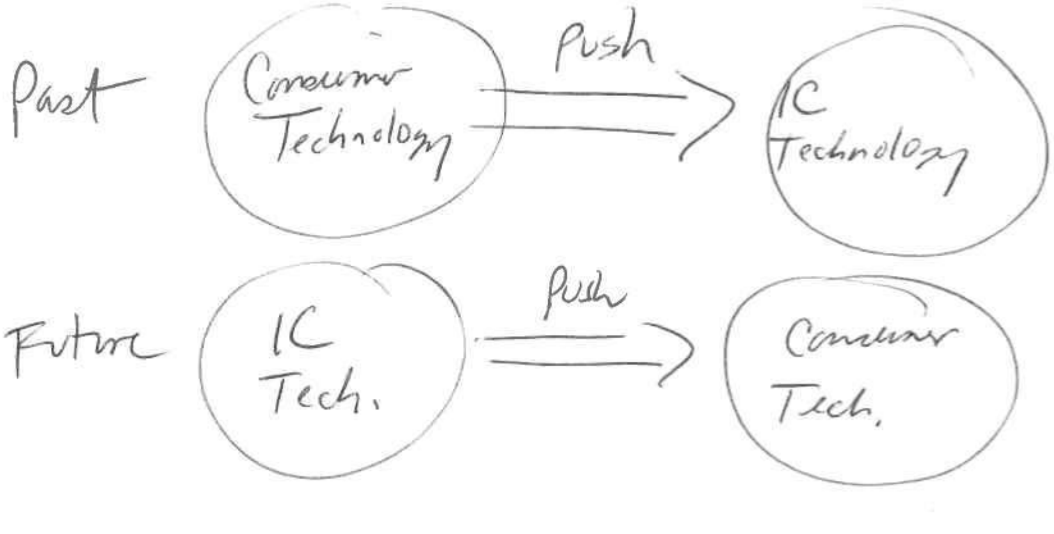

VTR recording density

Challenges

— miniaturization

- Trinitron – 4x density increase
- Audio –
- 1983 – CAMcorder
- New IC "Seeds" – low power linear
  – DSP
  – A/D & D/A converters
- Consumer requirements for ICs:
  Better picture performance
  Many optional features
  Economical
  Light & compact
  Expansion of application



- Color TVs

  - Flicker free
  - Non-interlace
  - Time base correction (freeze)
  - Windows-in-windows

} memory RAMs

Audio → new computer! (Audio-visual computer)
Video ↗

1) Need to educate consumer
2) ~~Need to~~ 3-yr. period — investigate needs of consumer

Q & A

1. New products using 8-bit MPUs?
   - Faster access time
   - New

THIS PRESENTATION WAS NOT AVAILABLE
IN TIME FOR PUBLICATION

APPLICATIONS: PRESENT AND FUTURE

Nagayoshi Nakano
Research Analyst
Japanese Semiconductor Industry Service
Dataquest Incorporated

Mr. Nakano is a Research Analyst for Dataquest's Japanese Semiconductor Industry Service and is based in Tokyo. He is responsible for gathering information, researching, analyzing, and compiling the JSIS end-use data base, editing the Japanese-language I.C. USA newsletter, compiling Dataquest's biweekly I.C. ASIA newsletter, and providing general research support on the Japanese market. Prior to joining Dataquest, Mr. Nakano worked for six years as a journalist, most recently as associate editor for the foreign correspondent department of Dempa Shimbun, Japan's largest daily electronics industry newspaper. Mr. Nakano is a graduate of Doshisha University, Kyoto, where he majored in English Linguistics.

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APPLICATIONS: PRESENT AND FUTURE

NAGAYOSHI NAKANO
Research Analyst
Dataquest Japan

THE MARKET

Equipment production value in Japan
from the viewpoint of
semiconductor consumption

ESTIMATED EQUIPMENT PRODUCTION GROWTH IN JAPAN FROM THE VIEWPOINT OF SEMICONDUCTOR CONSUMPTION

(Trillions of Yen)

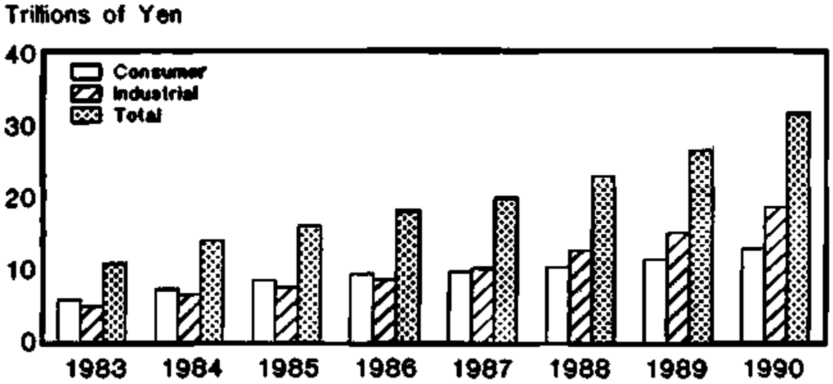
	1981	1986	1990	CAGR 1981-1990
Consumer	5.3	9.5	13.0	10.4%
Industrial	3.7	8.7	18.8	19.8%
Total	9.0	18.2	31.8	15.0%

Source: DATAQUEST

THE EQUIPMENT MARKET

Growth estimated at 15.0% CAGR
from 1981 to 1990

ESTIMATED EQUIPMENT PRODUCTION GROWTH IN JAPAN FROM THE VIEWPOINT OF CONSUMPTION



Source: DATAQUEST

ESTIMATED SEMICONDUCTOR CONSUMPTION IN JAPAN

Year	CAGR
1981-1985	21.2%
1986-1990	18.5%

Source: DATAQUEST

ESTIMATED JAPANESE SEMICONDUCTOR CONSUMPTION
(1981-1990) (shōhi)

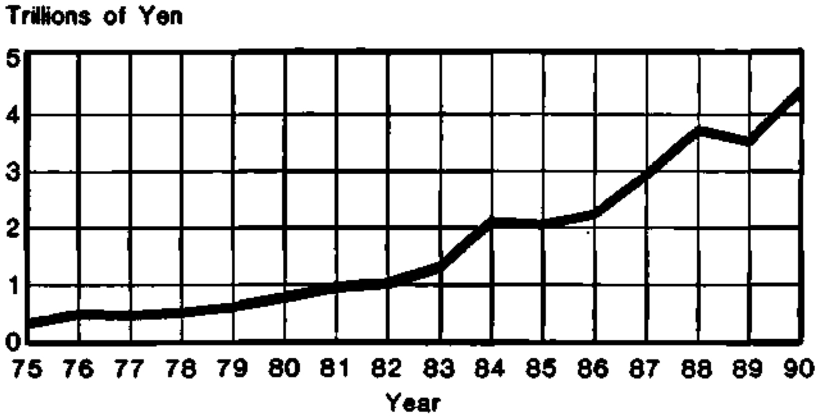
(Billions of Yen/Year)

1981 -- 950.0
1985 -- 2,048.2
1990 -- 4,416.7

Source: DATAQUEST

FORECAST CONSUMPTION IN JAPAN

(1975-1990)



Source: DATAQUEST

DEEP SLUMP IN VTRs

Production value decreased by
approximately 10% in 1985

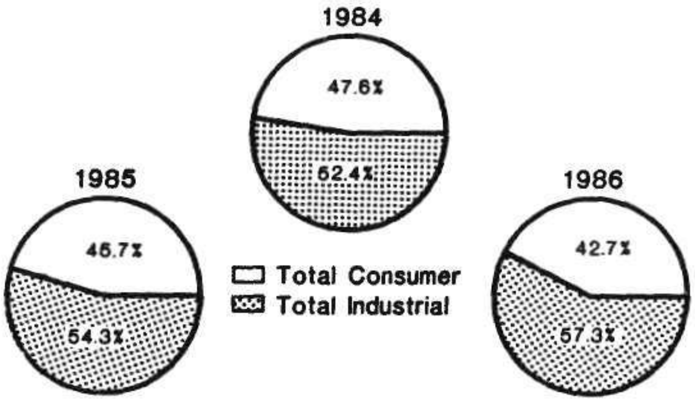
ESTIMATED SEMICONDUCTOR CONSUMPTION BY END-USE CATEGORY

(Billions of Yen)

	1984	1985	Change	1986	Change
Consumer	997.92	938.04	(6.0%)	957.12	2.0%
Industrial	1,098.48	1,110.12	1.1%	1,284.36	15.7%
Total	2,096.40	2,048.16	(2.3%)	2,241.48	9.4%

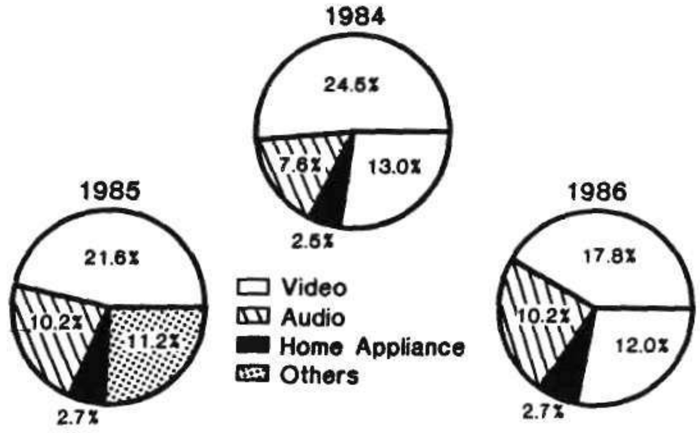
Source: DATAQUEST

ESTIMATED COMPOSITION OF SEMICONDUCTOR USAGE IN JAPAN



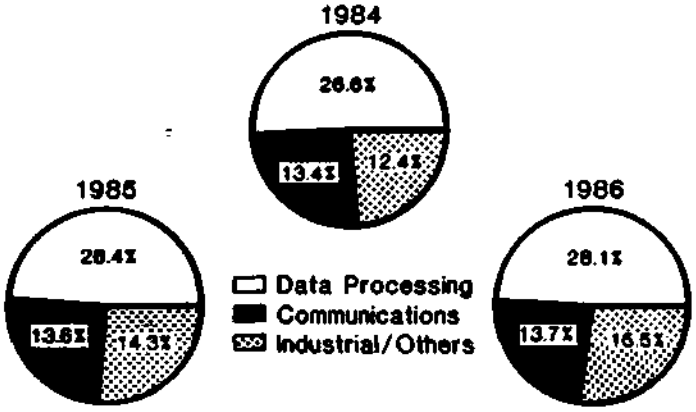
Source: DATAQUEST

ESTIMATED COMPOSITION OF CONSUMER SEMICONDUCTOR USAGE IN JAPAN



Source: DATAQUEST

ESTIMATED COMPOSITION OF INDUSTRIAL SEMICONDUCTOR USAGE IN JAPAN



Source: DATAQUEST

PRODUCTS WITH MAJOR GROWTH OPPORTUNITIES

	1982		1985	
	Ranking	Percent*	Ranking	Percent*
VTRs	1	16.3%	1	15.5%
Personal Computers	8	3.5%	2	7.9%
Mainframes	2	9.3%	3	5.1%
Peripherals	10	3.1%	4	5.1%
Automobiles	6	3.5%	5	4.9%
Radio Communications	5	4.1%	6	4.8%
Copying Machines	9	3.4%	7	4.4%
Tape Recorders	4	7.5%	8	4.4%
PBXs	7	3.5%	9	4.0%
Color TVs	3	8.9%	10	3.8%

*Percent of total semiconductor consumption in Japan

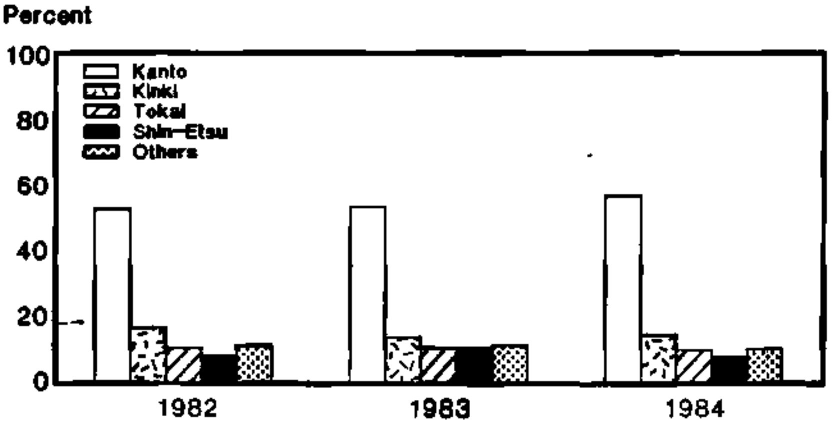
Source: DATAQUEST

FASTEST-GROWING NEW SEMICONDUCTOR APPLICATIONS - RANKINGS IN DATAQUEST'S TOP 50

	1982	1984	1985 (Est.)
Digital Audio Disk Players	47	33	18
Word Processors	31	17	12
Facsimiles	21	14	13

Source: DATAQUEST

ESTIMATED SEMICONDUCTOR END USE BY REGION



Source: DATAQUEST

ESTIMATED SEMICONDUCTOR CONSUMPTION BY PREFECTURE

	1982	1983	1984	1985
Kanagawa	20.0%	18.6%	20.8%	20.6%
Tokyo	13.4	14.5	13.6	11.9
Osaka	12.4	9.4	8.4	8.0
Saitama	4.6	4.1	5.4	7.6
Shizuoka	3.4	4.3	4.9	6.8
Ibaragi	4.4	5.2	5.9	5.6
Nagano	5.9	7.5	5.9	5.5
Tochigi	6.3	6.7	6.2	5.5
Gumma	3.6	4.0	4.5	4.1
Aichi	4.3	4.0	3.6	3.5
Others	21.7	21.7	20.8	20.9
Total	100.0%	100.0%	100.0%	100.0%

Source: DATAQUEST

FASTEST LADDER-CLIMBER

Shizuoka Prefecture

ESTIMATED SEMICONDUCTOR CONSUMPTION COMPARISON BETWEEN UNITED STATES, JAPAN, AND EUROPE IN 1985

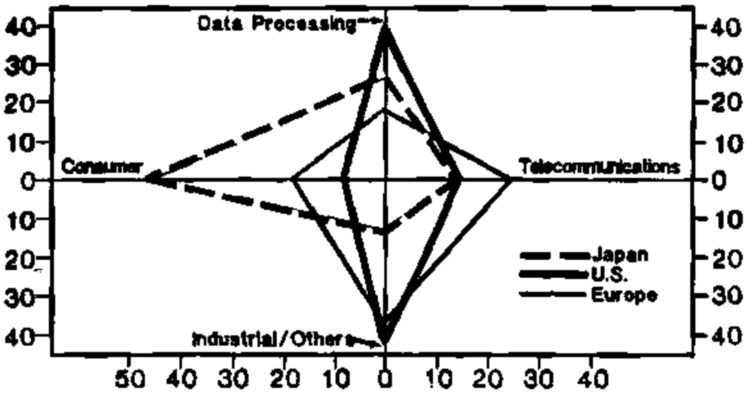
	United States	Japan	Europe
Data Processing	37.5%	27.4%	17.4%
Communication	13.9	13.6	25.4
Consumer	7.9	45.7	19.6
Industrial/Others	40.7	13.3	37.6
Total	100.0%	100.0%	100.0%

Source: DATAQUEST

ESTIMATED CONSUMPTION COMPARISON BETWEEN UNITED STATES, JAPAN, AND EUROPE IN 1985

(Percent)

Different industrial structures.



Source: DATAQUEST

SEMICONDUCTOR CONSUMPTION COMPARISON

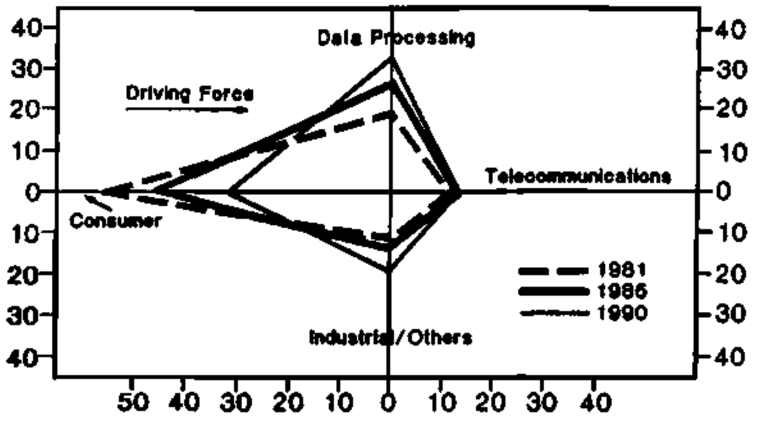
- Japan. Consumer/data processing-oriented/bipolar type
  - At prosperous times - big growth
  - At depression times - small decrease
- United States. Data processing/industrial-oriented/bipolar type
  - At prosperous times - big growth
  - At depression times - big decrease
- Europe. Well balanced
  - At prosperous times - small growth
  - At depression times - small decrease

DRIVING FORCE

- Japan - away from consumer
- United States - to data processing/industrial
- Europe - to telecommunications/industrial

HISTORICAL CONSUMPTION COMPARISON IN JAPAN

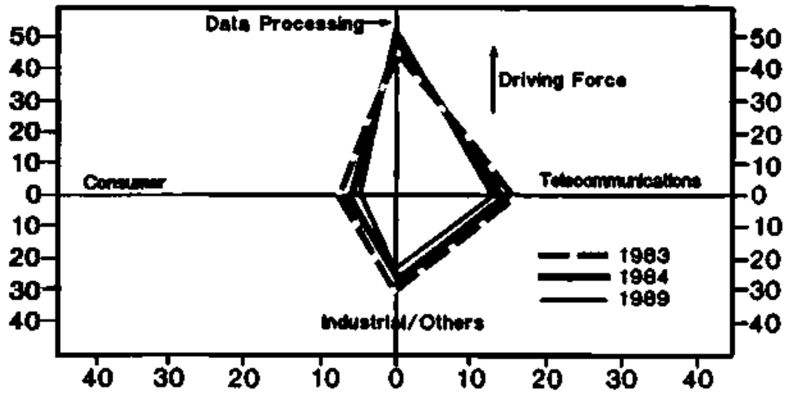
(Percent)



Source: DATAQUEST

HISTORICAL CONSUMPTION COMPARISON IN UNITED STATES

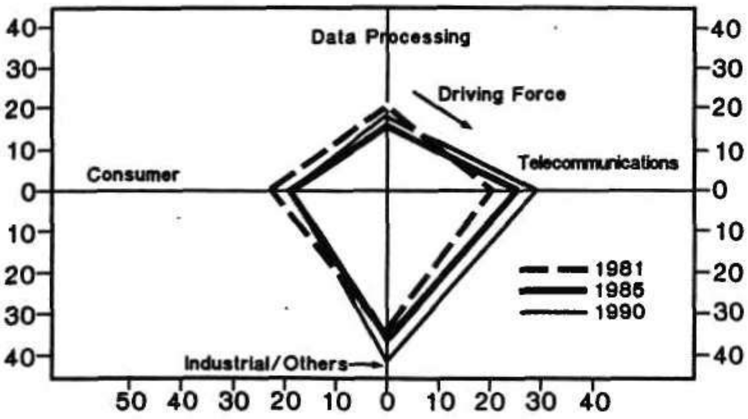
(Percent)



Source: DATAQUEST

HISTORICAL CONSUMPTION COMPARISON IN EUROPE

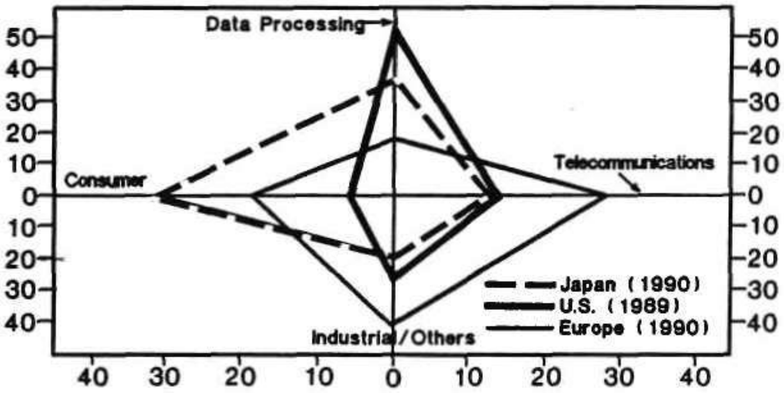
(Percent)



Source: DATAQUEST

FORECAST CONSUMPTION COMPARISON IN 1990 BETWEEN UNITED STATES, JAPAN, AND EUROPE

(Percent)



Source: DATAQUEST

CONCLUSION/OUTLOOK

- Good semiconductor consumption outlook
- Concern about trend to data processing
- Intense competition

Q&A

1. ~~Is~~ Are consumer & industry life cycles related?

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FUTURE VLSI APPLICATIONS FOR THE AUTOMOBILE

Dr. Charles Tracy — Chief

Robert J. McMillin
Director of Engineering
Delco Electronics Corporation

Mr. McMillin is Director of Engineering in charge of the automotive electronics, solid-state, and entertainment and control products at Delco Electronics Corporation. Mr. McMillin started with General Motors in 1949, where he served in various positions on the engineering staff. He was later named Chief Engineer of Delco Electronics Division's Santa Barbara operations and then became Director of Digital Systems Engineering at the division's main office. In that position, he had responsibility for design and introduction of digital electronic engine controls and other new electronic systems. Mr. McMillin received a B.E.E. degree from Marquette University.

B.SEE Rensaler
PhD Cornell U.

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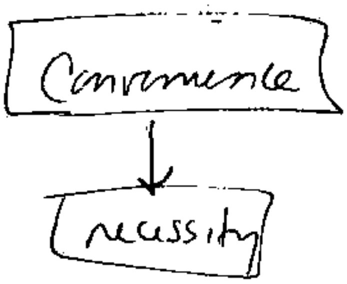

\$200 → \$600/car → \$900 (1990)

FUTURE VLSI APPLICATIONS FOR THE AUTOMOBILE

Robert J. McMillin
Director of Engineering
Delco Electronics Corporation

April 14, 1986

I appreciate the opportunity to be here today, and to be able to talk about a subject that is " dear to my heart", and ----"pocketbook",---- automotive electronics. I feel that most people will agree, ---- that there has been a tremendous change in the electronic content of the automobile over the past thirty or so years, and especially during the past fifteen years. Only ten years ago, a typical car had less than $200 of electronics. Today, the figure is more like $600, --- and some people predict that automotive electronics content will be in the neighborhood of $1000 by 1990. Thus, it is anticipated that automotive electronics will continue it's "explosive" growth into the future, ---- and will continue to be tied to advances made in integrated circuit technologies.

The evolution of automotive electronic systems has pretty well followed the integrated circuit evolution over the years. Each new or forward step in the IC evolution has resulted in lower cost IC's along with an increase in functional content, which has allowed us to consider greater functional content in our products. Also, the high volume bipolar IC production appearing in the early to mid 70's, ---- and the high volume MOS IC's of the mid-to-late 70's, primarily for hand held calculators and memory products, ---- finally reduced IC production costs to levels acceptable to the highly cost conscious automotive world,---- and opened the doors to an extensive use of IC's in our electronic products. The evolution that we have seen in this area shows no sign of slowing, --- and will probably continue into the future,--- and will again open the doors to many new automotive electronic applications that do not exist today .

My talk today will focus on the past history of automotive electronic products, past history of IC technology, present status of automotive electronics, future driving forces, and projections into the future.

First, --- looking at the past history of automotive electronics, --- we saw the first use of IC's in the passenger car voltage regulator for the 1968 Pontiac Grand Prix, ---only eighteen years ago. The PCVR input chip shown here was relatively simple by today's standard, ---only nine transistors and resistors. The regulator was followed by the High Energy Ignition System in 1971, ---and replaced a system that had been in use for almost sixty years. Power IC's such as the PCVR and ignition system have been ---and will continue to be a subject of great interest to us in the automotive world.

Now, let us turn our attention to what was our primary "bread and butter' product of the 60's and 70's, ---the automotive radio. In the early 50's, only AM automotive radios existed, and were designed around five or six vacuum tubes. The vacuum tubes were replaced by a sucession of discrete germanium and silicon devices during the 60's.

By the late 60's, silicon intregrated circuit technology had been developed to the point that it could be considered as a reliable and cost effective technology for our radio products. Silicon IC's were first introduced into some of our more complex and sophisticated radio products in 1970. Sophisticated in 1970 meant AM/FM stereo. This first introduction was followed by a proliferation of new IC's during the 70's, ---and includes the Bridge Audio that was first introduced in 1977, --- a major audio output change, --- and has led the way to the sophisticated and popular radios that we have today, --- such as the electronically tuned radio(ETR) shown here. It is now possible to make affordable AM/FM/Stereo/Tape radios that are several times smaller than the "older" AM radio of the 50's, ---with very small power dissipation, ---and with considerably better reliablility.

As you know, volume production of engine control systems began in 1980 in order to meet emission and fuel economy regulations. Hence, they do not have a long history like radio products. Even so, the evolution that has taken place in this area over the past few years has been just as spectacular as that for radios. Not only has the "parts" count been reduced considerably, ---but the functional content and circuit speed have been increased dramatically. Most of this has been brought about by a further up-integration of components and the greater functional capability of the newer IC's being used, ---mostly custom designs for our particular applications.

P-integration (systems in silicon)

That should be enough of the, --"this is where we have come from", ---a short historical background of our automotive electronic products of the past few years.

Now, we need to look at the future and see what our "crystal ball" has to say about future automotive electronic systems. However, before we attempt to make projections about the future, ---we need to form a basis for making the projections. Future projections for automotive electronics can be pretty well fomulated by considering past IC history, ---in the form of trends, --- customer desires, and what I choose to call "product/production driving forces". We will look at each of these in a little more detail.

· Not leading-edge; 1-generation behind.

First, in the IC area,---over the past 15-20 years, there has been a continual evolution in the type of IC technology being used,---and in the complexity of the IC's developed and produced. These changes have come about primarily because of two things,---transistor downsizing pressure, ---and circuit and systems needs. The results of these two driving forces can be graphically illustrated by the so-called trend charts, which in turn can be used as reasonably accurate models for future projections. These models can be used to make projections about transistor sizes, IC circuit complexities, chip sizes, process complexities, and----soforth. In essence, the trends show that transistors continue to be made smaller,---while circuit designers keep using more elements in their designs,---at a faster rate than transistors are being made smaller,---with the result being that chip sizes continue to get larger. All these things are happening as processes keep getting more complex,---through the use of more layers,---and a greater merging of device technologies. These trends have been occuring at a fairly "predictable" rate,---as shown on the following graphs.

Trends

If we couple the information from the trend models with the other product/production "driving" forces associated with system needs, customer requirements and ① production proliferation, a reasonable estimate of future complexity and IC technology can be made.

Customer demands upon our products are "producing" certain "driving" forces that must be considered. Our product lines are showing a proliferation from a few---to many models. Also, customers are demanding ② faster turn-around times, both during development stages and in high volume production. This has mandated a change in our design concepts in order to provide a certain degree ③ of flexibility in the manufacturing of our electronic products. This flexibility requires the ability to quickly program, or reprogram, a product on the manufacturing floor for particular applications. This will obviously influence the IC technology needs for our future products. As we all know, the alteration of fixed ROM memory, especially in a high volume production situation, is a lengthy process, and is no longer acceptable to our customers. Thus, the design of future automotive electronic will require a change in memory philosophy in order to meet the flexibility requirements that are only obtainable through ④ instant programmability, particularly on the production floor.

Now, we can use the IC trend infomation that has been discussed, along with a consideration of the so-called driving forces, to make projections about IC complexities that will be available and technologies that will be required for future automotive electronic products. A hypothetical integrated circuit for automotive electronic systems, say for five years in the future, might be characterized as follows: Minimum feature sizes will be in the neighborhood of 1.0 microns, transistor count will be about 500,000 elements on a chip about 300 mils square, pin count will be in the range of 90-120, mask levels about 16-18, and device technology will be a combination of CMOS and EEPROM.

CMOS logic reduces power dissipation, and at the same time improves operating performance and speed. Present automotive microprocessors are operated at 1-2 MHz clock-rates. The next generation will operate at higher clock-rates, perhaps in the 10-20 MHz range. Moreover, the lower power dissipation of CMOS IC's gives us much more flexibily in packaging and mounting schemes and makes underhood mounting more practicable.

The availability of EEPROM memory on the microprocessor or microcomputer chip addresses many of the product proliferation and flexibility issues that we are concerned with. The memory program contents that are the same for all engine control applications can be put into ROM type memory structures to take advantage of ROM's high packing density and inherently lower cost. On the other hand, some EEPROM memory can be used on the chip to provide the mechanism for on-chip programming, or reprogramming, that is becoming a necessity in order to meet our customer's demands and our own internal flexibility requirements. We are all aware that EEPROM memory technology is more expensive than ROM type memory. However, a consideration of the total design-production cycle of an automotive electronic system suggests that the slightly higher cost of EEPROM memory is more than offset by many factors,---and appears to be cost competitive in the long run.

This might be a good time to talk about memory/microprocessor interactions. If the semiconductor industry could come up with a reasonable and process "compatible" one transistor EEPROM memory cell, instead of having to use two transistors per memory cell as we do today, then EEPROM memory costs should approach that of ROM memory, and we could consider a wider usuage of EEPROM memory in our products in order to meet our product flexibility goals through memory programmability. Moreover, the availibility of a low cost EEPROM technology would open up the doors to many new uses in our production lines,--- and would allow certain system parameters to be "adjusted" or set during manufacturing stages. This presents some interesting possibilities.

Also, as we know, CPU operating speeds have increased considerably over the past few years. However, we find that memory access times have not been decreased at the same rate, and cannot be operated at some of the faster CPU clock rates. Therefore, we are not able to take full advantage of the faster CPU IC's. This appears to be an area that needs some "rethinking", either in terms of new technology, or in how to organize existing memory/CPU systems in order to accommodate the faster CPU clock-rates.

My talk so far has been concerned about the past history of automotive electronics up to the present time, --- and how it has been associated with the IC evolution. Also, a projection has been made to predict what future automotive IC's will look like in terms of complexity and technology. This in turn gives us a feeling for the functional capability of future generation IC products. Now we should say something about the future applications themselves.

The term, "systems in silicon", has often been used to describe future automotive electronic systems. Obviously, we will never get to the point where a total system is put onto one IC. However, we continue to push in this direction and have seen our products continuously up-integrated towards this end. If we look to the future, we can envision a lot of potential application areas. I would like to briefly talk about some of these areas. Some are realistic, while others have to be considered as "pie-in-the-sky" possibilities. That is, they are potentially possible, but perhaps questionable due to practical considerations.

Radio Systems- Basic radio broadcasting technology for automotive receivers will not change appreciably in the near future. First we had AM, then AM/FM, and now we have AM stereo. Therefore, near future radio receivers will be primarily associated with higher quality systems having better sound fidelity,---along with more customer convenience type features. These things represent "quality" and can be provided by the greater functional content of new ICs. Digital audio processing would fall in this category. Down the road, satellite communications could provide a source for digital transmissions and lead to digital receivers. It will be a while before this becomes a reality.

Engine Controls- New generations of engine controls will be required to meet changes in engine control functions. Each generation will be more complex than the last generation and control more functions. We have seen a major change in engine control systems about every five-six years. The GMCM system went into high volume in 1980 and has been followed by the GMP-4 system in 1986. Therefore, the next major change will probably be in the early 1990's time frame. The hypothetical ICs for this were described earlier.

Displays- This area probably represents one of the fastest changing areas in the automobile. The older "pointer" type indicators are being rapidly converted over to the more dynamic and more informative type displays that give the driver more information about what is occurring. Unfortunately, display technology cannot be considered a mature area, with new concepts showing up continually. Displays require many driver transistors, and potentially, more ICs in the display electronics. Most presently used displays have certain shortcomings for automotive applications. Some displays require operating voltages that are not readily available in the automobile, some exhibit poor contrast, especially in bright sunlight, colors are limited, and others have limited operating temperature ranges. Never-the-less, the display area will expand, and we will be seeing new display configurations in future automobiles. There should be enough incentive in this area to "prod" display technology people into developing better automotive display technologies.

Multiplex Systems- Automotive multiplex systems have a good chance of being produced in high volume quantities. Such systems have been considered for years. However, technology and semiconductor costs are just now getting to the point that multiplex systems can be considered practical. The ability to fabricate large power IC's along with control logic , "Smart Power", at automotive price levels now appears achievable. We all realize the magnitude of the IC volumes that would be required for such a product.

Other Systems- Some of the more "futuristic" or more "iffy" automotive electronic applications include electronic steering, collision-avoidance systems, navigation systems, perhaps coupled to satellite and cellular networks, and voice information systems. These applications represent "food-for-thought" possibilities and are continually being evaluated and prototype systems considered or built when practical.

Summary- We have seen automotive electronic systems start from almost nothing twenty years ago, and proliferate into the outstanding products that exist today. Moreover, this trend is expected to continue just as robustly in the future. All of us who have been involved in this venture feel a sense of satisfaction in the accomplishments that have taken place, and being part of it.

However, I would like to conclude this talk by quoting some statistics that might point out just how far we have come, or perhaps not come up to the present time in the technology arena. It has been stated that the total worldwide yearly memory production is about 1E14 bits. This amounts to about 20,000 bits per person, and appears to be a very impressive figure. However, it is also interesting that the human brain also has about 1E14 neurons. Thus, the world's total production of semiconductor memory bits is about equal to the memory capacity of one human brain. From this, a simple conclusion can be drawn,---we still have a long way to go.

Thank you!

1992 Auto Electronic IC (hypothetical)

- 1µm features
- 500K transistors
- 300 mils^2
- 90 – 120 pins
- 16 – 18 mask levels
- CMOS/EEPROMs
- 10 MHz speeds

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DESIGN SOLUTIONS WITH ASICs

Alfred J. Stein
Chairman of the Board and Chief Executive Officer
VLSI Technology, Inc.

Mr. Stein is Chairman of the Board and Chief Executive Officer at VLSI Technology, Inc. (VTI), an application-specific integrated circuit semiconductor company. Previously, he was President and Chief Executive Officer at Arrow Electronics. Prior to that, he spent five years at Motorola Semiconductor, where he initially held the position of Corporate Vice President, Integrated Circuits Division. Later, he became Assistant General Manager of Motorola's entire Semiconductor Group. Prior to joining Motorola, Mr. Stein was associated with Texas Instruments Incorporated for 18 years. His last position prior to joining Motorola was Corporate Vice President for TI's Electronic Devices Division, with responsibility for all discrete products in the United States and Canada. Mr. Stein received a B.S. degree in Physics from St. Mary's University in San Antonio, Texas, and a master's degree in Mathematics from Southern Methodist University in Dallas, Texas.

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JAPANESE SEMICONDUCTOR INDUSTRY CONFERENCE
April 13-15, 1986
Hakone, Japan

ASIC IS HERE!

**ASIC is now the solution of choice
for leading edge systems
in all industry segments.**

ASIC IS HERE!

APPLICATION-SPECIFIC INTEGRATED CIRCUITS ARE NOW THE SOLUTION OF CHOICE FOR LEADING EDGE SYSTEMS IN ALL INDUSTRY SEGMENTS.

IN A FEW SHORT YEARS, IN FACT IN LESS THAN 5 YEARS, ASIC TECHNOLOGY HAS EVOLVED FROM A TOTAL UNKNOWN TO THE INDUSTRY LEADING DESIGN TECHNOLOGY. IT HAS FOSTERED NUMEROUS ASIC FOCUSSED COMPANIES AND HAS ALREADY REACHED THE STAGE WHERE LOW-END PRODUCTS ARE TREATED AS COMMODITIES.

WORLD WIDE ASIC MARKET DATA

($ B)	1983	1984	1985	CAGR
PROG. LOGIC	0.11	0.24	0.29	62 %
GATE ARRAY	0.51	0.94	1.36	63 %
CELL BASED	0.05	0.13	0.25	123 %
FULL CUSTOM	1.00	2.12	2.69	64 %
TOTAL	1.67	3.43	4.59	65 %

SOURCE: DATAQUEST, FEB 1986

WORLDWIDE ASIC MARKET DATA

DATAQUEST'S HISTORICAL MARKET DATA, FROM 1983 THROUGH 1985, DEMONSTRATES THE DYNAMIC GROWTH OF ASIC IN ALL PRODUCT OFFERINGS: PROGRAMMABLE LOGIC, GATE ARRAYS, CELL BASED AND EVEN FULL CUSTOM. EVEN IN 1985, DURING PERHAPS THE DARKEST DAYS OF THE SEMICONDUCTOR INDUSTRY, THIS BUSINESS HAS CONTINUED TO GROW. ASIC IS TRULY A SPECTACULAR TECHNOLOGY, EQUALLY AS IMPORTANT, AND POTENTIALLY MORE PERVASIVE THAN THE MICROPROCESSOR REVOLUTION OF THE 1970'S. THE DATA SHOWN HERE REFER TO PROPRIETARY PRODUCTS USED BY SINGLE CUSTOMERS (USER SPECIFIC ICs). IN ADDITION, THERE IS A WIDE RANGE OF APPLICATION-SPECIFIC MEMORY AND LOGIC PRODUCTS THAT ARE AVAILABLE TO MULTIPLE USERS. IN THIS PRESENTATION I SHALL LIMIT MYSELF TO TRENDS IN THE USER-SPECIFIC PORTION OF THE ASIC MARKET.

SYSTEM BENEFITS FROM ASIC TECHNOLOGY

- INNOVATION & FLEXIBILITY IN DESIGN
- SYSTEM UNIQUENESS
- HIGHER SYSTEM PERFORMANCE
- IMPROVED ENGINEERING PRODUCTIVITY
- REDUCED SYSTEM SIZE
- LOWER SYSTEM COST

SYSTEM BENEFITS FROM ASIC TECHNOLOGY

THE DRIVING FORCES FOR ASIC COME FROM TWO DIRECTIONS: ONE SET OF FORCES RESULTING FROM THE CUSTOMER'S NEED TO HAVE INNOVATIVE DESIGN, UNIQUENESS, HIGHER PERFORMANCE AND PRODUCTIVITY, REDUCED SIZE AND COST IN HIS SYSTEM. THE SYSTEM BENEFITS THAT THE CUSTOMER IS LOOKING FOR FROM ASIC TECHNOLOGY, SHOWN IN THIS SLIDE, ARE VITAL FOR HIM TO STAY PRICE, PERFORMANCE AND SIZE COMPETITIVE.

NEW TOOLS UNLEASH
ASIC TECHNOLOGY

- **USER FRIENDLINESS**
- **SIMPLER WORKSTATION ACCESS**
- **INTEGRATED DESIGN ENVIRONMENT**
- **FIRST TIME SILICON SUCCESS GUARANTEE**
- **REDUCED CYCLE TIME**
- **MORE AUTOMATION**

NEW TOOLS UNLEASH ASIC TECHNOLOGY

THE SECOND SET OF FORCES COMES FROM THE DESIGN TOOL SIDE OF THE BUSINESS. NEW TOOLS HAVE INDEED UNLEASHED ASIC TECHNOLOGY. CHARACTERISTICS OF THESE TOOLS INCLUDE INCREASED USER FRIENDLINESS, SIMPLER WORKSTATION ACCESS, AND ALL OF THE POINTS SHOWN ON THIS SLIDE.

THE SPEED AND EASE OF DESIGN AND FIRST-TIME SUCCESS THAT APPLICATION-SPECIFIC ICs HAVE ACHIEVED USING THESE TOOLS HAVE SERVED TO DRIVE THE BUSINESS MUCH FASTER.

IT IS THE CONGRUENCE OF NEW TOOLS AND NEW SEMICONDUCTOR PROCESS AND DESIGN TECHNOLOGIES, COMBINED WITH THE COMPETITIVE PRESSURES OF THE MARKET THAT HAVE PLACED ASIC IN ITS CURRENT GROWTH POSITION.

INCREASING LEGITIMACY OF ASIC

START UPS

- VLSI TECHNOLOGY, INC
- Sierra Semi
- LSI LOGIC
- AMCC

ESTABLISHED COMPANIES

- ASIC BUSINESS UNITS
  INTEL, MOTOROLA, TI, AMD
- EMPHASIS BY
  FUJITSU, TOSHIBA, NEC

CORPORATE ALLIANCES

- VLSI TECHNOLOGY - SIERRA
- MOTOROLA - NCR
- TI - SIGNETICS
- LSI - TOSHIBA

INCREASING LEGITIMACY OF ASIC

ANOTHER MORE SUBTLE DRIVING FORCE IN THE INDUSTRY IS THE GROWING LEGITIMACY OF ASIC TECHNOLOGY. THE PRESENCE TODAY OF BOTH START-UP AND ESTABLISHED COMPANIES IN THE MARKETPLACE SERVES TO ATTRACT AND ENCOURAGE MORE RELUCTANT USERS TO ENGAGE THIS INNOVATIVE TECHNOLOGY.

IN ADDITION, THE GLOBAL MOVE TOWARD CORPORATE ALLIANCES IS NOWHERE MORE EVIDENT THAN IN ASIC. THE NEWSPAPERS ABOUND WITH STORIES OF ALLIANCES FORMING TO ENABLE COMPANIES ADD TO THEIR INDIVIDUAL STRENGTHS, AND THROUGH THIS TAKE ADVANTAGE OF THE BUSINESS OPPORTUNITIES IN THE FAST-GROWING ASIC SEGMENT OF THE SEMICONDUCTOR INDUSTRY.

ASIC MARKET PROJECTIONS

($ B)	1985	1986	1990	CAGR
PROG. LOGIC	0.29	0.36	1.00	28 %
GATE ARRAY	1.36	1.90	5.69	33 %
CELL BASED	0.25	0.45	3.97	74 %
FULL CUSTOM	2.69	3.09	2.51	(2)%
TOTAL	4.59	5.80	13.20	24 %

SOURCE: DATAQUEST, FEB 1986

ASIC MARKET PROJECTIONS

AS WE LOOK TO THE FUTURE, WE SEE THE STRONG MARKET GROWTH CONTINUE, IN EFFECT, REMAINING MUCH HIGHER THAN THAT OF THE TRADITIONAL SEMICONDUCTOR COMPONENT INDUSTRY. GATE ARRAYS AND CELL-BASED PRODUCTS, IN PARTICULAR, ARE PROJECTED TO GROW AT VERY HIGH RATES OVER THE NEXT 5 YEARS. FULL CUSTOM IS THE ONLY TECHNOLOGY LIKELY TO SEE NEGATIVE GROWTH AS SOPHISTICATED CELL-BASED TECHNOLOGIES USING MEGACELLS AND COMPILERS OFFER SOLUTIONS TO THIS SEGMENT OF THE MARKET. IN FACT, THE GROWTH PROJECTION FOR CELL-BASED PRODUCTS FAR EXCEEDS THAT FOR THE REST OF THE BUSINESS.

ASIC SOLUTION
MARKET APPLICATION SEGMENTATION

SYSTEM AND LOGIC DESIGNER

HIGH PERFORMANCE

HIGH INTEGRATION

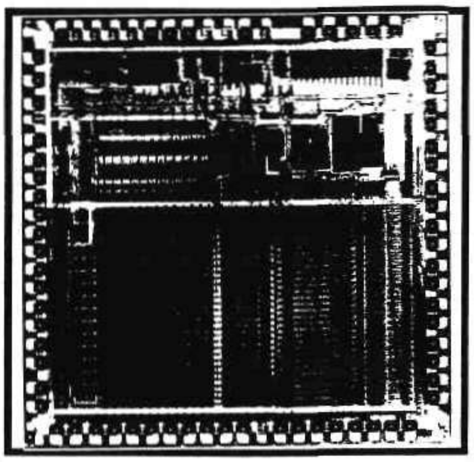
SIMPLE INTEGRATION

ASIC SOLUTION MARKET SEGMENTATION

ANALYZING THE ASIC MARKET AND ITS NEEDS HAS BEEN A REAL CHALLENGE. IN ORDER TO ADDRESS OUR STRATEGIC PLANNING PROCESS, WE HAVE DEVELOPED A MARKET APPLICATION VIEW THAT WORKS EXTREMELY WELL IN SEGMENTING THE NEEDS OF THE USERS AND THE REQUIREMENTS OF NEW PRODUCTS. THE THREE TYPES OF REQUIREMENTS SYSTEMS ENGINEERS HAVE ARE HIGH PERFORMANCE, HIGH INTEGRATION AND SIMPLE INTEGRATION APPLICATIONS. IN THE NEXT FEW SLIDES WE WILL SHOW ASIC EXAMPLES FOR EACH APPLICATION SEGMENT, AND HIGHLIGHT THE CRITICAL FEATURES OF EACH AND HOW THEY DIFFER FROM EACH OTHER.

ASIC SOLUTION EXAMPLES

HIGH PERFORMANCE



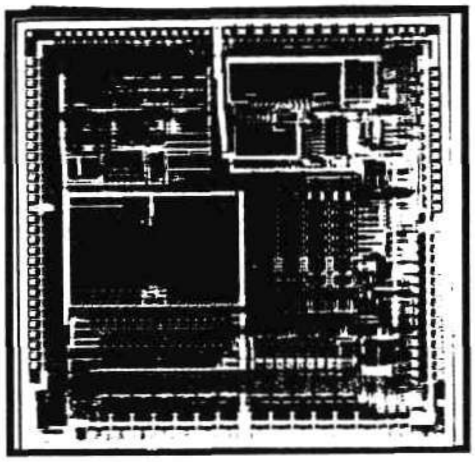
• **CUSTOMER:**	**ACORN**
• **REASONS:**	**PERFORMANCE**
• **COMPLEXITY:**	**8000 GATES**
• **TYPE:**	**FULL CUSTOM**
• **FUNCTION:**	**RISC LIMITED INSTRUCTION SET PROCESSOR**

ASIC SOLUTION EXAMPLES - HIGH PERFORMANCE

IN THE HIGH PERFORMANCE SEGMENT, WE HAVE A RISC-LIMITED INSTRUCTION SET PROCESSOR DESIGNED BY ACORN USING VLSI TECHNOLOGY'S TOOLS. THE KEY DESIGN OBJECTIVE WAS ATTAINMENT OF SPEED AND THE CHIP HAS 8000 GATES IMPLEMENTED IN FULL CUSTOM.

ASIC SOLUTION EXAMPLES

HIGH INTEGRATION



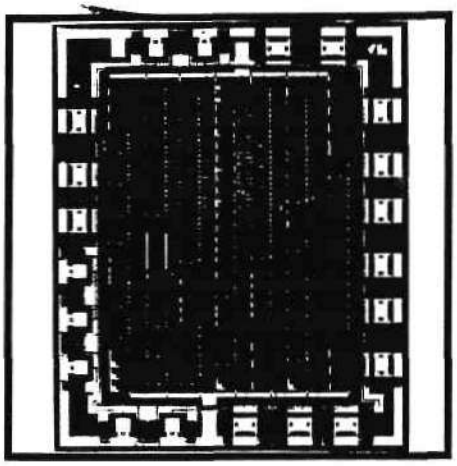
• **CUSTOMER:**	**WANG**
• **REASONS:**	**MAXIMIZE INTEGRATION**
• **COMPLEXITY:**	**18,000 GATES**
• **TYPE:**	**STD CELL & COMPILER**
• **FUNCTION:**	**CPU**

ASIC SOLUTION EXAMPLES - HIGH INTEGRATION

AN EXAMPLE OF HIGH INTEGRATION IS THE 18000-GATE, 16-BIT CPU DESIGNED WITH WANG USING OUR TOOLS. THE KEY DESIGN OBJECTIVE HERE WAS MAXIMIZATION OF INTEGRATION. THE DESIGN WAS IMPLEMENTED USING STANDARD CELLS AND COMPILERS.

ASIC SOLUTION EXAMPLES

SIMPLE INTEGRATION



• **CUSTOMER:**	**AT&T**
• **REASONS:**	**REPLACE TTL**
• **COMPLEXITY:**	**814 GATES**
• **TYPE:**	**STANDARD CELL**
• **FUNCTION:**	**TOUCH SCREEN CONTROLLER**

ASIC SOLUTION EXAMPLES - SIMPLE INTEGRATION

IN THE SIMPLE INTEGRATION SEGMENT, WE HAVE AN EXAMPLE OF AN 814 GATE TOUCH SCREEN CONTROLLER CHIP DESIGNED USING STANDARD CELLS. THIS CHIP WAS DESIGNED FOR AT&T.

ASIC SOLUTION
MARKET APPLICATION SEGMENTATION

SYSTEM AND LOGIC DESIGNER

HIGH PERFORMANCE	HIGH INTEGRATION	SIMPLE INTEGRATION

- PERFORMANCE CRITICAL
- MODERATE COMPLEXITY
- COST NOT KEY

ASIC SOLUTION MARKET APPLICATION SEGMENTATION

(DETAILS OF HIGH PERFORMANCE)

WE HAVE SEEN SPECIFIC EXAMPLES FROM EACH APPLICATION SEGMENT. NOW LET US LOOK AT THE CRITICAL FEATURES OF EACH SEGMENT AND EXAMINE HOW THEY DIFFER FROM EACH OTHER.

IN THE HIGH PERFORMANCE SEGMENT, THE ENGINEER'S PRIMARY NEED IS PERFORMANCE. HE IS WILLING TO SACRIFICE ALMOST ANYTHING FOR SPEED. THE NEEDS FOR COMPLEXITY ARE MODERATE AND COST IS NOT A KEY FACTOR. APPLICATIONS ARE THE HIGH END OF COMPUTER LINE, DIGITAL SIGNAL PROCESSING SYSTEMS, GRAPHICS ENGINES, ETC. SUCH ASIC DESIGNS ARE REQUIRED BY COMPUTER, TELECOM AND MILITARY CUSTOMERS.

ASIC SOLUTION
MARKET APPLICATION SEGMENTATION

SYSTEM AND LOGIC DESIGNER

HIGH PERFORMANCE	HIGH INTEGRATION	SIMPLE INTEGRATION
• PERFORMANCE CRITICAL	• DESIGN COMPACTION	
• MODERATE COMPLEXITY	• INTEGRATION: LSI, ANALOG & MEMORY	
• COST NOT KEY	• COST & COMPLEXITY TRADE OFF	

ASIC SOLUTION MARKET APPLICATION SEGMENTATION

(DETAILS OF HIGH INTEGRATION)

THE DRIVING FORCE IN THIS SEGMENT IS THROUGH DESIGN COMPACTION, INTEGRATING LSI, ANALOG, MEMORY AND OTHER FUNCTIONS SO THAT A LARGE PART OF A SYSTEM OR A TOTAL SYSTEM IS DESIGNED ON ONE CHIP. THE CHIP COULD BE A CPU OR OTHER SUCH MAJOR BUILDING BLOCK. IN THIS SEGMENT, A TRADEOFF IS GENERALLY INVOLVED BETWEEN COST AND COMPLEXITY.

ASIC SOLUTION
MARKET APPLICATION SEGMENTATION

SYSTEM AND LOGIC DESIGNER

HIGH PERFORMANCE	HIGH INTEGRATION	SIMPLE INTEGRATION
• PERFORMANCE CRITICAL	• DESIGN COMPACTION	• SIMPLE & FAST DESIGN
• MODERATE COMPLEXITY	• INTEGRATION: LSI, ANALOG & MEMORY	• SSI & MSI INTEGRATION
• COST NOT KEY	• COST & COMPLEXITY TRADE OFF	• COST REDUCTION DRIVEN

↑

Japan
~~[illegible]~~
consumer market

ASIC SOLUTION MARKET SEGMENTATION (DETAIL OF SIMPLE INTEGRATION)

THIS SIMPLE INTEGRATION SEGMENT IS TYPIFIED BY "GLUE-LOGIC" INTEGRATION TASKS, WHERE THE LEVEL OF INTEGRATION IS LESS THAN 8K GATES. THE DRIVING FORCE IN THIS SEGMENT IS COST REDUCTION. THERE ARE SEVERAL ASIC VENDORS WHO OFFER SOLUTIONS IN THIS SEGMENT. VENDORS ARE CHOSEN BASED ON COST, RELIABILITY, AND SPEED OF DELIVERY. THIS PORTION OF THE ASIC MARKET IS THE MOST COMPETITIVE, BUT IS ALSO THE LARGEST IN UNIT VOLUME. SYSTEM ENGINEERS DOING THEIR FIRST ASIC DESIGN OFTEN START AT THIS COMPLEXITY LEVEL.

ASIC SOLUTION REQUIREMENTS

ASIC SOLUTION REQUIREMENTS

NOW LET US LOOK AT THE ASIC SOLUTION REQUIREMENTS, I.E., THE TECHNOLOGIES AND CAPABILITIES THE VENDOR MUST SUPPLY TO MEET THE USER NEEDS IN EACH OF THE APPLICATION SEGMENTS - HIGH PERFORMANCE, HIGH INTEGRATION AND SIMPLE INTEGRATION.

ASIC SOLUTION REQUIREMENTS

SYSTEM AND LOGIC DESIGNER

*

HIGH PERFORMANCE | **HIGH INTEGRATION** | **SIMPLE INTEGRATION**

- **ASIC TECHNOLOGY: HIGH DENSITY, HIGH PERFORMANCE GATE ARRAYS, SCAN PATH TEST, MULTI CHIP SIMULATION**
- **FAB TECHNOLOGY: 1.25 TO 1.5 MICRON**
- **TEST: AUTO TEST, BUILT IN TESTABILITY**
- **PACKAGE: HIGH PIN COUNTS > 120 PINS**

ASIC SOLUTION REQUIREMENTS (HIGH PERFORMANCE)

THE HIGH PERFORMANCE AREA IS THE ONE WHICH WILL STRETCH THE PROCESS TECHNOLOGY. DESIGNERS IN THIS SEGMENT ARE WILLING TO TAKE SOME RISK AND MAY START DESIGNS BEFORE THE PROCESS IS FULLY AVAILABLE. IN THE TEST AREA THEY OFTEN DEMAND SPECIAL AUTOMATIC TEST GENERATION TECHNIQUES. THESE USERS ARE USUALLY DRIVING PACKAGE TECHNOLOGY WITH VERY HIGH-PIN COUNT DEVICES DUE TO THE COMPLEXITY OF THEIR ARCHITECTURE AND INADEQUATE LEVELS OF INTEGRATION AVAILABLE TO DATE.

ASIC SOLUTION REQUIREMENTS

SYSTEM AND LOGIC DESIGNER

*

HIGH PERFORMANCE

HIGH INTEGRATION

SIMPLE INTEGRATION

* **ASIC TECHNOLOGY:**	**COMPILERS, MEGACELLS, ANALOG, COMPLEX PLACE ROUTE AND SIMULATION CAPABILITY**
* **FAB TECHNOLOGY:**	**1.5 TO 2.0 MICRON**
* **TEST:**	**EXTENSIVE TEST DEVELOPMENT, HIGH FAULT COVERAGE**
* **PACKAGE:**	**LOW COST: 68 TO 150 PINS**

ASIC SOLUTION REQUIREMENTS (HIGH INTEGRATION)

USERS IN THIS HIGH INTEGRATION SEGMENT USUALLY FIND THEMSELVES APPLYING ADVANCED CELL-BASED OR FULL-CUSTOM ASIC TECHNOLOGY INCORPORATING COMPILERS, MEGACELLS, ANALOG, ETC., TO ATTAIN THE HIGHEST LEVELS OF INTEGRATION POSSIBLE. THESE USERS WANT THE MAXIMUM SPEED AND DENSITY BUT WILL TYPICALLY SETTLE FOR THE LATEST QUALIFIED OR PROVEN PROCESSES RATHER THAN TAKE A RISK WITH THE NEWEST FAB TECHNOLOGIES.

IN THE TEST AREA, CONCERN FOR DIE SIZE AND DENSITY KEEPS THESE PEOPLE FROM SACRIFICING AREA FOR IN-BUILT TESTABILITY. HOWEVER, THEY ARE CONCERNED ABOUT TEST COVERAGE AND MAY CHOOSE FULL FAULT SIMULATION TO VERIFY THE TEST COVERAGE.

IN THE PACKAGE AREA, THESE USERS TYPICALLY DO NOT REQUIRE THE HIGH-PIN COUNTS OF THE HIGH-PERFORMANCE SEGMENT DUE TO THE HIGHER LEVELS OF INTEGRATION. THEY ALSO CANNOT ABSORB THE COST OF THESE PACKAGES AS THIS IS A MUCH MORE COST SENSITIVE SEGMENT OF THE MARKET.

ASIC SOLUTION REQUIREMENTS

SYSTEM AND LOGIC DESIGNER

HIGH PERFORMANCE | **HIGH INTEGRATION** | * **SIMPLE INTEGRATION**

- * **ASIC TECHNOLOGY:** **WORK STATION SUPPORT, FULLY AUTOMATIC PLACE AND ROUTE**
- * **FAB TECHNOLOGY:** **2.0 TO 3.0 MICRON**
- * **TEST:** **SIMPLE AND LOW COST**
- * **PACKAGE:** **LOWEST COST: 16 TO 68 PINS**

ASIC SOLUTION REQUIREMENTS (SIMPLE INTEGRATION)

FOR SIMPLE INTEGRATION CUSTOMERS, INEXPENSIVE PROVEN ASIC TECHNOLOGY IS ADEQUATE TO MEET THEIR PERFORMANCE NEEDS. ACCESSIBILITY OF LIBRARIES ON LOW-COST WORKSTATIONS IS CRITICAL FOR PENETRATING THIS MARKET. THESE DESIGNERS TYPICALLY WANT LOW-COST, RELIABLE TEST AS THEIR DEVICES ARE RELATIVELY SIMPLE. INEXPENSIVE PACKAGING IS ALSO CRITICAL.

ASIC SOLUTION REQUIREMENTS

SYSTEM AND LOGIC DESIGNER

HIGH PERFORMANCE	HIGH INTEGRATION	SIMPLE INTEGRATION
HIGH PERFORMANCE GATE ARRAYS, SCAN PATH TEST, MULTI CHIP SIMULATION	COMPILERS,MEGACELLS ANALOG, COMPLEX P&R, SIMULATION	WORKSTATION SUPPORT, FULLY AUTOMATIC P&R
1.25 TO 1.5 MICRON	1.5 TO 2.0 MICRON	2.0 TO 3.0 MICRON
AUTO TEST, BUILT IN TESTABILITY	EXTENSIVE TEST DEV., HIGH FAULT COVERAGE	SIMPLE & LOW COST TEST
>120 PINS	68 TO 150 PINS	16 TO 68 PINS

ASIC SOLUTION REQUIREMENTS

IN SUMMARY, WE SEE THAT EACH OF THESE MARKET SEGMENTS HAS MANY DIFFERENT NEEDS. EACH HAS ITS OWN DEMANDS IN TERMS OF ASIC DESIGN, FAB, TEST AND PACKAGING TECHNOLOGIES. EVEN THE TYPE OF SELLING IS DIFFERENT. VENDOR CHOICES FOR HIGH INTEGRATION AND HIGH PERFORMANCE MARKETS ARE DETERMINED BY A BALANCE OF TECHNICAL AND COMMERCIAL CONSIDERATIONS. FOR THE SIMPLE INTEGRATION MARKET, VENDOR CHOICE IS GENERALLY DETERMINED BY PRICE AND DELIVERY.

WE HAVE SEEN THE ASIC SOLUTION MARKET APPLICATION SEGMENTATION,
WHAT THE SYSTEM DESIGNER'S REQUIREMENTS ARE, AND
ALSO WHAT FEATURES OF ASIC SOLUTIONS ARE NEEDED
TO MEET THESE REQUIREMENTS.

LET US NOW ANALYZE THE EXISTING DESIGN METHODOLOGIES
AND SEE HOW THEY NEED TO EVOLVE TO MEET THESE REQUIREMENTS.

THE TWO ESTABLISHED SOLUTIONS FOR ASIC ARE
GATE ARRAYS AND CELL-BASED DESIGNS.

LET US EXAMINE THE EXPECTED EVOLUTION
OF EACH OF THESE.

EVOLUTION OF ARRAY BASED DESIGN

1980

GATE ARRAY

- NET LIST ENTRY
- MANUAL PLACE & ROUTE
- SEMICONDUCTOR MANUFACTURERS' DESIGNS
- 200 TO 1000 GATES
- 15 TO 20 WEEKS

1986

GATE ARRAY

- USER DESIGN ON WORKSTATIONS
- AUTOMATIC PLACE & ROUTE
- 1K TO 20 K GATES
- 6 TO 10 WEEKS

1990

ARRAY BASED DESIGN

- HIGH LEVEL COMPILERS
- ARRAY, MEGACELL AND COMPILERS
- 10K TO 100K SEA OF GATES
- 2 TO 4 WEEKS

EVOLUTION OF ARRAY-BASED DESIGN

IN 1980, GATE ARRAYS INVOLVED NET LIST ENTRY AND MANUAL PLACE AND ROUTE. USERS WERE MAINLY IC DESIGNERS AND COMPLEXITIES WERE OF THE ORDER OF 200 TO 1000 GATES, WITH DESIGN TIMES OF 15 TO 20 WEEKS. ARRAY-BASED DESIGNS HAVE EVOLVED TOWARD USER DESIGNS GENERATED ON WORKSTATIONS, WITH AUTOMATIC PLACE AND ROUTE. INCREASINGLY, THE SYSTEM DESIGNER IS GETTING INVOLVED IN THE CHIP DESIGN PROCESS. BY 1990, WE WILL BEGIN TO SEE COMBINATIONS OF HIGH LEVEL COMPILERS, MEGACELLS, ARRAY AND CELL ELEMENTS. GATE COMPLEXITY WILL CONTINUE TO INCREASE, ACCOMPANIED BY RAPIDLY DECREASING DESIGN CYCLE TIME.

EVOLUTION OF CELL BASED DESIGN

1980

CUSTOM

- MANUAL, 'HAND CRAFTED'
- 10 K GATES
- 20 - 100 WEEKS

1986

CELL BASED

- STD CELLS, MEGACELLS, SELECTED COMPILERS
- AUTOMATIC DESIGN FOR STD CELLS
- SEMI AUTOMATIC CHIP COMPOSITION
- 10 K TO 40 K GATES
- 10 TO 30 WEEKS

1990

COMPILED

- AUTO COMPOSITION FROM HIGH LEVEL INPUT
- CELLS, MEGACELLS & COMPILED STRUCTURES
- 10 K TO 200 K GATES
- 10 TO 20 WEEKS

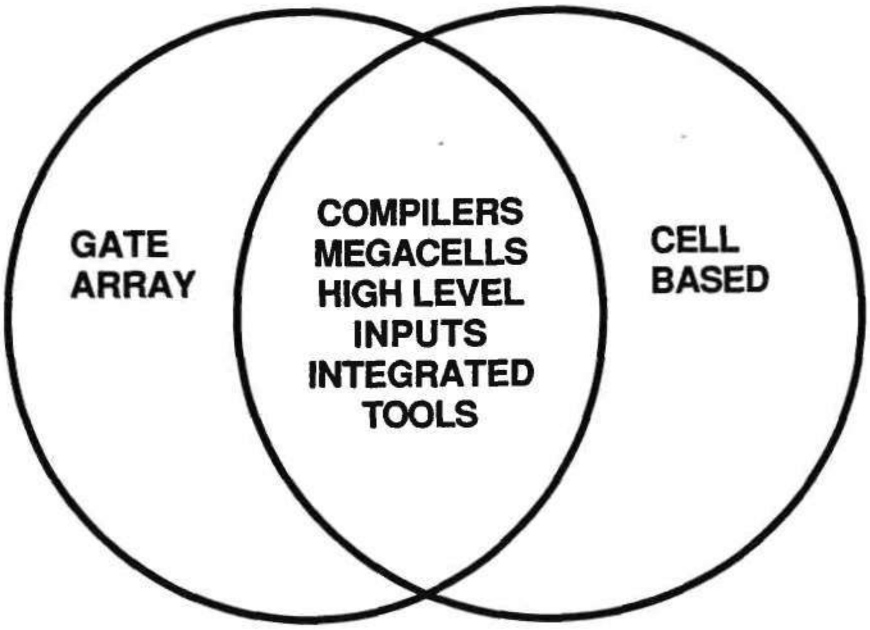
EVOLUTION OF CELL-BASED DESIGN

WE SEE SIMILAR TRENDS IN THE EVOLUTION OF CELL-BASED DESIGNS. IN 1980, THE EMPHASIS WAS ON MANUAL, HANDCRAFTED DESIGNS. DESIGN CYCLE TIMES WERE VERY LONG AND GATE COMPLEXITIES WERE OF THE ORDER OF 10K GATES.

HERE, TOO, WE SEE INCREASING AUTOMATION OF THE DESIGN PROCESS. STANDARD CELLS, MEGACELLS AND SELECTED COMPILERS ARE BEING USED TO DESIGN CHIPS SUBSTANTIALLY REDUCING THE DESIGN CYCLE TIME.

BY 1990, WE WILL SEE INCREASING AUTOMATION IN CHIP COMPOSITION AND CONTINUED EMPHASIS ON CELLS, MEGACELLS AND COMPILED STRUCTURES. INCREASING AUTOMATION AND THE USE OF LARGE BUILDING BLOCKS WILL CONTINUE TO INCREASE GATE COMPLEXITY AND REDUCE DESIGN CYCLE TIME.

DESIGN SYSTEM IN 1990's



GATE ARRAY

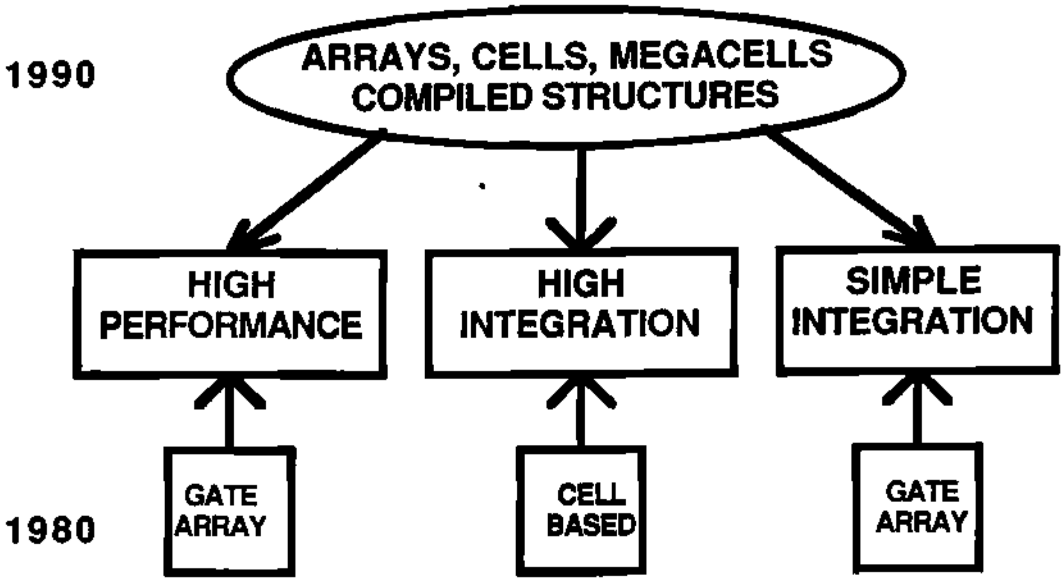
COMPILERS
MEGACELLS
HIGH LEVEL
INPUTS
INTEGRATED
TOOLS

CELL BASED

DESIGN SYSTEM IN 1990'S

CONSIDERING THE EVOLUTION OF CELL-BASED AND ARRAY-BASED DESIGN METHODOLOGIES OUT THROUGH 1990 THAT WE HAVE JUST LOOKED AT, WE FIND THAT, IN THE FUTURE, BOTH OPTIONS WILL BEGIN TO CONTAIN CERTAIN COMMON ELEMENTS SUCH AS COMPILERS, MEGACELLS, HIGH-LEVEL INPUTS AND INTEGRATED DESIGN TOOLS.

ASIC SEGMENTATION
SOLUTIONS AND METHODOLOGIES


1990

ARRAYS, CELLS, MEGACELLS COMPILED STRUCTURES

HIGH PERFORMANCE

HIGH INTEGRATION

SIMPLE INTEGRATION

GATE ARRAY

CELL BASED

GATE ARRAY

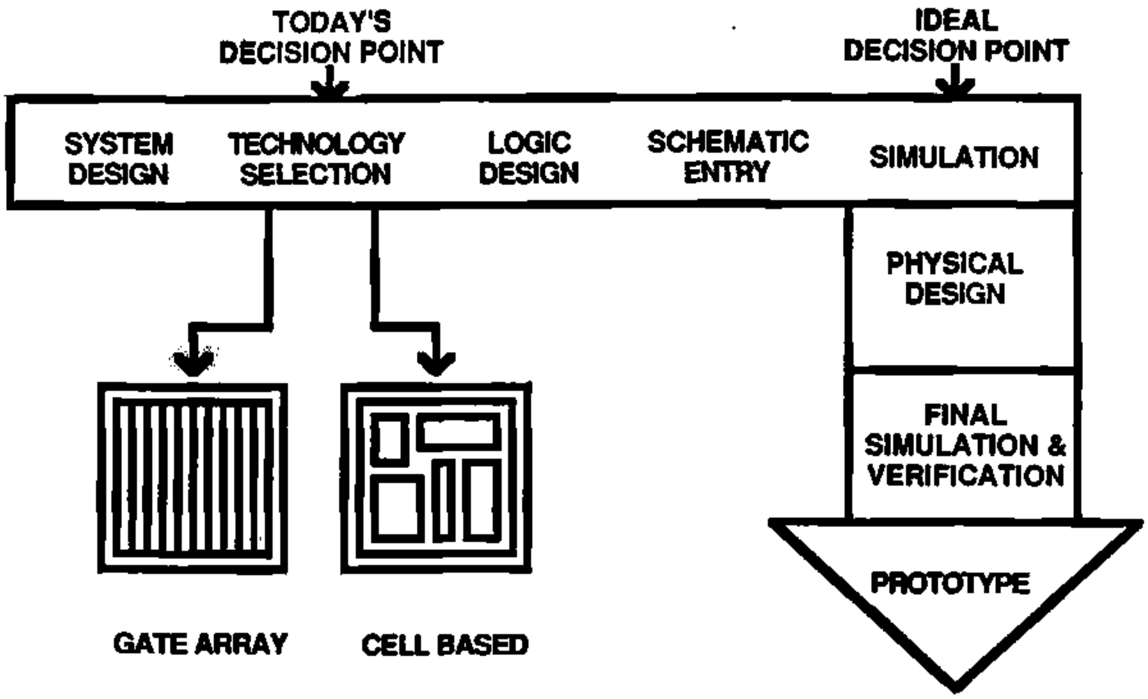
1980

ASIC SEGMENTATION SOLUTIONS AND METHODOLOGIES

IN 1980, THE OPTIMUM SOLUTIONS FOR THE DIFFERENT MARKET APPLICATION SEGMENTS WERE PURE AND MUTUALLY EXCLUSIVE, E.G., GATE ARRAYS FOR HIGH PERFORMANCE AND SIMPLE INTEGRATION AND CELL-BASED FOR HIGH INTEGRATION.

WE SEE THIS CHANGING OVER THE NEXT FEW YEARS. BY 1990, USERS WILL BE IN A POSITION TO CHOOSE BUILDING BLOCKS FROM COMMON LIBRARIES OF COMPILED STRUCTURES, MEGACELLS, ARRAY AND CELL ELEMENTS TO OPTIMIZE FUNCTION AND COST. THESE BLOCKS WILL BE APPLIED USING EITHER ALL LEVEL OR PARTIAL LEVEL CUSTOMIZATION. I BELIEVE COMPANIES WITH A RICH SET OF LIBRARIES, COMPILERS AND INTEGRATED DESIGN SOFTWARE, SUCH AS WE HAVE AT VLSI TECHNOLOGY, INC., WILL BE WELL POSITIONED TO BENEFIT FROM THIS EMERGING TREND.

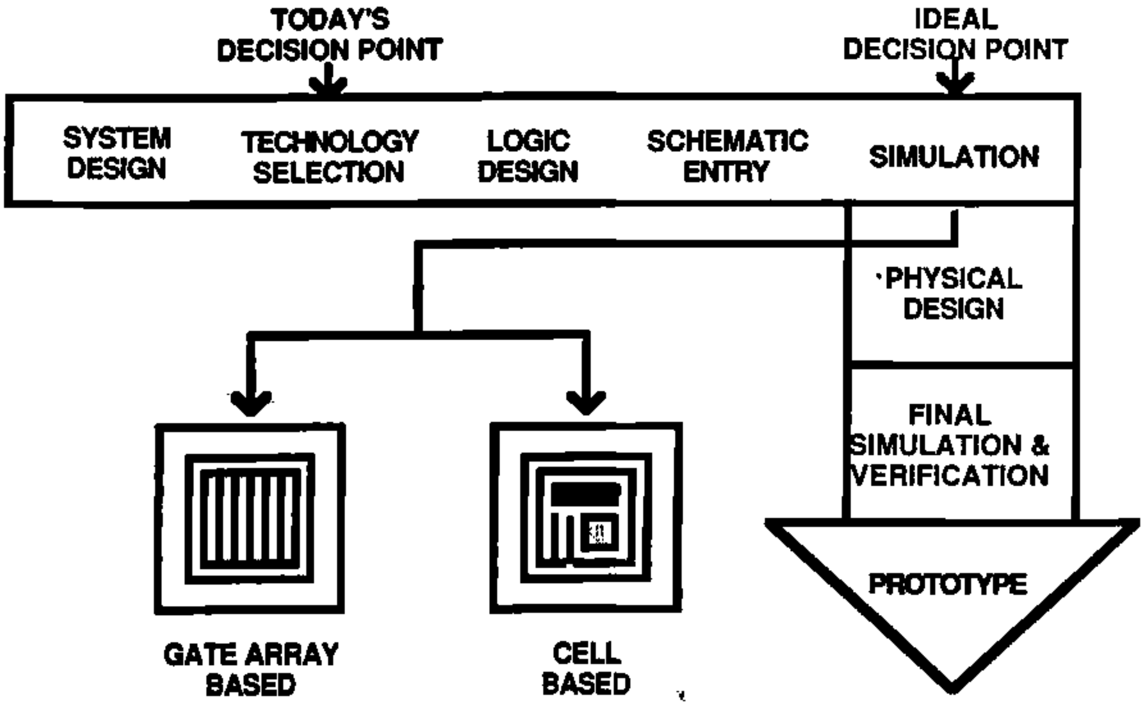
THE DESIGN CYCLE
MIGRATION OF DECISION POINT



MIGRATION OF DECISION POINT

ONE ESPECIALLY POWERFUL OUTGROWTH OF THIS MERGING WILL BE MOVEMENT OF THE TIME WHEN THE DESIGNER MUST MAKE HIS DECISION ABOUT WHICH TECHNOLOGY TO CHOOSE. NOW, HE HAS TO MAKE HIS DECISION EVEN BEFORE THE DETAILED DESIGN IS STARTED.

CHOICE AT THE IDEAL DECISION POINT



CHOICE AT THE IDEAL DECISION POINT

IN THE FUTURE, WELL BEFORE 1990, I BELIEVE THAT ADVANCES IN THE STATE-OF-THE-ART OF DESIGN TECHNOLOGY WILL ENABLE THE ENGINEER TO CHOOSE HIS IMPLEMENTATION METHOD AFTER THE SIMULATION STAGE AND BEFORE THE ACTUAL PHYSICAL DESIGN. THE TREND I HAVE DESCRIBED IS ALREADY TRUE FOR SIMPLE INTEGRATION DESIGNS AND WILL BE POSSIBLE FOR EVEN HIGH INTEGRATION AND HIGH PERFORMANCE DESIGNS IN THE FUTURE.

SUMMARY

ASIC MARKET APPLICATIONS ARE SEGMENTED INTO HIGH PERFORMANCE, HIGH INTEGRATION AND SIMPLE INTEGRATION.

SOFTWARE IS PROVIDING A MERGING OF CELL BASED AND ARRAY BASED SOLUTIONS.

FRONT END DESIGN PROCESS IS BECOMING IMPLEMENTATION INDEPENDENT.

SUMMARY

IN CONCLUSION, I WOULD LIKE TO STRESS THE FOLLOWING KEY POINTS I HAVE MADE IN THIS PRESENTATION:

(A) ASIC MARKET APPLICATIONS ARE SEGMENTED INTO THREE DISTINCT CATEGORIES -- HIGH PERFORMANCE, HIGH INTEGRATION AND SIMPLE INTEGRATION.

(B) DEVELOPMENTS IN DESIGN SOFTWARE ARE PROVIDING A MERGING OF CELL-BASED AND ARRAY-BASED SOLUTIONS.

(C) THE FRONT END OF THE DESIGN PROCESS IS BECOMING IMPLEMENTATION INDEPENDENT, PROVIDING GREATER FREEDOM OF CHOICE TO THE DESIGNER.

Dataquest
a company of
The Dun & Bradstreet Corporation

THE IMPACT OF VLSI ON AUTOMATIC TESTING

Alex d'Arbeloff
Chairman and President
Teradyne, Incorporated

Mr. d'Arbeloff is Chairman and President of Teradyne, Inc., a manufacturer of automatic test equipment and interconnection systems for the electronics industry. Mr. d'Arbeloff cofounded Teradyne in 1960 and served as Vice President until 1971, when he became President. He is also a Director of Thermo Electron Corporation, Stratus Computer Corporation, Lotus Development Corporation, and BTU Engineering, Inc. Mr. d'Arbeloff graduated from the Massachusetts Institute of Technology.

Dataquest Incorporated
JAPANESE SEMICONDUCTOR INDUSTRY CONFERENCE
April 13-15, 1986
Hakone, Japan

Testing Costs

SSI – 5% of IC cost
MSI – 20%
LSI – 40%

Ways to cut test costs:

1) design for testability – ~~level~~
2) Common simulation software
3) self-test

1) Parallel/multiplex testing
2) Non-stop testing
3)

Memory test heads

106	212	434 (304)	848 (600)
x4	x8	x16	x32

THIS PRESENTATION WAS NOT AVAILABLE
IN TIME FOR PUBLICATION

TOWARD USER-FRIENDLY INTEGRATED CIRCUITS (UFICs)

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UFIC =

Dataquest Incorporated
JAPANESE SEMICONDUCTOR INDUSTRY CONFERENCE
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1. Movement towards User-friendly Circuitry

Recent years have seen the appearance of a variety of words to describe semiconductor products aimed at specific user or application needs. One such expression is ASICs, short for application-specific integrated circuits, which was first coined by Dataquest, Inc. There are, however, several other terms in use, as can be seen from Fig. 1.

Looking at this list, there seem to be many differences of nuance from expression to expression; yet, there also seems to be a common thread tying them together. In each case, the designer, manufacturer, or whomever, seems to be aiming at what could be called user-friendly integrated circuits, or UFICs. Again, though, this UFICs term itself is not something that can be defined in great detail, but is rather only indicative of a broad current.

Over the past decade, the semiconductor industry has been predominantly geared toward producing high-performance and highly functional, yet standard, microprocessor and memory devices. The next ten years look to be a UFICs decade, however, with quite a few such devices already proposed or realized. Many more more-sophisticated UFICs are sure to appear in the very near future (see Fig. 2).

No matter what the UFIC, though, it will need to display high performance and sophisticated functions. Moreover, it will need to meet extremely specialized customer needs. And, it will need to do so in a way guaranteed to minimize necessary lead time to the greatest possible extent.

2. Why UFICs?

Tremendous improvements in user systems have been the result of the ongoing advances being made in semiconductor technologies. One major area of progress is in decreasing the number of required system componenents (Fig. 3). A particularly appropriate example is hand-held calculators, because of the important role they have played in driving early-stage MOS development.

Progress has been remarkable. Early on, these calculators made use of thousands of transistors and diodes. With advances in IC technology, the number of components was then reduced to 2-300. Moving on to the LSI era, it has finally became possible to configure the entire calculator circuitry from only a single chip. What is more, major improvements have also been registered in ease of function execution, power consumption and a variety of other areas during this same period. Current state-of-the-art is a calculator with virtually the same dimensions as a business card.

Advances in IC integration are also playing a major role in reducing the number of necessary components in many other types of systems and equipment (see Fig. 4). Looking at TVs. the early 1970s saw a one order drop from the need for hundreds of transistors and diodes to the need for tens of them. At the present. television sets are being manufactured with use only of a few ICs or LSIs and a few tens of transistors and diodes. Progress in the facsimile terminal area also is remarkable. Again. hundreds of ICs were required early in this decade. Now. however. sets are coming out that embody only a few tens of such integrated circuits.

The advances referred to in semiconductor technologies have come together with progress in other areas to facilitate development of so many sophisticated and convenient equipment systems that could not even have been envisioned only a few years ago. Whether in the form of personal computers or auto-focussing cameras. supercomputers or digital telecommunications switching equipment. industrial robots or what have you. examples are almost too numerous to name. Semiconductor technology progress has supported reduced costs and expanded applications in systems making use of ICs. thus in turn contributing to a huge expansion in demand for the very same semiconductor devices. This explosion of demand has itself provided the driving force for further technological leaps. thus working out very symmetrically.

New types of semiconductor products are. however. becoming necessary as a result of these trends toward greater integration and expanded application areas (see Fig. 5). The application system designers and manufacturers making use of such devices are faced with developing and marketing systems that not only fit the needs of end-users to the greatest possible extent, but that also display some distinguishing difference from those systems put out by their competitors. When ICs were not so highly integrated it was possible to provide such distinguishing characteristics through unique arrangements of standard LSIs. In this time of VLSIs and UlSIs, however. such arrangements have to be made on the actual chips themselves. Applied system developers accordingly need chips that match the systems they are in the process of putting together.

Looked at from the semiconductor manufacturer side of things. there are other problems arising in this period of increasingly greater integration. Leaving aside the general-purpose megabi memories and high-end microprocessors now becoming possible for the first time, the combination on a single chip of 4/8 bit CPUs and peripheral ICs that used to be individual chips in themselves has thrown into danger the whole general-purpose nature of such LSIs. At this juncture, UFICs look to have a major role to play in dealing with the problems faced by both application system developers and semiconductor manufacturers.

Based on the discussion above (see Fig. 6). UFICs can possibly be defined as devices that will facilitate movement from a user's system concept to implementation of the actual system in the shortest possible amount of time--that is. realization of the quickest possible turn around time.

Considering any system to fundamentally consist of both hard and software. two things look to be of increasingly greater importance in the software area: supply of sophisticated support tools that will speed-up software development by the user. and provision of field programmable LSIs that will facilitate the quickest possible writing into the device of the developed software. In the hardware area the key appears to be how to get the chips fitted to the needs of the particular user to him in the shortest possible amount of time. Here. design automation. or DA. has a vital role to play. This DA also needs to be capable of dealing with the problem of testability that is becoming increasingly more intractible as integration scale increases.

3. Underlying UFICs Technologies

3.1 Field-programmable Devices

There are two approaches to making the dedicated ICs that users now require (Fig. 7). First is by manufacturing mask-programmable devices. or MPDs for short. and the second via production of field-programmable devices. or FPDs. MPDs are customized during the wafer manufacturing process through use of hot masks designed to fit each particular device. Representative examples are mask ROMs and gate arrays. FPDs are LSIs where. after purchase from the manufacturer, the user can employ support-tool programmers to write-in software of his own specification. Examples here are electrically programmable ROMs. or EPROMs. and programmable logic devices. or PLDs.

With MPDs. it takes approximately one month or more before samples can be shipped to the user after an order has been received by the manufacturer. Because the user himself can undertake programming in a most simple manner with FPDs. however. turn-around time, or TAT. is reduced to virtually zero. Accordingly, FPDs can be labeled as being quite user-friendly.

Field-programmability would thus look to be a basic UFICs technology. Let's take a look, here, at an example.

Hitachi's ZTAT microprocessor is a plastic packaged microcomputer with a built-in EPROM. Compared to conventional single-chip microprocessors with internalized mask ROMs. this ZTAT facilitates a multitude of benefits. including:

1. ROM programming with a turn-around time of zero;
2. little risk of software bugs because there is no need for the user to order out his ROM programming; and
3. optimal suitability as a bridge to future mass production through use of later-developed masks (quick mass-production startup is possible and user opinions

can be received and responded to before beginning mass production).

Development of this advanced type of device became possible upon consolidation of the several underlying technologies (refer also to Fig. 8):

1. high-performance microprocessor architecture:
2. CMOS EPROM techniques;
3. chip passivation to insure increased reliability, as well as plastic packaging techniques; and
4. highly efficient testing techniques for EPROMs and microcomputers accomodated together on the same chip.

Single-chip microprocessors with quick TATs were available before the advent of this ZTAT microcomputer (Fig. 9). However, comparing the ZTAT to conventional single-chip microprocessors with built-in mask ROMs should provide a clearer understanding of the advantages provided by this new device.

Microprocessors with internalized mask ROMS do provide economicality, yet the TAT needed for ROM programming is a problem. To achieve a quicker TAT, the piggy-back configuration made an appearance. What this entails is making it possible to place a commercial EPROM on the back of a microprocessor package. A virtually zero TAT could be achieved, but price problems appeared with this configuration. Microprocessors with built-in EPROMS accordingly next appeared on the scene. Because these were ultraviolet erasable PROMs, windows had to be equipped in the packages. This made it impossible to drop prices down to suitable levels.

Finally, we come to development of the ZTAT. In appearance it looks the same as a conventional mask ROM, while the price is also close.

Let's look at what kind of applications have become possible as a result of development of this ZTAT (see Fig. 10). In the past there was little need to change the software to be written into a ROM. Moreover, mask ROM devices have been employed for applications where large numbers of chips are required. On the other hand, when the frequency of changes to software was high and the volume needed low, window-type microcomputers have been employed. In respect to intermediary applications, however, use of mask ROMs carries with it a risk, while use of window-type devices is expensive, thus facing the user with a dilemma.

ZTAT devices are ideal single-chip microprocessors for plugging this gap. The user can employ any number of chips whenever and wherever he desires. As you can see, then, UFICs aims have been advanced.

3.2 Electrically Erasable PROM (EEPROM) Technology

In comparison to EPROMs which are erasable with applied use of ultraviolet light, EEPROMs are PROMs which can be written and erased electrically. Though EEPROMs are larger than EPROMs, they offer major advantages in that a windowed package does not need to be employed and that programs can be written into them and changed even after the devices are assembled into a system. EEPROMs are accordingly a prime candidate for UFIC status.

EEPROMs have a long history (see Fig. 11). Only now, however, have 64 k-bit level devices come onto the market. Compared to the 16 k-bit circuits of only a few years ago, these now offer such advantages as:

1. a single, 5 V power supply rather than the previous dual source;
2. variable widths (byte-wide as well as chip-wide) for programming and erasure, greatly quickening these two activities;
3. high-speed operation; and
4. built-in circuitry that was formerly on peripheral devices.

The 64 k-bit devices are accordingly a lot easier to use.

Let's look a little more closely at these technological trends (Fig. 12). The cell area needed for one bit of EEPROM memory differs according to process resolution. At the same resolution, however, EEPROMs fall midway between DRAMs and SRAMs. In other words, while EEPROMs require two transistors per single bit of memory, DRAMs take one and SRAMs (in the Hitachi case) need four plus two resistors.

Taking Hitachi's EEPROMs as an example (see Fig. 13), cell size has tended to shrink to one fourth over a five year period. This has been accomplished not only by employing processes with finer line resolution but also by making use of a three-dimensional configuration (a tri-gate structure) for the two transistors needed for each bit.

There are two main technologies employed for EEPROMs: MNOS (or metal nitride oxide semiconductor), and floating gate (see Fig. 14). Each has its strengths and weaknesses; in short, MNOS provides a structure that is in principle simple, while the floating gate process is compatible with that for conventional EPROMs.

One current trend is to load an EEPROM on-chip. One such example can be seen in Fig. 15. This is an 8-bit microcomputer realized via a 2 um CMOS EEPROM process that provides, on-chip, 3 k-bytes of ROM, 128 bytes of RAM and a 2 k-byte EEPROM. A protection circuit is also provided which prevents external reading of written data without use of a stipulated procedure.

Sample applications (see Fig. 16) for just such a microprocessor with internalized EEPROM include:

1. individualized information registry taking the form of, for example, a credit or ID-type IC card;
2. precision machinery systems requiring fine adjustments: and

3. updating of software used in remote equipment.

Field programmability is, in this way, serving to meet the most minute user needs. Moreover, it is likely to be subjected to even further development in the future as a central UFICs technology.

3.3 Chip Design Automation

One fundamental UFICs feature involves getting the dedicated chip the user needs to him as fast as possible, as has already been mentioned (see Fig. 17). What this actually entails, however, is streamlining as well as fully automating the process from system to chip design.

In the days when integration density was not so great, it was possible for designers to manually put together circuits even when the logic was somewhat random or arbitrary. At the present day, however, where hundreds of thousands of transistors are being put onto one chip and the circuit diagram has become something several square meters in area, it is getting extremely difficult to do things manually. Disciplined design with DA backup is now becoming a vital requirement. What this "disciplined" design signifies is the modularization of logic, and structuring of the circuitry by means of a modular assembly approach. DA then involves automatic module design or automatic design of chips combining these logical modules.

The ultimate goal of DA is development of the necessary tools that make it possible to input the system concept and merely wait for the output of a silicon chip (see Fig. 18). Automatic design techniques are now being established for each stage from system to chip design. Accordingly, problems for solution in the near future are integration of each of these techniques in a total. overall process as well as automated realization of chips that compare favorably with manually designed chips in terms of chip size and performance.

With establishment of the optimal DA system as envisioned today (see Fig. 19), all the designer will need to do is describe system functions in a high-level language and confirm simulation results to realize a fully designed dedicated chip. The DA system will then undertake generation of a logical diagram from the input functions, generation of the necessary cells, layout of the overall chip through combination of these cells, and output of the data necessary for fabrication of the required hot mask. Simultaneously, a test pattern for confirmation of the suitability, etc. of the fabricated LSI will be automatically generated.

Currently, there are several ways to go about realizing dedicated LSIs (Fig. 20). These include a full-custom, standard cell, gate array, and PLD approach. In each case, the TAT and chip size characteristically differ. With the UFICs goal being minimum chip size with minimum turn-around time, it is apparent that a major DA system advance is now needed.

3.4 Testability

Unfortunately, 100% of all manufactured semiconductors do not end up meeting original quality objectives (see Fig. 21). Accordingly, some kind of test is necessary for the culling out of defective products. One unfortunate result of the recent trend toward increasedly dense LSIs, however, is that chip testability has markedly decreased.

Just what signal strings will be output with input of just what signal strings--what is known as the test pattern is the series of signal strings that makes this determination possible. "Fault coverage" is a unit of measurement clarifying to what extent defects appearing in LSI circuitry can be detected. Comparing test pattern fault detection rates with the percentage of defective devices found among good quality devices at each sorting, it can be seen that the test pattern fault detection rate needs to be at least 90-95% for assurance of reasonable quality.

However, manpower required for realization of this 90-95% goal via use of fault simulators tends to increase greatly with LSI integration scale (see Fig. 22). This is because the number of places where defects may occur increase proporionately to the density of the circuit, and it accordingly becomes more difficult to monitor all such locations within the chip from "outside" the chip. Not only, then, is automatic design of the chip important.

but another vital requirement is automatic generation of the above-mentioned test patterns.

Let's take a look at one method of automatic test pattern generation (Fig. 23). With automatic addition of a test circuit covering all flipflops in any user logic circuit, it becomes possible to freely conduct flipflops and to read and write data from outside the LSI. Employment of this technique assures relatively simple automatic test pattern generation no matter how complex the chip.

5. Conclusions

"Systems on chip" have already begun to appear in calculator and watch applications. Semiconductor progress is sure to make it possible to realize other large-scale systems on a single chip. Depending on the application it will become necessary not only to integrate the CPU, memory and similar digital circuitry but also analog circuits on the same chip.

The UFICs that have been discussed in this paper are aimed at assuring that the user can freely combine a wide variety of semiconductor circuitry, with it ultimately becoming possible to mount it all on a single chip. Moreover, it must be possible to do this with minimum TAT, and within a minimum chip size. Once such devices make an appearance, it will become possible to offer truly friendly systems to end users, and to greatly improve the

TOWARD
USER-FRIENDLY INTEGRATED CIRCUITS

T. MAKIMOTO
MUSASHI WORKS
HITACHI, LTD.

ASIC : Application Specific IC
- Gate Array
  - Structured Array
- Standard Cell
  - Super Integration
- Programmable Logic Device (PLD)
  - Programmable Array Logic (PAL)

ASSP : Application Specific Standard Product
  - Video RAM

ZTAT : Zero Turn Around Time

Fig. 1 UFICs RELATED TERMINOLOGY

SUPERIOR COST PERFORMANCE
SOPHISTICATED FUNCTIONS

+

SPECIALIZED CUSTOMER NEEDS
QUICK TAT

Fig. 2 UFICs REQUIREMENT

2400

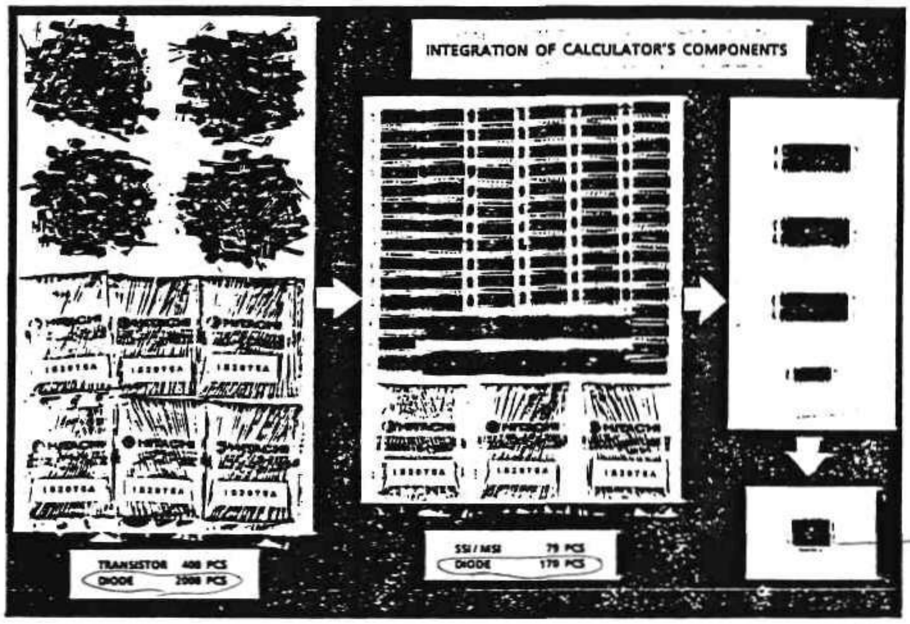

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Fig. 3 INTEGRATION OF CALCULATOR'S COMPONENTS

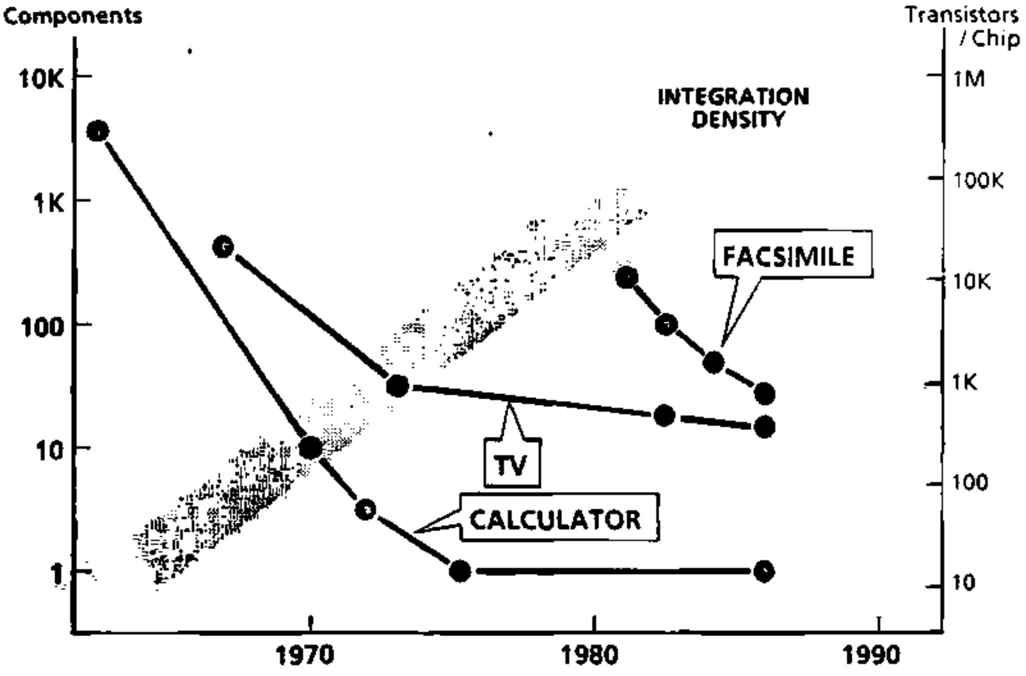


Fig. 4 DRASTIC DECREASE IN NO. OF COMPONENTS

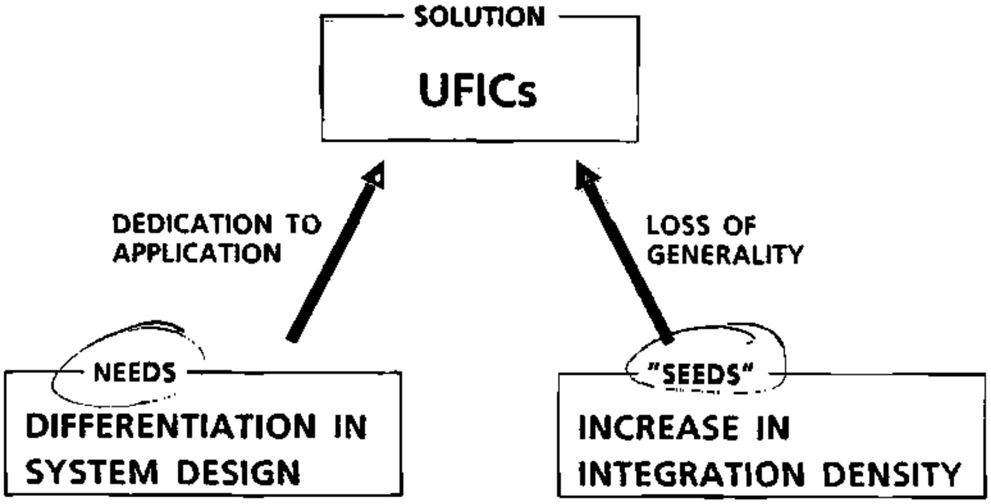
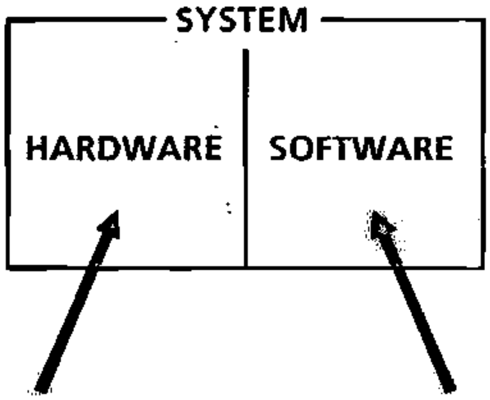


Fig. 5 WHY UFICs



SYSTEM

HARDWARE

SOFTWARE

- DESIGN AUTOMATION FOR DEDICATED CHIPS (Senyo chip)
- TESTABILITY

- SUPPORT TOOLS FOR PROGRAMMING
- FIELD PROGRAMMING

Fig. 6 REQUIREMENTS FOR QUICK TAT FROM CONCEPT TO IMPLEMENTATION

—PLASTIC ENCAPSULATED EPROM ON-CHIP MICROPROCESSOR —

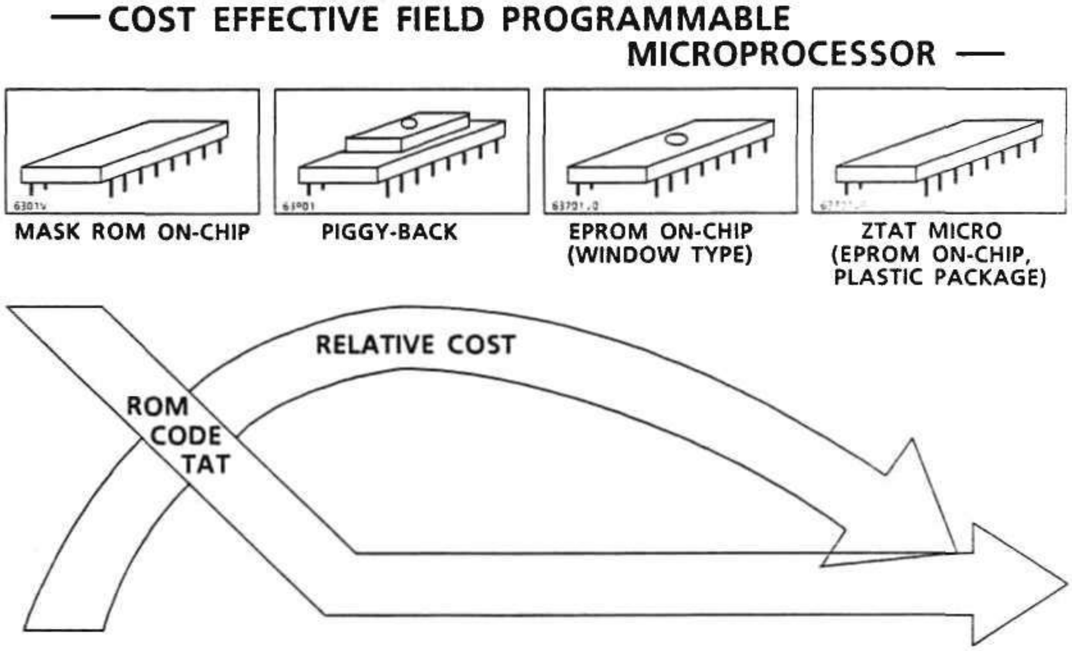
ZTAT OFFERS

- ZERO TURN AROUND TIME FOR MASK PROGRAMMING
- ZERO RISK OF ROM CODE ORDER PROBLEMS
- INTERIM SOLUTION BEFORE MASKED PRODUCT INTRODUCTION

Fig. 7 WHAT IS THE "ZTAT"

- HIGH PERFORMANCE MICROPROCESSOR ARCHITECTURE
- CMOS EPROM PROCESS TECHNOLOGY
- RELIABLE PASSIVATION AND PLASTIC PACKAGING
- EFFECTIVE TESTING OF MICROPROCESSOR / EPROM

Fig. 8 TECHNOLOGY UNDERPINNINGS OF ZTAT



— COST EFFECTIVE FIELD PROGRAMMABLE MICROPROCESSOR —

Fig. 9 ZTAT EVOLUTION

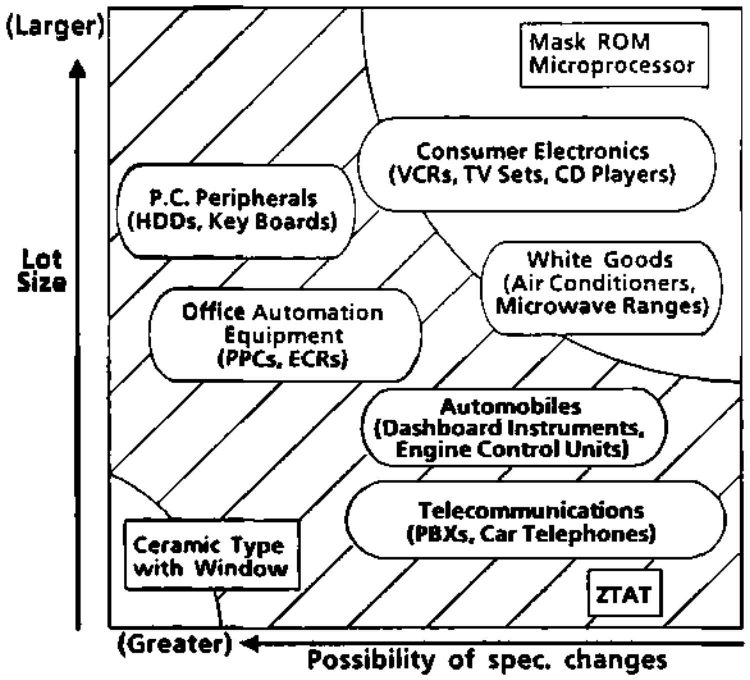


Fig. 10 ZTAT APPLICATION

1979	1985
16K bit (2K × 8)	64K bit (8K × 8)
3µm N-MOS	2µm C-MOS
Double Power Supply	Single 5V
Chip Erase	Chip / Byte / Page Erase
Byte Write	Byte / Page Write
Read Access Time 350 / 450 ns	200 / 250 ns
Write Time 20 ms	10 ms
	Peripheral Circuits on Chip Address, Data Latches, Data Protection etc.

Fig. 11 EVOLUTION OF EEPROM TECHNOLOGY

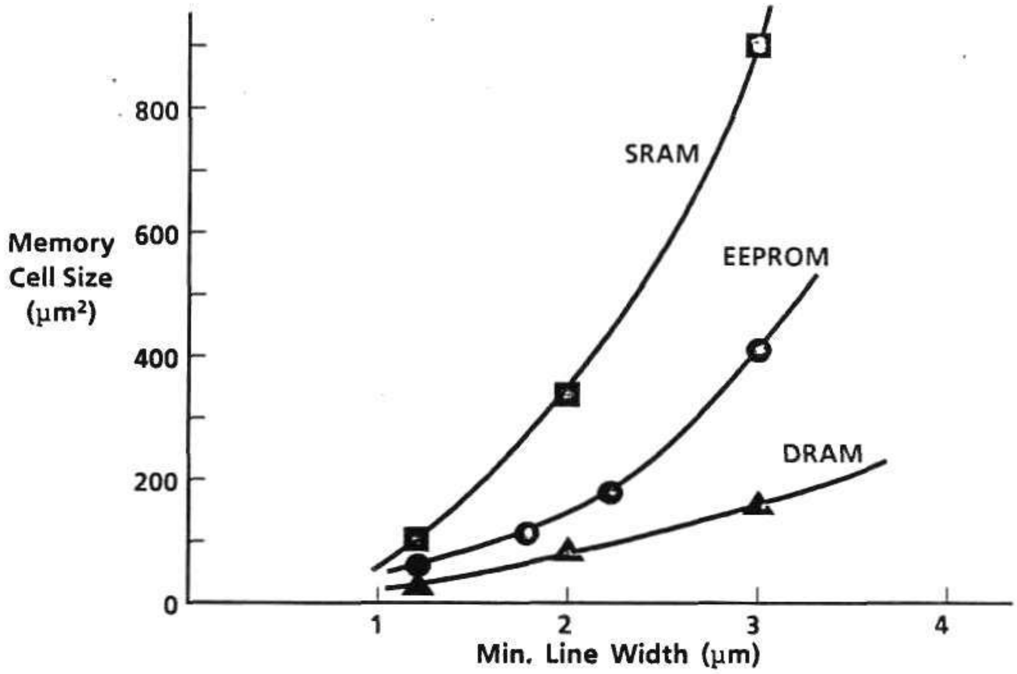


Fig. 12 CELL SIZE FOR MOS MEMORIES

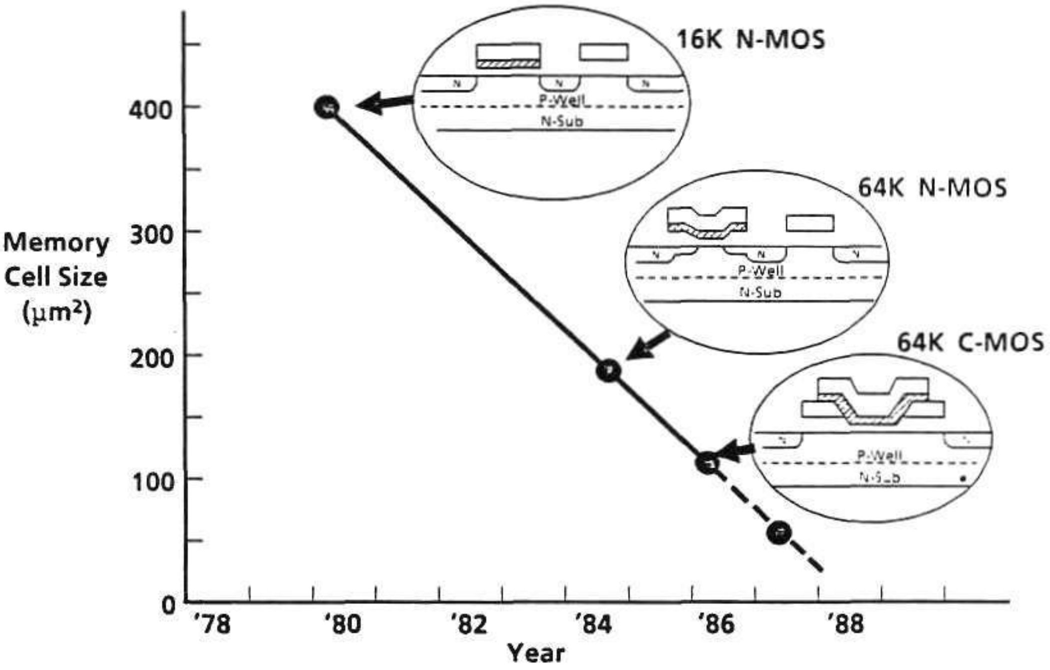


Fig. 13 EEPROM MEMORY CELL SIZE TREND

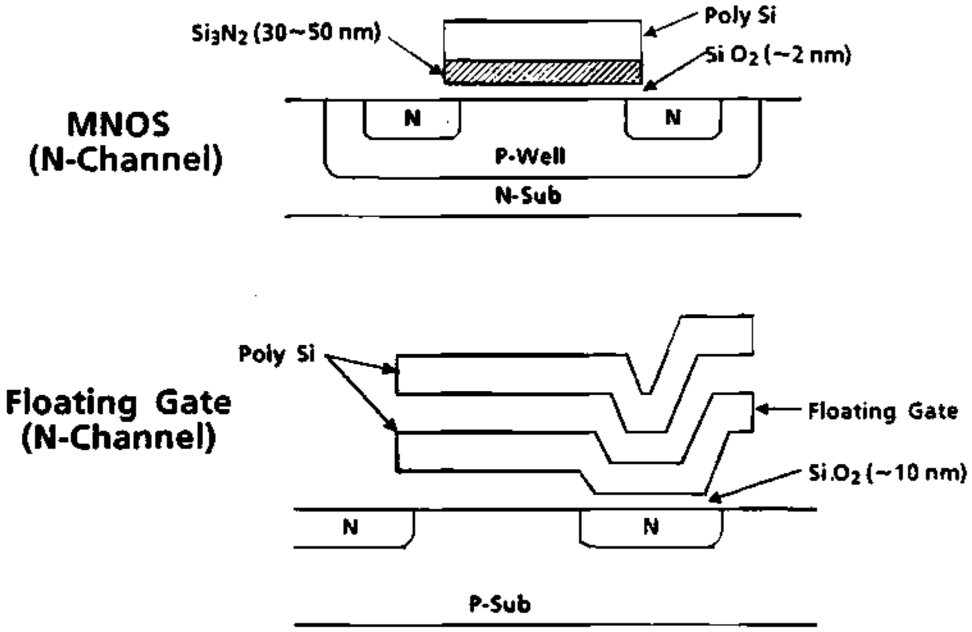
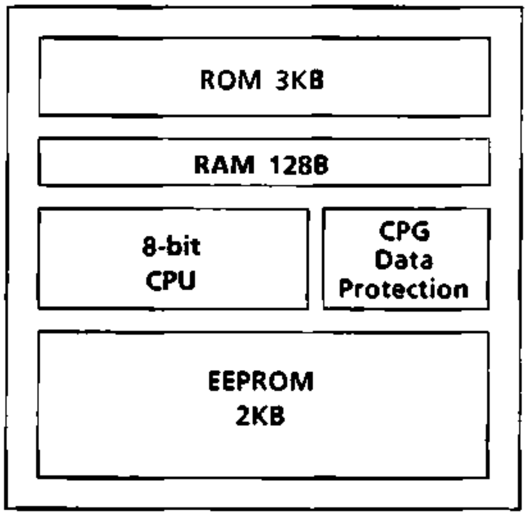


Fig. 14 EEPROM STRUCTURES

- 2μm CMOS EEPROM process
- 2K byte EEPROM on-chip 8 bit microprocessor
- Integrated data protection circuit
- Chip size : 5.6 × 5.7 mm²



IC Card

Fig. 15 EEPROM ON CHIP MICROPROCESSOR

Type of Applications	Examples
Personal Information Storage	▪ IC Card (Bank Card, Credit Card etc.) ▪ Security System ▪ ID Card
Data Calibration	▪ TV Tuner Control ▪ Automotive Applications ▪ Robotics, Precision Control
In-Circuit Software Up-date	▪ Remote Controller ▪ Factory Automation

Fig. 16 APPLICATIONS OF EEPROM ON CHIP MICROPROCESSOR

- OVERALL AUTOMATION FROM CONCEPT TO SILICON CHIP

PROBLEMS TO BE SOLVED

- SYSTEM INTEGRATION
- CHIP COMPETIVENESS
  - CHIP SIZE
  - PERFORMANCE

Fig. 17 DESIGN AUTOMATION OBJECTIVES

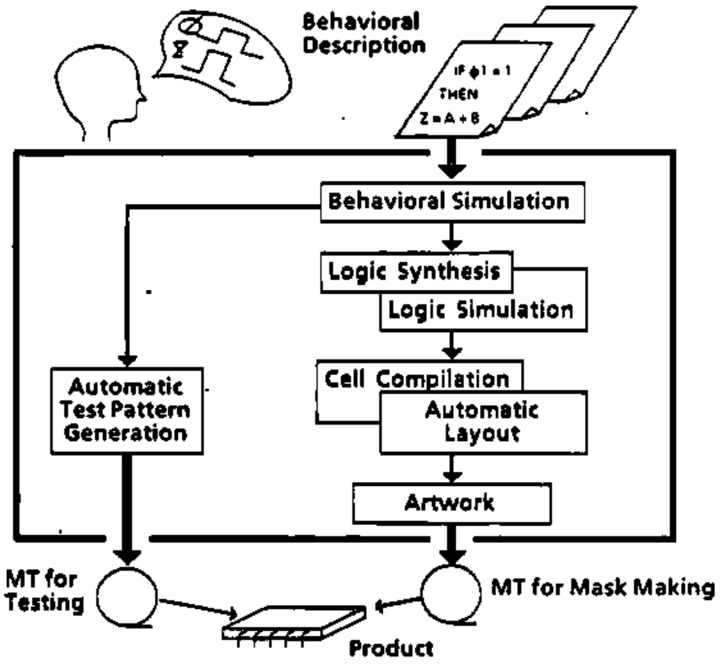


Fig. 18 INTEGRATED DESIGN AUTOMATION SYSTEM

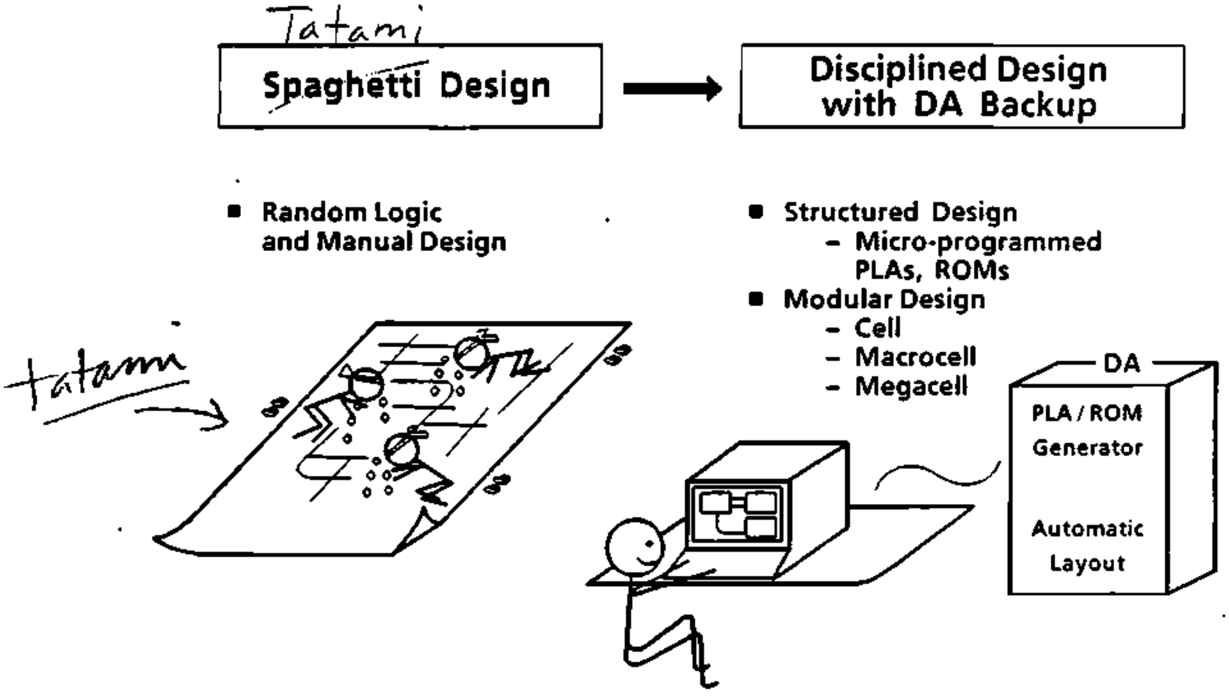


Fig. 19 DESIGN METHODOLOGY

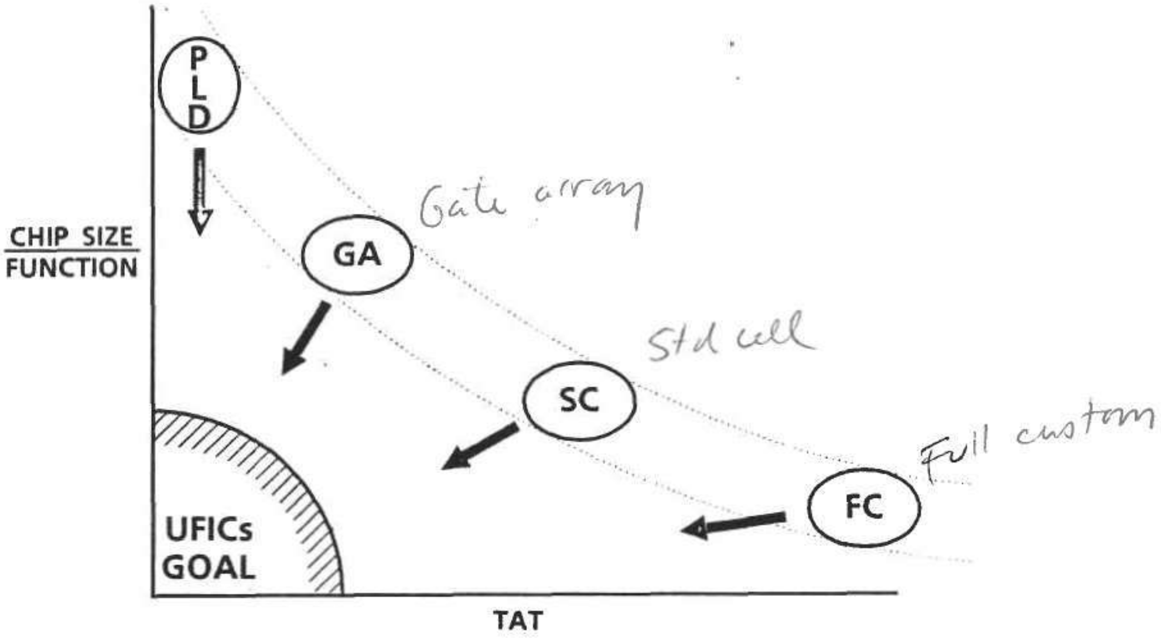


Fig. 20 TRADE-OFF BETWEEN TAT AND CHIP SIZE

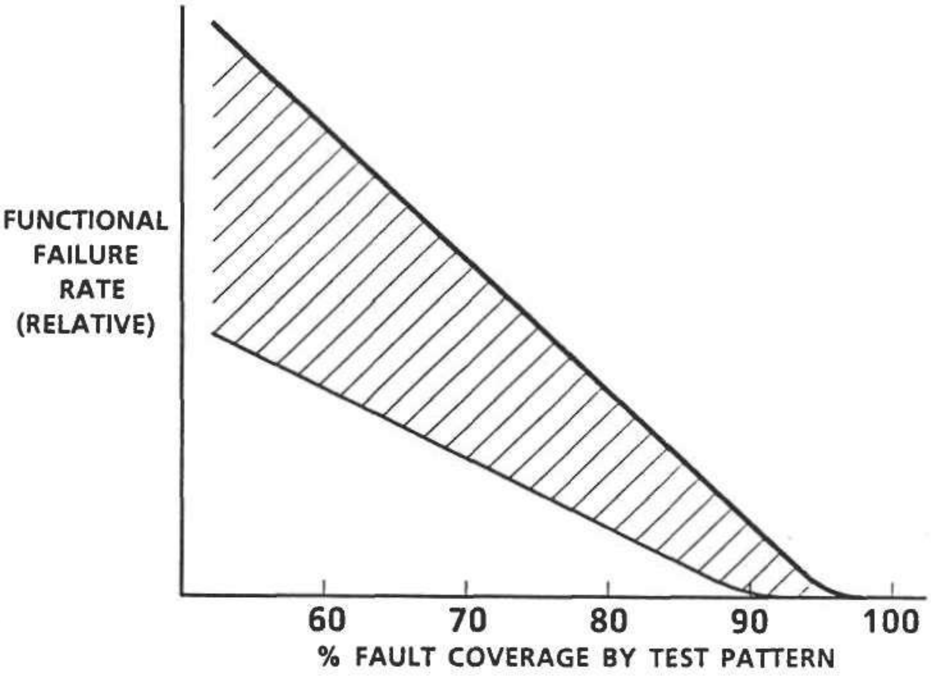


Fig. 21 PROBLEMS CAUSED BY POOR TESTABILITY

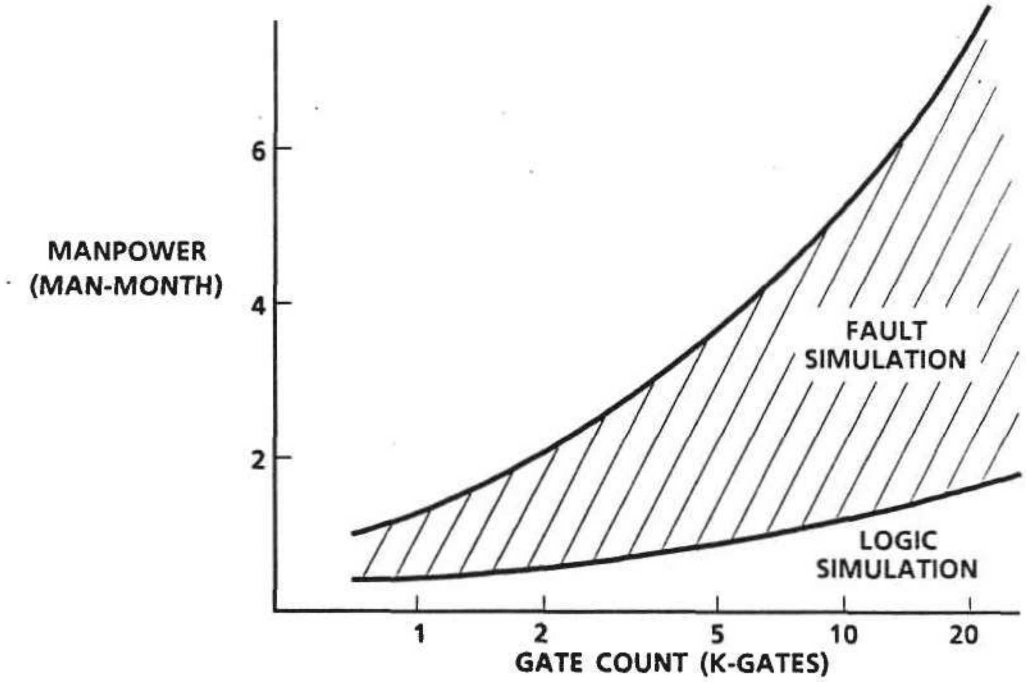


Fig. 22 MANPOWER REQUIRED FOR TEST PATTERN GENERATION

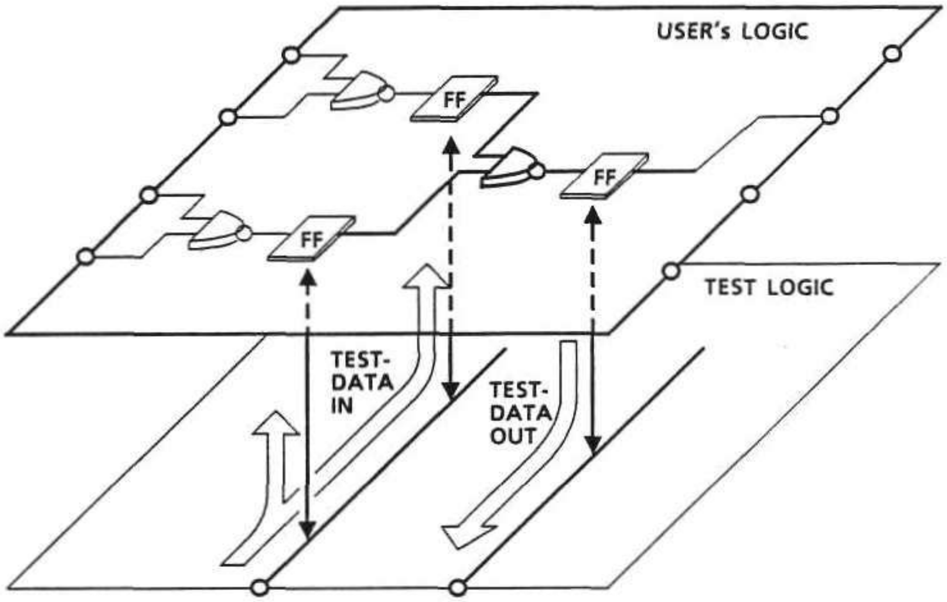


Fig. 23 AUTOMATIC TEST LOGIC ADDITION AND TEST PATTERN GENERATION

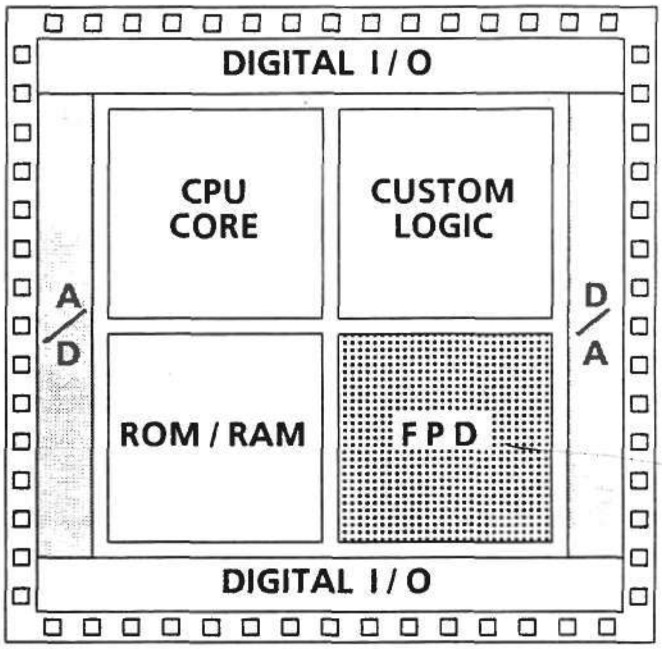


Fig. 24 FUTURE UFIC IMAGE

→ Portable translator

Dataquest
a company of
The Dun & Bradstreet Corporation

１．Ｕｓｅｒ ＦｒｉｅｎｄｌｙなＩＣへの動き

図 1 近年ＡＳＩＣ(Application Specific Integration Circuit)を初めてとして、ユーザ指向、応用指向の半導体を示す多くの言葉を聞くようになってきた。これらの言葉には、ねらいに多少の相異があるもののその底流には共通するものがある。“Ｕｓｅｒ Ｆｒｉｅｎｄｌｙ”なＩＣを提供しようという点である。そこでこれらをまとめて、ここではＵＦＩＣ(User Friendly Integrated Circuit)と呼ぶことにする。ＵＦＩＣは厳密に定義された特別な製品というよりは、むしろ大きな潮流を示す概念と考えてよい。

図 2 過去１０年間の半導体産業は、メモリ･マイコンに代表される高性能･高機能な標準品を中心に動いてきた。しかし今後の１０年間はＵＦＩＣがその中心的役割を担うだろう。現在までに多くのＵＦＩＣがすでに提案・実現されている。今後もさらに多くの方向のＵＦＩＣが現れるだろう。ＵＦＩＣは高性能・高機能ということに加えて、ユーザの要求する仕様にぴったりのＩＣを、短期間に開発できるものでなければならない。

２．なぜＵＦＩＣか

図 3 半導体技術の進歩によるユーザシステムの性能向上には目覚しいものがある。集積度向上によるシステムの部品数低減は、現在半導体の主流技術であるＭＯＳ　ＬＳＩの初期の牽引車であった電卓の例を見れば、その効果は歴然としている。初期の電卓は数１０００本のトランジスタ・ダイオードで構成されていたが、ＩＣ化によって２００～３００個の部品数ですむようになり、さらにＬＳＩ化によってついには一個のＬＳＩで電卓ができるようになった。しかも、この間に機能・セット形状・消費電力等あらゆる面で飛躍的な改善がなされている。カード電卓はその最先端を行く例である。

図 4 ＬＳＩの集積度向上は電卓以外のあらゆる機器でもその部品点数低減に役立っている。例えばカラーＴＶでは１９７０年代前半のＩＣ化により従来必要とした数１００個のトランジスタ・ダイオードの大半を数１０個のＩＣに置換えた。そして現在では数個のＩＣ／ＬＳＩと数１０個のトランジスタ・ダイオードでＴＶを作れるようになっている。またファクシミリも１９８０年初期にはやはり数１００個のＩＣを必要としたが、今では数１０個ですむようになっている。

半導体技術の進歩は、他の技術進歩とあいまって、従来では実現不可能であった機器を次々と現実のものとしている。例えばパーソナルコンピュータやオートフォーカスカメラ、あるいはスーパコンピュータやデジタル交換機、高性能な産業用ロボット等々枚挙にいとまがない。
このように半導体技術の進歩により、それを使用する機器のコストダウンと応用範囲の拡大が、半導体需要を著しく拡大したきた。またこの需要の拡大が半導体技術の跳躍の進歩の原動力でもあった。

しかし半導体の高集積化と応用分野の拡大は新らたなタイプの半導体製品を必要としている。 図 5

半導体のユーザは、エンドユーザのニーズによりマッチした独自システム商品の開発、すなわち競合メーカとは一味違う商品の「差別化」を必要としている。ＬＳＩの集積度の低い時代には、標準的ＬＳＩの組合せ方でその｢差別化｣ができた。しかしＬＳＩの高集積化によって、その組合せやそのものをＬＳＩの上で行う必要が生じてきている。すなわちシステムメーカは、その独自商品にマッチした専用ＬＳＩを必要とするようになってきている。

一方半導体メーカ側から見ると、高集積化により初めて達成できるメガビットメモリ・ハイエンドマイコンのような汎用的機能の標準ＬＳＩは別として、４／８ビットＣＰＵ・周辺ＩＣのように従来はそれ自体が１個のＬＳＩであった機能モジュールを組合せて１個の高集積ＬＳＩを標準品として開発することは、そのＬＳＩの一般性が失われるため困難になりつつある。

こうした半導体ユーザ・メーカの問題を解決する製品としてＵＦＩＣは今後重要な役割を演ずると思われる。

以上のような考えから、ＵＦＩＣの基本は｢ユーザのシステムコンセプトからその実現までをいかに速く行うか｣にある。 図 6

システムは一般にハードウエアとソフトウエアから成る。

ソフトウエアに関しては、ユーザが迅速にソフト開発ができるようなより優れたツールの提供に加えて、完成したソフトを速やかにＬＳＩに書込めるようなＦｉｅｌｄ ＰｒｏｇｒａｍｍａｂｌｉｔｙをＬＳＩに持たせることも今後重要になるだろう。

ハードウエアに対しては、いかに速くユーザの求める専用チップを提供できるかがキーポイントになる。このためにはチップのＤｅｓｉｇｎ Ａｕｔｏｍａｔｉｏｎが重要になる。またＤｅｓｉｇｎ Ａｕｔｏｍａｔｉｏｎは、集積度向上にともなってますます困難になるテスタビリティ劣化の問題も解決するものでなければならない。

3．UFIC’Sを支える技術

3．1 Field Programmable Devices(FPD)　図７

ユーザの求める専用ICを作る方法は次のふたつに大別できる。

(1) Mask Programmable Device　(MPD)
(2) Field Programmable Device　(FPD)

MPDは専用IC用のホトマスクを使ってウエハの製造工程中でカストマイズする製品で、マスクROM、ゲートアレイがその代表例である。FPDは半導体メーカから購入した後でユーザが求める仕様にプログラムをライタを使って書き込むことのできるLSIで、その代表例にはEPROM (Electrically Programmable ROM)、PLD (Programmable Logic Device)がある。

MPDは、半導体メーカにその発注を行ってからサンプルを入手するまでに約１ヵ月あるいはそれ以上の開発期間(TAT=Turn Around Time)を必要とする。これに対して、FPDはユーザ側で簡単ににプログラムできるので実質的ににZero TATであるという利点を有する。この意味でFPDは、よりUser FriendlyなICと言うことができる。

Field Program技術はUFICの基本的な技術のひとつとなると考えられる。以下に例をとって詳しく述べる。

日立のZTATマイコンはEPROM内蔵のプラスチック封止のマイコンで、従来のマスクROM内蔵のシングルチップマイコンに比べて、

(1) ROM書込みがZero TATで行える。
(2) ROM書き込みの発注が不要なため、ソフトウエアのバグに対するリスクが小さい。
(3) 将来のマスク版による大量生産への橋渡しとして最適である。（速やかに量産立ち上げ可能なこと、大量生産前にエンドユーザの評価を得られること）
等々の利点を有する。

図 8　こうした利点を持つＺＴＡＴマイコンは以下のような技術ベースがあって初めて開発された。

(1) 高性能マイコンアーキテクチャ
(2) ＣＭＯＳ　ＥＰＲＯＭプロセス技術
(3) 高信頼度化のためのチップパッシベーションとプラスチック封止技術
(4) ＥＰＲＯＭ／マイコン同居チップの高効率なテスト技術

図 9　ＺＴＡＴマイコンの出現以前にも、シングルチップマイコンをQuick ＴＡＴ化する製品はあった。これらを比較することでＺＴＡＴの優れた点をよりよく理解することができる。

マスクＲＯＭ内蔵のマイコンはコストは安価であったが、ＲＯＭ書き込みのＴＡＴが短かくないという問題があった。よりQuick　ＴＡＴをというユーザニーズに応えるためＰＩＧＧＹ　ＢＡＣＫが登場した。これはＲＯＭ無しのマイコンのパッケージ上に市販のＥＰＲＯＭを挿入できるようにすことでＺｅｒｏ　ＴＡＴを達成したが、構造上高価なものになった。次いでＥＰＲＯＭ内蔵のマイコンが現れた。しかしＥＰＲＯＭの紫外線による消去のための窓付きパッケージを採用しているため、十分に価格を下げることはできなかった。そしてＺＴＡＴマイコンの登場となる。外見上はマスクＲＯＭ版と同一で、価格もかなり近いものとすることができた。

図 １０　ＺＴＡＴマイコンの出現によって、どんな応用が可能になるかを見て見よう。従来、ＲＯＭに書き込むべきソフトの変更が少なく、生産数量の大きい用途にはマスクＲＯＭ版が使用された。逆にソフト変更の頻度が高く、生産数量の少ない用途には窓付きマイコンが使用された。しかしその中間にあるものは、マスクＲＯＭ版にするためにはリスクが大きく、窓付マイコンにするにはコスト高になるというジレンマがあった。ＺＴＡＴマイコンはこのようなギャップを埋めるために最適のシングルチップマイコンである。ユーザが「いつでも、どこでも、好きな数量だけ」使うことができる。ＵＦＩＣをめざしたひとつの新しい動きである。

３．２　ＥＥＰＲＯＭ（Electrically Erasable ＰＲＯＭ）技術

ＥＰＲＯＭが紫外線消去の電気的書込みの形のＰＲＯＭであるのに対してＥＥＰＲＯＭは電気的に消去・書込みのできるＰＲＯＭである。

ＥＥＰＲＯＭはＥＰＲＯＭに比べてチップ面積は大きくなるが、窓付きパッケージを用いなくとも消去できること、システムに組込んだままプログラムの書き込み・変更ができることという大きな利点を有するため、今後のＦＰＤにとって注目すべき技術である。

　ＥＥＰＲＯＭの歴史は長いがようやく６４Ｋビットレベルのものが市　図　１１
場に登場するようになった。数年前の１６Ｋビットのものと比べると、

(1) 電源が２本から５Ｖ　１本に
(2) 消去・書き込み方法の選択の巾が広り
(3) 高速動作可能
(4) 周辺回路の内蔵化

と種々の改善がなされ、非常に使い易いものとなっている。

　もう少し詳細に技術動向を見てみよう。ＥＥＰＲＯＭの１ビットあた　図　１２
りのセル面積はプロセスの微細化の程度で異なるが、同一の微細化であればＤＲＡＭとＳＲＡＭの中間に位置する。これはＥＥＰＲＯＭでは１ビットあたり２個のトランジスタで構成されるが、ＤＲＡＭは１個、ＳＲＡＭは４個のトランジスタと２個の抵抗で構成されることによる。

　また、ＥＥＰＲＯＭのセルサイズ（日立）の推移を見ると、過去５年　図　１３
間で約１／４に縮小されている。これはプロセスの微細化だけではなく、１ビットに必要な２個のトランジスタを立体的に配置すること（トライゲート構造）で達成できたものである。

　ＥＥＰＲＯＭのデバイス技術には２種類ある。ＭＮＯＳ(Ｍｅｔａｌ　図　１４
Ｎｉｔｒｉｄｅ Ｏｘｉｄｅ Ｓｅｍｉｃｏｎｄｕｃｔｏｒ)とFloating Gateである。それぞれ利害得失があるが、一言でそれぞれの利点をあげると、ＭＮＯＳは構造が原理的に単純であること、Floating Gateは従来のＥＰＲＯＭとプロセスがコンパチブルなことである。

　このようなＥＥＰＲＯＭをマイコンに搭載する動きもある。これは(図　図　１５
15)ひとつの例である。２μ　ＣＭＯＳ　ＥＥＰＲＯＭプロセスを使って、３ＫバイトのＲＯＭ、12ＧバイトのＲＡＭに加えて2ＫバイトのＥＥＰＲＯＭを搭載した８ビットマイコンである。ＥＥＰＲＯＭに書込まれたデータを外部から正規でない手順で読み出すことを防止したセキュリティ回路も内蔵している。

ＥＥＰＲＯＭ内蔵マイコンの出現により、新しい応用分野が拓れつつ 図 １６
ある。その例をあげると、

(1) ＩＣカードのような個人情報記録
(2) 機械ごとに微調整の必要な精密機械
(3) 遠隔地で動作する機器のソフトウエア更新

等である。

以上のようにＦｉｅｌｄ Ｐｒｏｇｒａｍ技術はユーザのニーズによりきめ細かく対応するもので、ＵＦＩＣのひとつとして今後も発展して行くだろう。

３．３ チップの設計自動化

ユーザの求めるハードウェアをいかに早く専用チップとして実現する 図 １７
かというアプローチもＵＦＩＣのひとつの方向である。この実現のためには、システム設計からチップ設計に至るまでの設計手法の改良と設計の自動化（ＤＡ＝Design Automation)が鍵となる。

集積度の低い時代には、論理が「ゴチャゴチャ」としている設計もそれなりに人手でＬＳＩとして実現することができた。しかし最近のように１００Ｋトランジスタを越えるような規模となると、その図面はたたみ数畳位の大きさになり人手では容易に設計できない。これを解決するためには、規律ある設計とＤＡシステムが必要である。

規律ある設計とは、論理のモジュール化、モジュールの組合せによる構造化等を意味する。このような設計に対して、ＤＡシステムは、モジュールの自動設計、あるいはモジュールを組み合せたチップの自動設計を行う。

ＤＡシステムの最終ゴールは「システムコンセプトを入力して、シリ 図 １８
コンチップを出力する」ツールの開発である。システム設計からチップ設計に至るまでの各段階ごとの自動設計技術は確立されつつある。今後の課題はトータルなＤＡシステムとしての統合化と、人手設計に比べてチップサイズ・性能等で見劣りしないものに完成して行くことである。

最終的なＤＡシステムを使うと、設計者はシステムコンセプトに基づき　図 19

(1) システムの機能を高級言語で記述する。
(2) シュミレーションの結果を見て動作確認をする。

のみで自分の求めるＬＳＩを設計できる。ＤＡシステムは、機能記述から論理図の生成、必要とするセルの生成、セルを組み合わせたチップ全体のレイアウト、そしてホトマスク作成用のデータを出力する。また同時に、製造されたＬＳＩの良否を判定するテストパターンも自動生成する。

ユーザの専用ＬＳＩを実現する具体的方法には、現在、フルカスタム、　図 ２０
スタンダードセル、ゲートアレイ、ＰＬＤといくつかの方法がある。それぞれＴＡＴとチップサイズが異なり、それぞれの特徴となっている。しかしＵＦＩＣの最終ゴールは「ミニマムＴＡＴでミニマムチップサイズ」にある。この目標に近づくためＬＳＩの設計手法およびＤＡシステムの一層の改善が必要である。

３．４　テスタビリティ

製造された半導体は、残念ながら１００％の良品率にならない。した　図 ２１
がって何らかのテストによって良品のみを選びだす必要がある。しかし集積度の増大にともない、一般にＬＳＩのテスタビリティは著しく低下するという問題がある。

ＬＳＩにどんな信号列を入力すると、どんな信号列が出力されるべきかという一連の信号列をテストパターンと呼ぶ。テストパターンがＬＳＩ中に発生しうる不良をどの程度検出できるかを示すものとして不良検出率という尺度がある。テストパターンの不良検出率と、選別後に不良品が良品に混じり込む不良品率には相関がある。十分な品質を得るためにはテストパターンの不良検出率は少なくとも９０～９５％以上とする必要がある。

一方、不良検出率９０～９５％のテストパターンを、故障シュミレー　図 ２２
タを利用しながら人手で作成する労力は、ＬＳＩの集積度増大とともに指数関数的に増大する。これは集積度の増大に比例して故障の起りうる場所が増大することに加えて、ＬＳＩの外部から故障検出のために内部を「覗く」ことが困難になるためである。したがって高品質のＬＳＩをを得るためには、チップそのものの設計もさることながら、テストパターンの自動生成も重要な技術となる。

テストパターンの自動生成方法のひとつを紹介する。　図 23

ユーザの任意の論理回路の中にあるフリップフロップのすべてにテスト回路を自動的に付加することで、テストモードにおいてL·S I の外部から自在にフリップフロップとデータのやりとりができるようにする。この方法によりどんな複雑な論理回路も比較的簡単にテストパターンを自動生成できるようになる。

4. まとめ

電卓・時計などでは、System On Chipがすでに実現されている。半導体の技術進歩は他のより大きなシステムをもひとつのチップに収容することを可能にするであろう。この時システムによっては、CPU、メモリといったデジタル回路ばかりでなく、アナログ回路も同一チップに取り込む必要が生じるだろう。UFICはこうしたあらゆる半導体回路をユーザが自由に組合せて、究極的にはシングルチップにまとめることをめざす製品である。しかも「ミニマムTAT、ミニマムチップサイズ」でこれを可能にしなければならない。　図 24

このようなデバイスの出現は結局エンドユーザに、よりFriendlyなシステムを提供し人間と機械のインタフェースの改善に大きく寄与するだろう。

THE TAIWAN VLSI INDUSTRY: 1986 AND BEYOND

Dr. Chintay Shih
Vice President and ERSO General Director, ITRI

Dr. Shih is a Vice President of ITRI (Industrial Technology Research Institute) and General Director of ERSO (Electronics Research and Service Organization). He is responsible for the management of all research and development activities of ERSO, including VLSI, small systems, and automation. Before being promoted to his current position, he was Deputy Director of ERSO and Director of IC Operations, with responsibility for VLSI R&D and the UMC technology transfer project. Dr. Shih received a B.S. degree in Electrical Engineering from the National Taiwan University, an M.S. degree in Management from Stanford University, and a Ph.D. in Electrical Engineering from Princeton University.

Dataquest Incorporated
JAPANESE SEMICONDUCTOR INDUSTRY CONFERENCE
April 13-15, 1986
Hakone, Japan

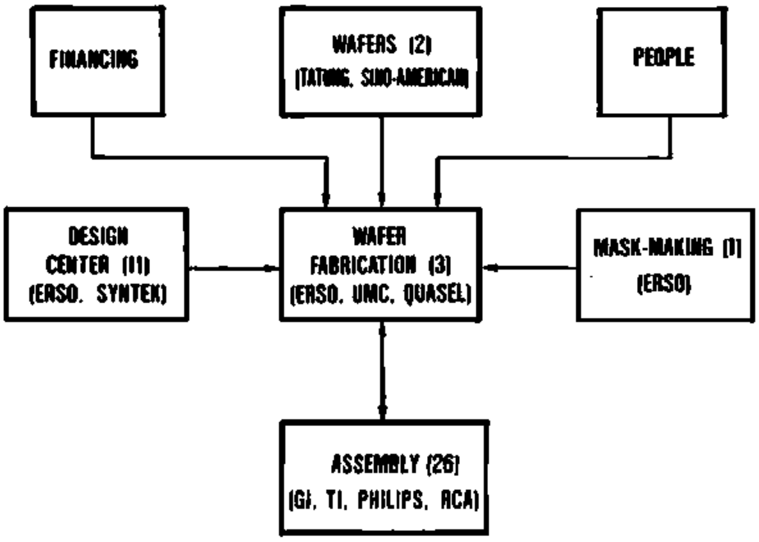
THE TAIWAN VLSI INDUSTRY: 1986 AND BEYOND

DR. CHINTAY SHIH

Vice President and
ERSO General Director,
ITRI

ERSO

INFRASTRUCTURE OF TAIWAN'S IC INDUSTRY



FINANCING

WAFERS (2)
(TATUNG, SINO-AMERICAN)

PEOPLE

DESIGN
CENTER (11)
(ERSO, SYNTEK)

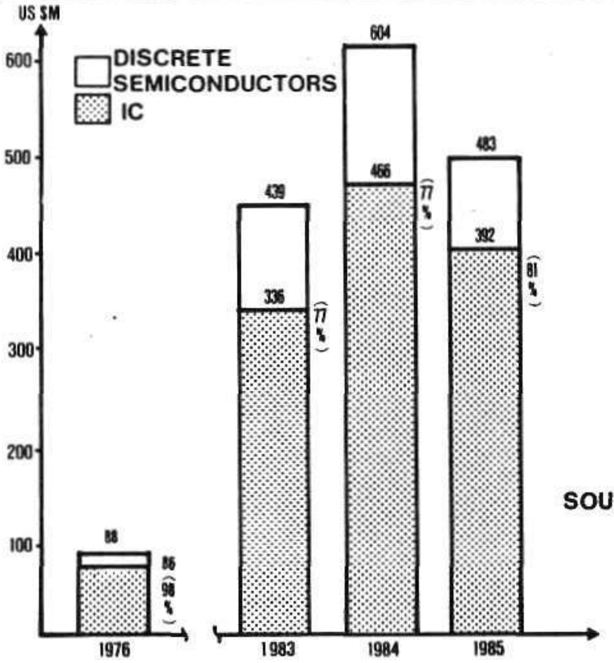
WAFER
FABRICATION (3)
(ERSO, UMC, QUASEL)

MASK-MAKING (1)
(ERSO)

ASSEMBLY (26)
(GI, TI, PHILIPS, RCA)

ERSO

TAIWAN'S IC PRODUCTION



SOURCE: MOEA,
EXECUTIVE YUAN, ROC

ERSO

THE ASSEMBLY INDUSTRY

- STARTED IN THE LATE 1960'S BY MULTI-NATIONAL COMPANIES
  - —GI, TI, PHILIPS, RCA
- PRODUCED 1.1 BILLION PIECES OF IC, VALUED AT US $ 350M IN 1985
- 60% OF THE PRODUCTION CAPACITY OCCUPIED BY MULTI-NATIONAL MANUFACTURERS
- LACK OF HIGH PIN COUNT CAPACITY
- HEALTHY GROWTH FORECAST FOR THE FUTURE

ERSO

THE FABRICATION INDUSTRY

IC Startups

MANUFACTURER	REPRESENTATIVE PRODUCTS	REMARKS
ERSO	(PILOT PRODUCTION)	
UMC	8-BIT μC/μP, GATE ARRAY, MEMORIES, CONSUMER ICs, FOUNDRY	SPUN OFF FROM ERSO IN 1979, WENT PUBLIC IN 1985
VITELIC	64K/256K/1M CMOS DRAM, APPLICATION SPECIFIC MEMORIES	STARTED UP IN 1984; R/D AT ERSO, MASS PRODUCTION AT FOUNDRY SERVICE
MOSEL	16K/64K CMOS SRAM	STARTED UP IN 1984; R/D AT UMC, MASS PRODUCTION AT FOUNDRY SERVICE
QUASEL	64K/256K CMOS DRAM	SMALL FABRICATION LINE

THE DESIGN INDUSTRY

- COMPRISED OF 11 COMPANIES, OF WHICH
  - —7 WERE SET UP IN 1985
  - —5 WERE MULTINATIONAL COMPANIES (MOTOROLA, PHILIPS, TI, NS, NEC) (1982) — 1st private co. — ERSO founder; ASICs
- MAIN PLAYERS: ERSO, SYNTEK, UMC & Unicorn design house
- TAIWAN HAS AN ENVIRONMENT SUITABLE FOR DEVELOPMENT OF THE VLSI DESIGN INDUSTRY:
  - —QUALITY/QUANTITY OF ENGINEERING WORKFORCE
  - —R/D PROGRAMS IN ERSO
  - —INCENTIVES ON TAXATION/FINANCING
  - —BIG INVESTMENT NOT REQUIRED

PROPOSED WAFER FOUNDRY

potential for Silicon Valley

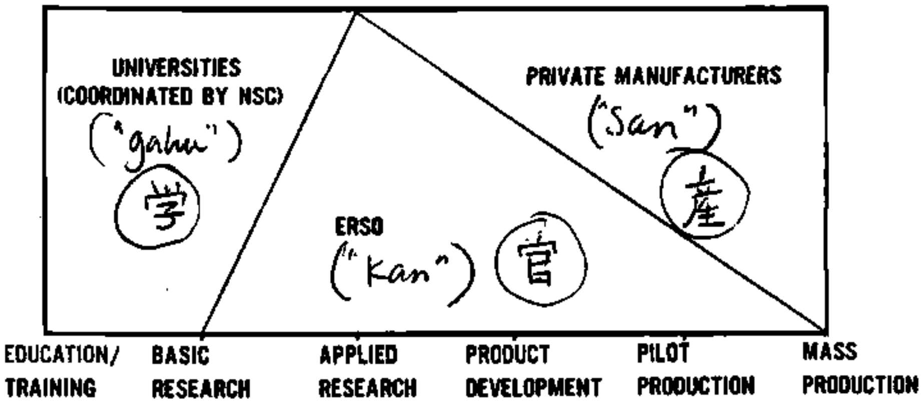
CONCEPT: A ONE-STOP VLSI MANUFACTURING SERVICE
- —WAFER FABRICATION BEING THE MAIN BUSINESS
- —MASTERING IN SUB-2 MICRON CMOS PROCESS

REASONS: IT WILL
- —CARRY A MUCH SMALLER MARKET RISK
- —HAVE A WEALTH OF TALENT AND EXPERIENCE
- —COMPLEMENT FUTURE ERSO ACTIVITY IN AUTOMATED DESIGN
- —NOT COMPETE WITH ITS CUSTOMERS

SCALE
- —10,000 6" WAFER START PER MONTH IN 1987
- —40,000 6" WAFER START PER MONTH IN 1990

ERSO

R/D AND TRAINING OF VLSI TECHNOLOGIES



ERSO'S ROLE: BRIDGING THE UNIVERSITY RESEARCH AND THE INDUSTRY

ERSO

VLSI ACTIVITIES IN ERSO

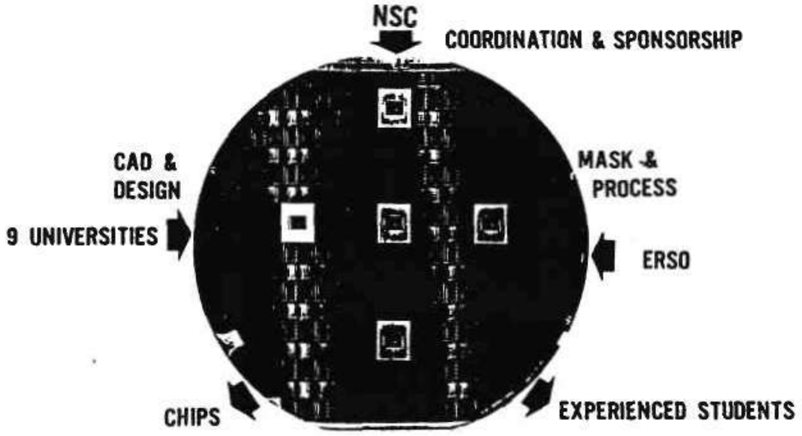
THEME: CMOS PROCESS, ASIC DESIGN
- —CURRENT: 2/1.5μm
- —1987: 1.5/1.25μm
- —1988: 1μm

COMMON DESIGN SERVICE
E-BEAM MASK SERVICE

ERSO

MULTI PROJECT CHIP

—A NATIONAL EFFORT TO FOSTER THE VLSI DESIGN INUSTRY (1981-)



NSC

COORDINATION & SPONSORSHIP

CAD & DESIGN

9 UNIVERSITIES

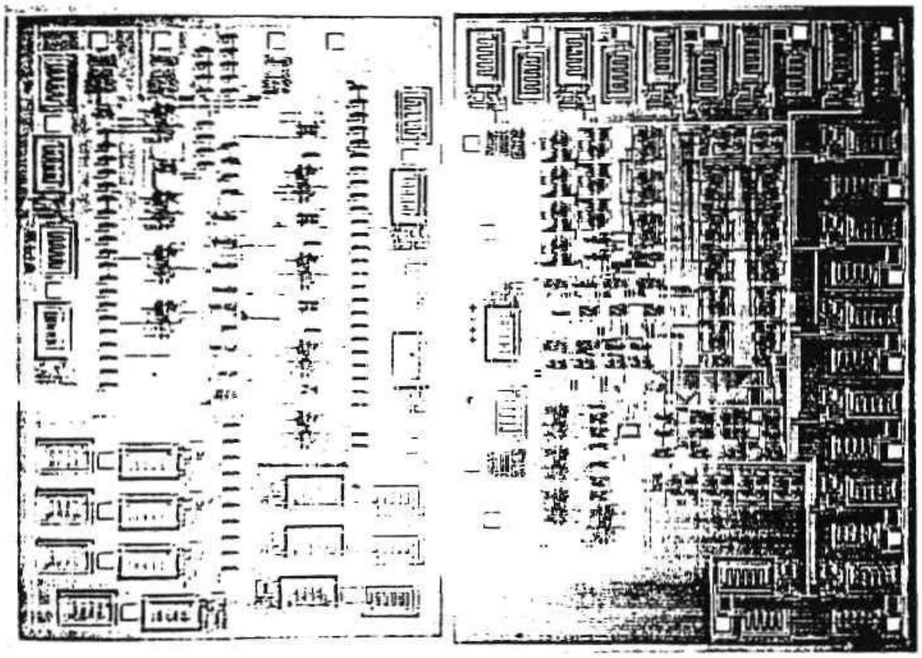
MASK & PROCESS

ERSO

CHIPS

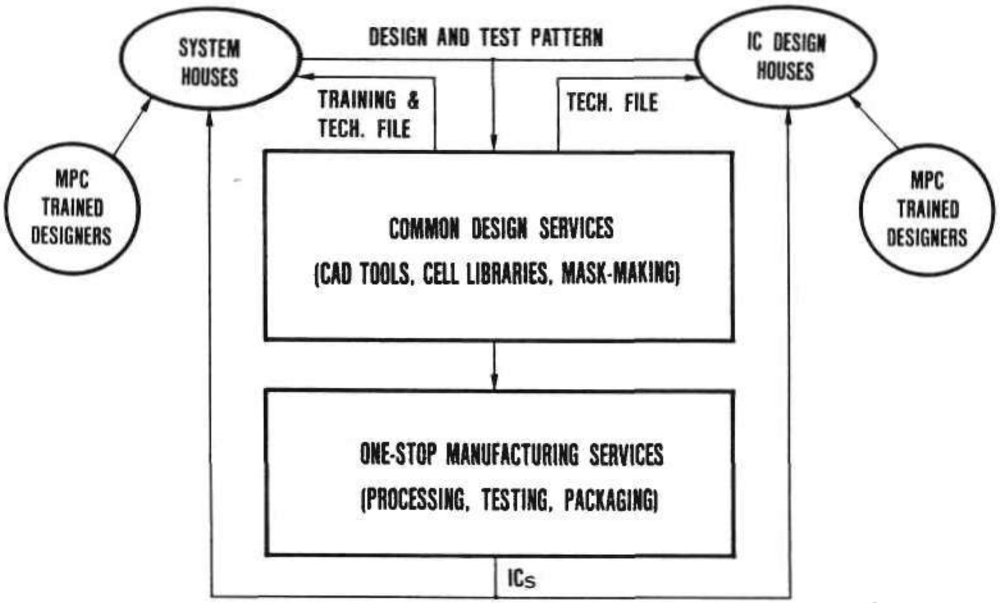
EXPERIENCED STUDENTS

ERSO



ERSO

LOOKING TO THE FUTURE: A COMPLETE INFRASTRUCTURE



SYSTEM HOUSES

DESIGN AND TEST PATTERN

IC DESIGN HOUSES

TRAINING & TECH. FILE

TECH. FILE

MPC TRAINED DESIGNERS

MPC TRAINED DESIGNERS

COMMON DESIGN SERVICES

(CAD TOOLS, CELL LIBRARIES, MASK-MAKING)

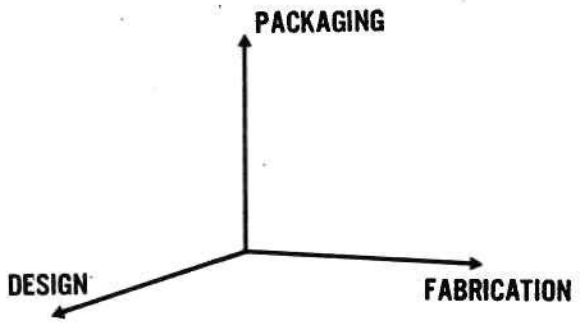
ONE-STOP MANUFACTURING SERVICES

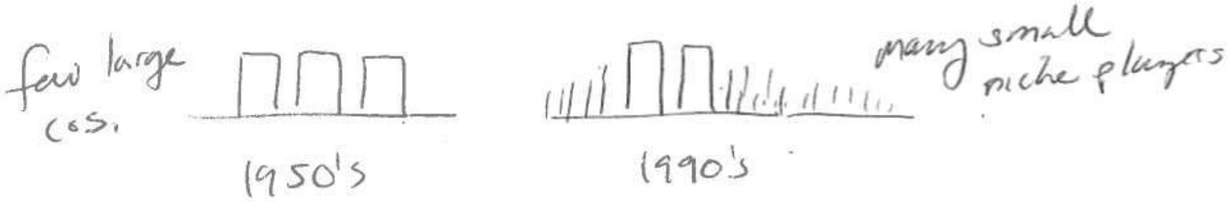
(PROCESSING, TESTING, PACKAGING)

ICs

ERSO

LOOKING TO THE FUTURE: SPECIALIZATION AND COOPERATION





ERSO

OUTLOOK

THE FUTURE OF TAIWAN VLSI INDUSTRY IS VIEWED WITH GREAT OPTIMISM:

- **THE CENTER OF WORLD VLSI INDUSTRY IS SHIFTING TO ASIA**
  - **——TAIWAN IS READY TO PLAY A ROLE**
- **PRODUCT EMPHASIS WILL SHIFT TO ASIC**
  - **——TAIWAN HAS BEEN MOVING IN THIS DIRECTION**

ERSO

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DINNER SPEAKER

Gary L. Tooker
Executive Vice President and General Manager
Semiconductor Products Sector
Motorola Inc.

Mr. Tooker is Executive Vice President and General Manager of the Semiconductor Products Sector at Motorola Inc. Earlier, he was Director of Operations for Discrete Products at Motorola, and later became Corporate Vice President and General Manager of the Discrete Semiconductor Division of the newly created Semiconductor Group. He subsequently headed the group's Discrete Electronic Components Divisions and Materials, and then became Vice President and General Manager of the group's International Semiconductor Division before assuming his present position. Mr. Tooker is a graduate of Arizona State University where he received a bachelor's degree in Electronic Engineering and did post-graduate studies in Business Administration.

Dataquest Incorporated
JAPANESE SEMICONDUCTOR INDUSTRY CONFERENCE
April 13-15, 1986
Hakone, Japan

THIS PRESENTATION WAS NOT AVAILABLE
IN TIME FOR PUBLICATION

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DINNER SPEAKER

Hiroshi Asano
Executive Vice President and Director
Hitachi, Ltd.

Mr. Asano is Executive Vice President and Director of Hitachi, Ltd. Previous positions at Hitachi, Ltd., have included General Manager of the Omika Works, General Manager of the Musashi Works, General Manager of the Semiconductor and IC Division, and Group Executive of the Electronic Devices Group. Mr. Asano received a Bachelor of Engineering degree in Electrical Engineering from the First Faculty of Engineering at the Ex-Tokyo Imperial University in Japan.

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ULSI APPLICATIONS, INS AND FUTURE

Dr. Yasasuda Kitahara
Senior Executive Vice President
Nippon Telegraph and Telephone Corporation

Dr. Kitahara is Senior Executive Vice President at Nippon Telegraph and Telephone Corporation. He is known as an advocate of the Information Network System (INS), and was the first person to promote the concept of INS at the International Computer and Communication Conference in 1978. Prior to this position, he held a variety of managerial positions with the Ministry of Communications, including Managing Director of the Plant Engineering Bureau and Senior Managing Director--Chief Engineer. Dr. Kitahara graduated in Electrical Engineering from the School of Science and Engineering at Waseda University and later received a Bachelor of Engineering degree in the study of coaxial cable.

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ULSI APPLICATIONS, INS AND FUTURE

Dr. Yasusada Kitahara
Senior Executive Vice President
Nippon Telegraph and Telephone Corporation

1. Introduction

The age is emerging in which information produces a value equal to or greater than that of goods and energy. Our society is making steady progress toward the establishment of an advanced information society. Through the efficient utilization of information, people hope to achieve happiness of mankind, affluence of culture, prosperity of business, and even development of.a nation.

This trend became evident about two decades ago when on-line, real time date communications made its debut through the integration of computers and telecommunications. Prior to that time, telecommunications mainly took the form of information transmission, while computers were mainly for information processing. With the advent of data communications, however, it became possible to process information and transmit it to any place instantaneously. Moreover, the integration of computers and telecommunications has had a cross-influence on each other's areas, thereby resulting in the rapid development of information and communications processing to the present advanced level.

One of main factors supporting this trend has been the remarkable progress made in the field of electronics, especially with regard to LSI technology. Moreover, the costs associated with information processing and transmission have dropped significantly, while reliability has been improved greatly, thus strongly supporting the trend toward the advanced information society.

The impact brought about by the growth of the semiconductor industry is exerted not only on the information and communications processing industry but also on the entire industrial world. Thus its influence is incalculably far and wide.

Looking ahead to the forthcoming society, it is certain that customer demands for information and communications processing services will continue to increase, and that the computer and communications technologies of the future will be far more advanced than they are today. Therefore, the trend toward a more advanced information society can be expected to intensify even further in the future.

2. From Monopoly to Competition

More than one hundred years have elapsed since telecommunications made its debut. In Japan, the telephone service is regarded as essential to individual life, and constant efforts have been made, to attain the objective of providing the service nationwide in a fair manner. As the telephone has become fully diffused in society, however, the social needs for less expensive and more diversified services have increased markedly. Under such circumstances, it was feared that the traditional monopolistic operating structure would be unable to meet such needs satisfactorily, and that the development of society would be hindered if the situation remained as it was.

For this reason, Japan chose the way of liberalizing its telecommunications industry, in April last year. To cope with this new situation, the Nippon Telegraph and Telephone Public Corporation closed its history as a public-operated entity, which had lasted over a century, and made a restart as the Nippon Telegraph and Telephone Corporation (NTT), a stock company.

The following two points are believed important for promoting the sound development of information and communications processing services as well as providing truly useful services to customers.

First, it must be recognized that free competition is extremely important in order to realize price reductions and the diversification of services.

Second, in spite of the importance of free competition, however, it muust be recognized as well that the introduction of free competition into every part of the business will not be desirable.

Free competition is generally a prerequisite also for the future development of telecommunications. Nonetheless, it is most important for us engaged in the telecommunications business to properly answer the question, "How can telecommunications best serve the interests of the people?" before discussing regulation versus deregulation.

3. Approach to the INS

With the progress toward the information society, the scope of the telecommunications infrastructure is gradually broadening. The times have changed from the day when telecommunications meant telephone service alone. With the spread of computers, data communications gained inclusion; and no doubt video services will be added to the infrastructure, in as much as human beings get a great deal of their information through their sight.

Since it is impossible to provide these various services through the existing networks, NTT is now busily engaged in formation of the Information Network System (INS), as one of its major management objectives, for the purpose of providing "more diverse services, which can be used economically, anytime and anywhere, irrespective of distance". This system is based upon the Integrated Services Digital Network (ISDN), for which the ITU is in the process of deciding international standards. One of its aims is the rationalization of the rate structure. The system will be constructed by expediting the sophisticated use of rapidly advancing technologies such as digital, optical fiber and LSI technologies.

NTT intends to promote the realization of the INS concept based upon the following viewpoints:

First, the network must be made easily available for users to meet their needs.

Second, existing separate networks must be integrated through the promotion of digitization whenever new or additional installation or system conversion is implemented. This is because digital technology has the advantage over analog technology in realizing cost reductions.

Third, high-speed and broadband services are to be provided to develop nontelephone services, particularly video services. These must be realized through a new digital network, not analog network, for reasons of profitability.

Fourth, the introduction of packet switching technology must be promoted, since the technology is highly efficient in providing various services of different traffic characteristics effectively.

Fifth, the introduction of optical fiber technology must be promoted actively, in order to make possible transmission of quantity of information at less cost and greater speed.

4. Challenges in the Telecommunicatins Field

4.1 Development of New Technologies:

As noted earlier, the growth of the information and communications processing industry to the present level is a result of striking developments in various fields of technology. These are backed by the electronics revolution, represented by LSI technology, which has resulted in low costs and achieved miniaturization of equipment and energy-saving. As a result, more sophistication and higher reliability of information and communications processing system have been realized, which in turn have largely contributed to their further spread.

In particular, LSI technology is an indispensable basis for the development of each of the systems forming the INS, such as switching, transmission, information processing and customer premises equipment. With the progress of high integration technology, it has become possible to realize miniaturization and economization of electronic switching equipment, as well as of NTT's Information Processing System (DIPS). The advancement of high-speed technology has enabled us also to achieve higher performance in a large DIPS system, and larger capacity in an optical fiber transmission system. In addition, LSI technology is playing versatile roles such as its application to subscriber circuits for telephone service, digital telephone and mobile phone.

In order to realize the forthcoming advanced information society, development and introduction of newer technologies are necessitated, and the importance of research and development activities from now on is expected to increase more than ever before. In particular, four major technologies now considered most important are digital network technology, artificial intelligence (AI), nanoelectronics and optoelectronics. Also important are the software supporting them, and large-capacity satellite communications technology.

4.2 From Telephone Society to Video Society:

Although it is expected that telephone service, the main component of existing information and communications systems, will continue to play an important role as a public service, it is no exaggeration to say that technologies and standards supporting the telephone service have already come close to full maturity.

On the other hand, from 60 to 80% of the information people obtain is said to be visual. In this sense, existing networks built around the teleohone service can be considered insufficient. Therefore, it will become necessary to develop broadband services, centering around video service, into a public service. To this end, it will be necessary to make video service easily available by providing it at a much lower cost.

4.3 Insuring Telecommunications Connectivity:

The most important purpose of a telecommunications system is to insure that every one can make use of it at any time. The communicable range of a telecommunications system is called connectivity, and this is regarded as the most important function of any telecommunications system.

However, even in case of data communications, which has become indispensable to our life and bears the character of infrastructure, there are many instances where communications between different kinds of computers or customer premises equipment is impossible. Although further progress is fully expected to be made in providing intelligence for networks and terminal equipment, their intelligent functions will not be fully demonstrated unless due consideration is given to their interconnectivity. Therefore, great expectations exist for the standardization efforts now being made at CCITT, ISO, and IEC to solve these problems. Securing connectivity is a matter requiring international cooperation.

5. Conclusion

The trend toward the advanced information society is an unstoppable tide, proceeding worldwide. this trend can be observed not only in industrialized nations but also in developing countries. In order to bring about creative developments in the 21st century, it is extremely important that a large number of private enterprises and business organizations in information and communications processing industries worldwide exchange views and ideas, in an environment of both competition and cooperation.

The forthcoming advanced information society will be more complex than today's society, and many problems wil arise. Examples range from invasion of privacy, information control, and vulnerability inherent in an information society, to alienation.

No one can deny that progress in science and technology has greatly contributed to improvement in our living standard. Although science and technology has provided us with knowledge and abilities that no one could imagine in former days, it is also true that it can be a danger depending on how it is used. Therefore, to ensure that the advent of the advanced information society will actually bring about human happiness, it will be imperative to upgrade science and technology, making it an aspect of human culture, by establishing its harmony with social sciences and cultural sciences.

The aim of making the INS the new telecommunications infrastructure in support of the advanced information society is based on the philosophy of desiring both the progress of science and technology and the happiness of mankind.

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超々ＬＳＩの応用，ＩＮＳそして未来

日本電信電話株式会社
副社長　北 原 安 定

1．はじめに

情報が物質やエネルギーと同等またはそれ以上に大きな価値を生む時代が到来しつつあり、社会の流れは世界的規模で高度情報化社会へと向かっている。人々は、情報を有効活用することにより、人類の幸せや文化の豊かさ、さらには企業の繁栄や国家の発展という期待を抱いている。

このような動きは、いまから20年ほど前、コンピュータと電気通信が初めて結びつき、オンラインリアルタイムの、いわゆるデータ通信が誕生して以来顕著(kencho)になってきた。それ以前は、電気通信は主として情報の伝達を、コンピュータは主として情報の処理を行ってきたものが、データ通信の誕生以来情報を処理・加工し、かつ好きな場所へ即時に伝達することが可能になった。そして、両者の融合は、互いの分野に相乗的効果を及ぼしあい、情報通信処理の分野が今日の形態(keitai)まで急速に発展してきたのである。

こうした情報化への急速な流れを支えたのは、ＬＳＩを始めとするエレクトロニクス技術の驚異(kyoi)的な発展である。情報の処理の分野においても、また伝達の分野においても、それに要するコストを急激に低減し、信頼性を高め、社会の情報化への流れを強力にサポートすることとなったのである。

半導体産業の成長によってもたらされるインパクトは、このような情報通信処理産業のみならず産業界全体に及ぶわけであり、その影響は計り知れない程大きなものがあるといえる。

これからの社会を展望すると、情報通信処理サービスに対する顧客ニーズは益々高まり、また、コンピュータ技術や電気通信技術が今以上に急速に進歩することも確実であり、従って、高度情報化の傾向は今後一層強まっていくものと考えられる。

2．独占から競争へ

電気通信が登場して以来、既に１００年以上が経過致した。日本では電話サービスを人々の生活に不可欠のものと考え、全国の隅々まであまねくかつ公平に提供することを目標に掲げ今日まで努力を重ねてきた。しかし、電話社会が完成するにつれ、社会には、より安く、より多様なサービスに対するニーズが一段と高まり、従来の独占体系のままではこうした期待に充分応えることは不可能となり、このままでは社会の発展を阻害してしまう

という懸念が生じてきた。

こうしたことから、日本は、昨年４月、電気通信事業の自由化の道を選択した。そして、日本電信電話公社は、この新しい制度に対応するため、１００年余り続いた公営としての歴史を閉じ、日本電信電話株式会社、すなわちＮＴＴとして再出発したのである。

今後、情報通信処理の分野が健全な発展をし、お客様に真に役立つようになるためには、次の２つの点が重要と考えている。

第一は、価格の低減とサービスの多様化のためには自由競争が極めて大切であるとの認識である。

第二は、しかし、そうは言っても、全ての部分を自由競争に委ねることが好ましいわけではないとの認識である。

電気通信の分野においては、これからも、基本的には自由競争が発展の前提であるが、結局、「規制か非規制か」ということ以前に、「国民のために電気通信は如何にあるべきか？」という問に適切に答えて行くことが、我々電気通信事業に携わる人間にとって最も重要なことであると考えている。

３．ＩＮＳへの取り組み

社会の情報化とともに、インフラストラクチャとみなせる範囲も次第に変化してきている。電話サービスだけが対象であった時代から、コンピュータの普及にともないデータ通信もその仲間入りをしたといえるし、人間の得る情報の多くは視覚によると言われることから映像サービスも加わっていくものと考えられる。

しかし、こうした様々なサービスを提供していくためには現在のネットワークでは不可能であるため、ＮＴＴでは「より豊富な」電気通信サービスを、「より安く」、「より距離の影響を少なく」かつ「より便利に」提供することを目的としたInformation Network System（ＩＮＳ）を形成することを経営目標として取り組んでいる。これは、世界的な標準としてＩＴＵが定めようとするＩＳＤＮを基本とし、さらには料金体系の整合を図っていくことを目指しているものであり、近年急速に進歩しているディジタル技術、光ファイバ技術、ＬＳＩ技術などの高度利用を早めることによって構築されるものである。

ＮＴＴでは、このようなＩＮＳ思想を、次の五点を柱として推進していく考えである。

第一は、利用者の希望にそって、ネットワークの利用が自由に出来るようにすることである。

第二は、コストダウンするためには、アナログ技術よりディジタル技術の方が有利であるため、新増設や更改時にディジタル化を進め、ネットワークを国際化して統合することである。　第三は、映像を中心とした非電話系サービスを発展させるため、高速・広帯域サービスの充実を図るが、採算性からアナログ網で実現するのではなく、新しいディジタル網によって実現することである。

第四は、トラヒック特性の違うサービスを効率よく提供するためには、パケット技術が非常に有効であるので、パケット交換の導入を進めることである。

第五は、大量の情報を高速かつ安く送るために光ファイバを積極的に導入することである。

第六 — intelligent functions; ~~data~~ comm. processing

4．テレコミュニケーション分野における課題

4.1 新しいテクノロジーの開発

Connectivity key - user access

情報通信処理産業が今日のような発展をしてきた原動力は、前述のようにＬＳＩ技術に代表されるエレクトロニクス革命を背景とした、各種技術の開発によるものである。このことが低コスト化を生み、さらには装置の小型軽量化や省エネルギー化を実現し、その結果、情報通信処理システムの高機能化、高信頼化が実現され、その普及に大きな貢献をしてきたのである。

10/85 Synchrotron began construction

特に、ＬＳＩ技術は、ＩＮＳを構成する交換、伝送、情報処理、宅内機器などのあらゆるシステムの発展に不可欠の基盤である。高集積化技術の進歩によって電子交換機やDIPSの小型経済化システム等の実現を可能とし、高速化技術の進歩はDIPS大型システムの高性能化および、光ファイバ伝送システムの大容量化を可能にした。その他にも、電話用加入者回路ＬＳＩ、ディジタル電話機、自動車電話への適用等、多彩な役割をはたしている。

来るべき高度情報社会を現実のものとするためには、一段と新しいテクノロジーの開発導入が必要であり、今後の研究開発は益々その重要性を増している。特に、ディジタル網技術、知能処理（ＡＩ）、ナノエレクトロニクス、光エレクトロニクスの４つを大きな柱とし、それらをサポートするソフトウェア及び大容量衛星通信技術等が重要な技術であると考えている。

nanoelectronics

4.2 電話社会の多様化から映像社会への発展

現在の情報通信システムの主力である電話サービスは、今後ともパブリックサービスとして重要な役割を担っていくものであるが、電話サービスを支える技術や種々の基準は完成の域に達しているといっても過言ではない。

一方、人間の得る情報の60～80％は視覚によると言われており、その意味では現在の電話を中心としたネットワークでは十分ではない。従って、今後は映像を中心とした広帯域サービスをパブリックサービスへと発展させる必要性があり、そのためには、映像サービスを安くして大いに利用出来るようにすることが必要である。

4.3 コネクティビティ（Telecommunication's connectivity）の確保

電気通信システムの最も重要な目的は、すべての人が、いつでも自由に通信できる、ということにある。電気通信における通信可能範囲に関わる機能をコネクティビティと呼び、電気通信システムの最も重要な機能と位置付けている。

しかし、私たちの生活に欠かせない存在となり、インフラストラクチャとしての性格を持ったデータ通信も、異機種コンピュータ間や宅内機器間の通信は不可能な場合が多い。また、ネットワークやターミナルもインテリジェント化が進み、それぞれ発展をとげていくが、お互いを接続できることを考えていかないとせっかくの機能も十分発揮されないこ

とになる。これらの問題を解決するために進められているＣＣＩＴＴ、ＩＳＯおよびＩＥＣでの標準化の努力に大いに期待を寄せており、コネクティビティの確保に世界的な協力が必要であろう。

５．おわりに

情報化の高まりはおしとどめることのできない、世界的な潮流となっている。そして、この流れは、工業先進国のみで起っているわけではなく、開発途上国を含めた世界的規模で認識されだしている。来るべき21世紀が創造的発展を遂げるためには、情報通信処理産業の分野において、多くの企業、多くの事業体が、国際的規模で、お互いの競争、協調の中で知恵を出し合うことが極めて大切なことである。

また、一方で、この時代は現代社会以上に複雑で、多くの問題を抱えることになるであろう。例えば、プライバシーの侵害、情報コントロールという問題や情報社会の持つ脆弱性、さらには人間疎外の問題まで多くの課題が出てくることが考えられる。

科学技術の進歩が人類の生活向上に多大な貢献を果たして来たことは何人も否定できない。科学技術は、昔は予想もつかなかったような知識と力を我々に与えてくれたが、使い方によっては人類にとってマイナスになるような要素を持っていることも事実である。それ故、高度情報社会の到来を人間の幸せにつなげていくためには、社会科学・人文科学との調和を得ることによって人間社会の文化にまで昴揚されることが必要である。

そして、科学技術の進展と人類の幸せを願うこのような考えがＩＮＳを通信インフラストラクチャとした高度情報社会を支える哲学であると考えている。

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JAPANESE INITIATIVE AND COOPERATION IN HIGH-TECH INDUSTRY

Minoru Yoshida
President
Tokyo Electron Limited

Mr. Yoshida is President of Tokyo Electron Limited (TEL). Since joining TEL, he has held a variety of managerial positions, including Manager of Electric Equipment Department, Managing Director, and Senior Managing Director. Mr. Yoshida received a Bachelor of Engineering degree in the Electrical Course of Osaka Junior College of Engineering.

US strengths

1. Conceptual ability in system design
2. Educational system
3.

Japanese strengths

1. ~~Company~~ Employee loyalty; high
2. Educational level
3. Long-term horizon for ini
4. Best engineers in production
5. ~~Little~~ Life time employment

Dataquest Incorporated
JAPANESE SEMICONDUCTOR INDUSTRY CONFERENCE
April 13-15, 1986
Hakone, Japan

TEL-Thermco - Est. 1983. Diffusion furnace from Thermco. 50/50. ~~of~~ Up to 9/85 - ¥20B profits.
1986 - same level.

TEL-Genrad -

TEL-Varian - Est. 1982. 9/85 - ¥10B. ~~up~~
Up to 9/86 - lower.

TEL-Lam - Est 1983. 50/50. Plasma etcher.
1985- ¥30B sales.

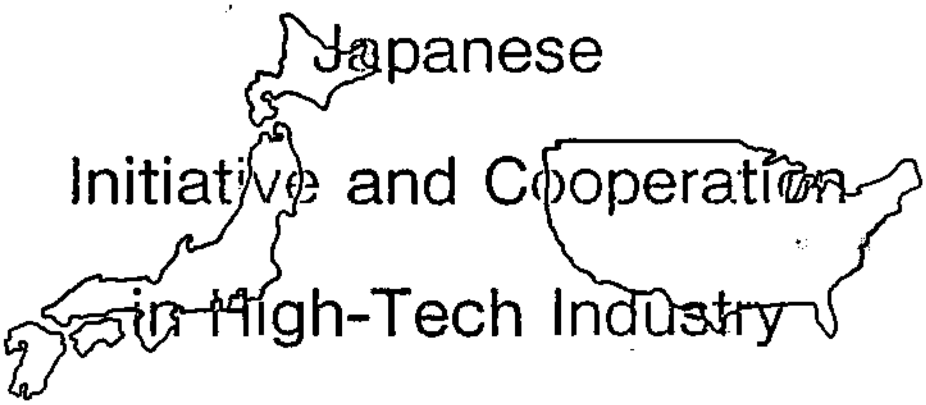
「The Prospects and Applications of VLSIs」

Theme

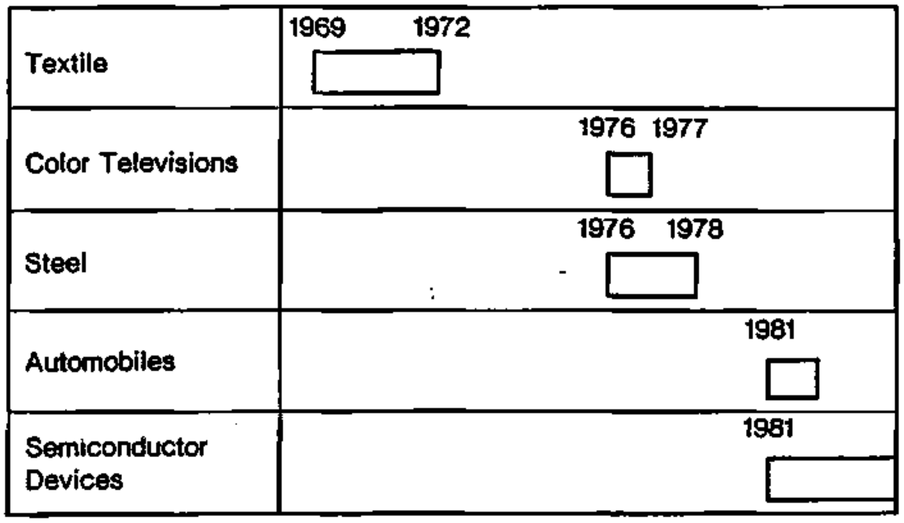
Japanese Initiative and Cooperation in High-Tech Industry

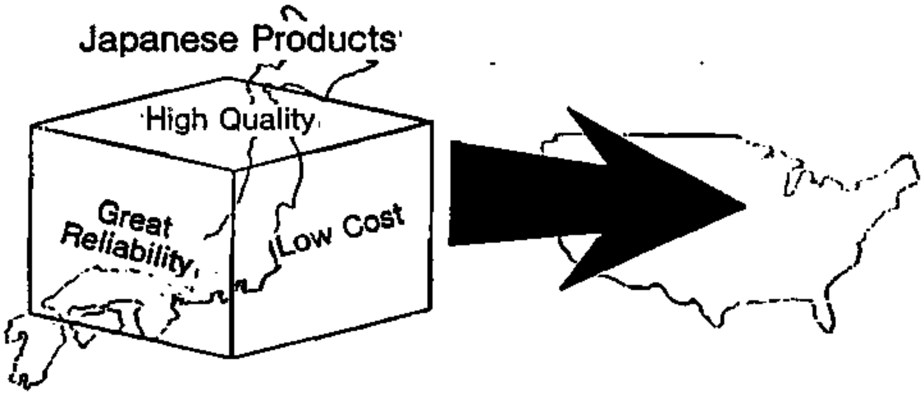
Panelist

Minoru Yoshida
President, Tokyo Electron, Ltd.



Trade Friction between Japan and the U.S.A.





A Comparison of the Strengths of Japan and the U.S.A. as Involved in Trade Frictions

——Related to the Strengths of Japanese Products at the Mass Production Stage——

Ample supplies of highly mobile personnel

Strengths of the U.S. in Japan-U.S. Trade Frictions

1) Superior power to conceptualize systems
2) An educational system that trains outstanding individuals in specialized fields
3) Easier to gather the best possible engineers for a development in resort period of time
4) Most of the best enginners and technical specialists employed in development operations

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⇩

Development of original products and systems

Strengths of Japan in Japan-U.S. Trade Friction

1) Strong loyalty to the firm; high quality of work
2) An educational system that provides more averaged standardized, balanced training for personnel
3) Appraisal standards for corporations facilitate forward-looking investment
4) The best engineers and technical specialists employed not only in development operations but also in production technology operations
5) Little mobility of personnel due to life time employment system

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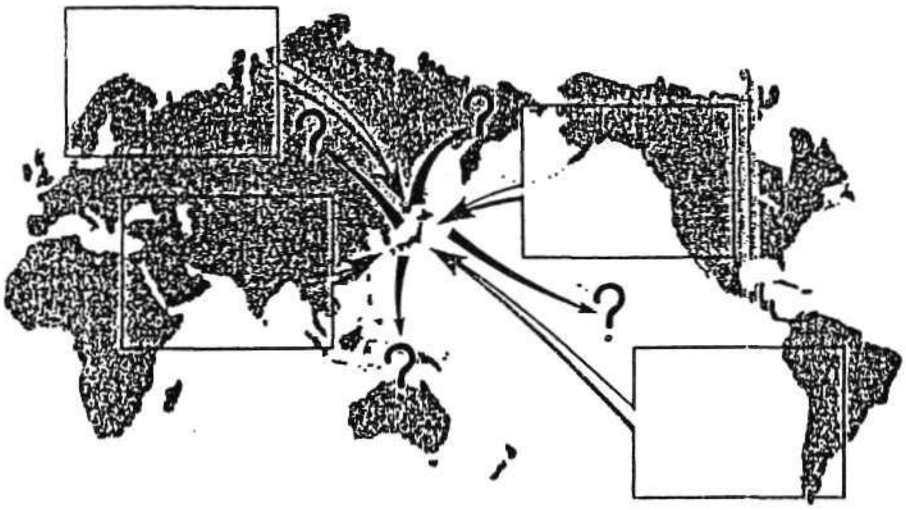
5) Little mobility of personnel due to life time employment system

⇩

Production of high-quality, very reliable products



The Path to Eliminating Japan-U.S. Trade Frictions

——Going Beyond Economic Principles——

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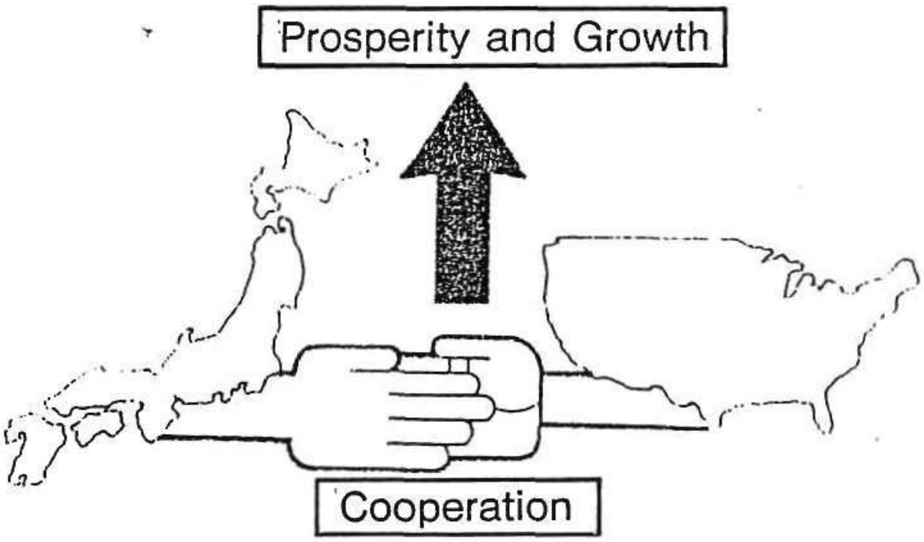
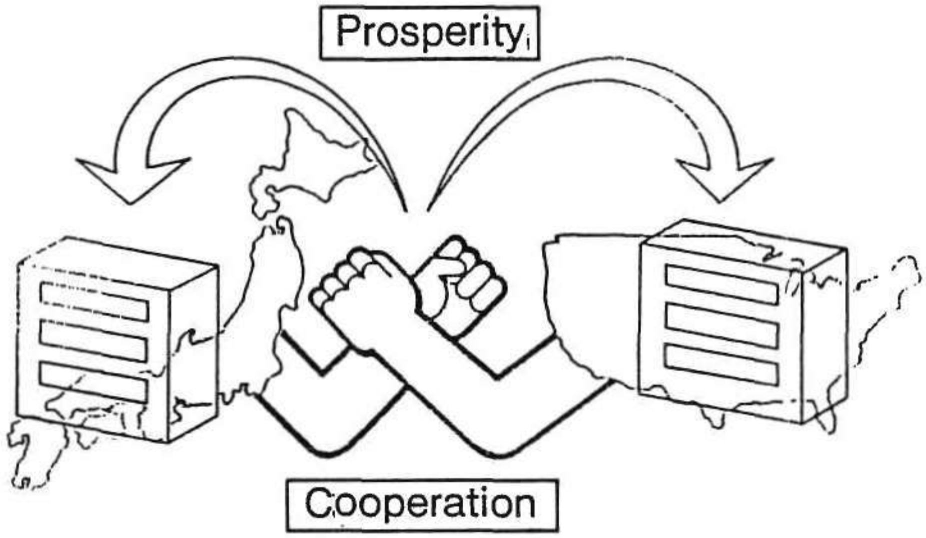
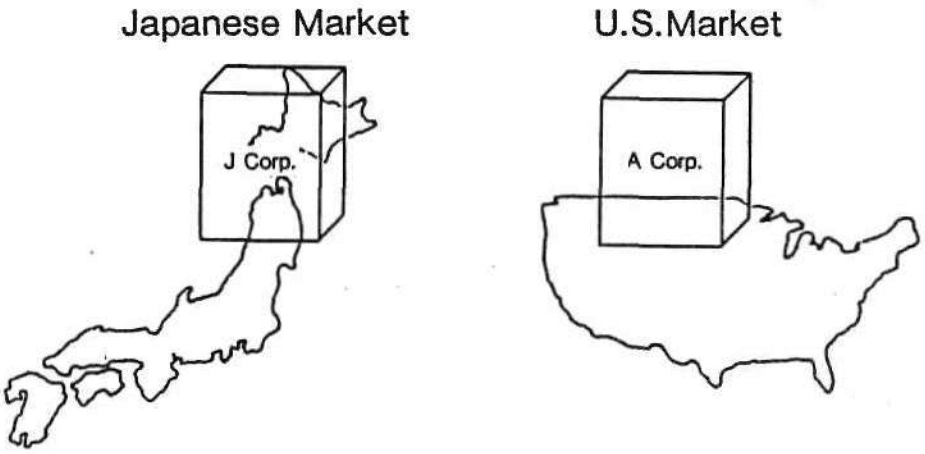
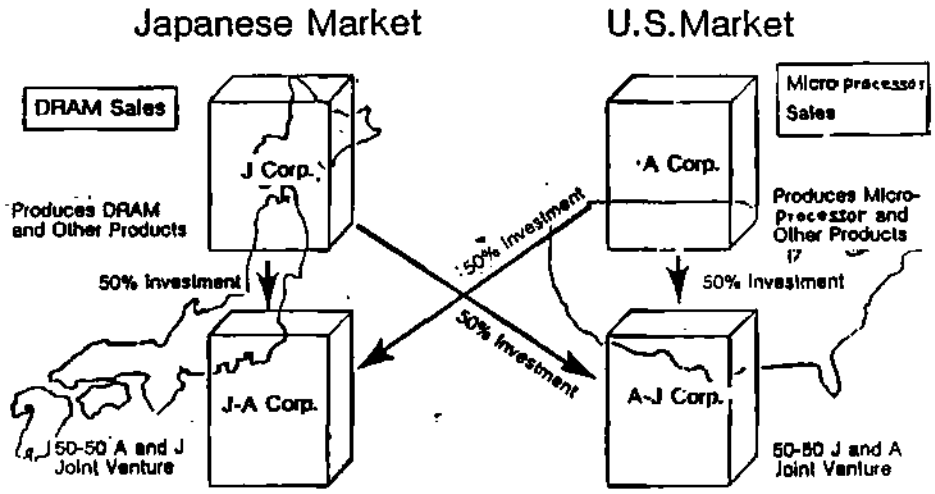




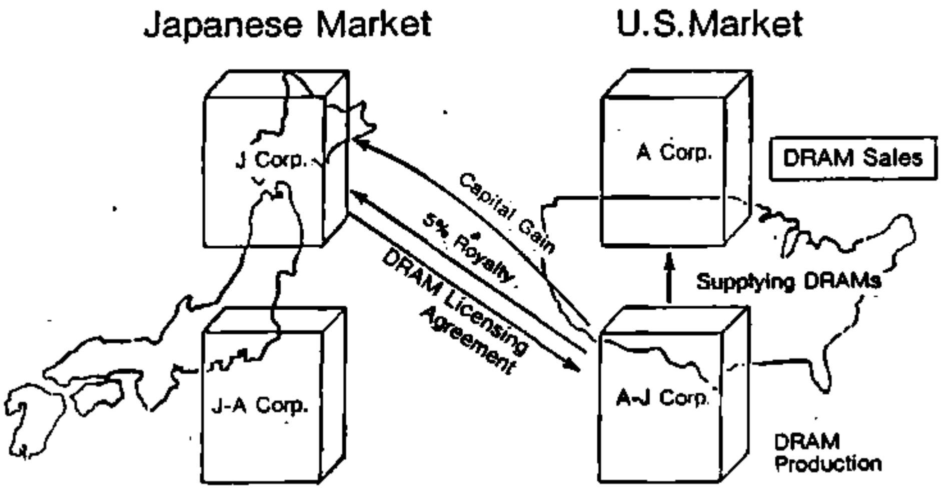
Cooperation in the Form of Joint Ventures Brings Prosperity and Growth for Both Partners



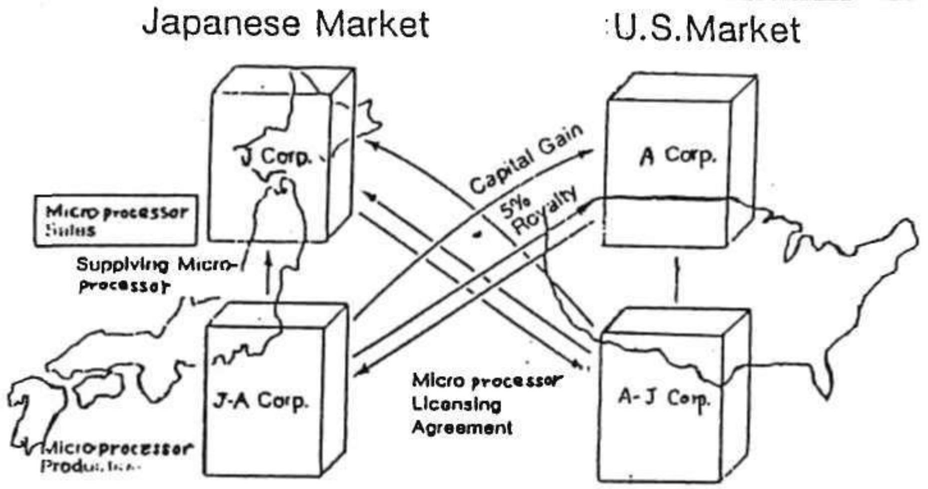
Cooperation in the Form of Joint Ventures Brings Prosperity and Growth for Both Partners



Cooperation in the Form of Joint Ventures Brings Prosperity and Growth for Both Partners



Cooperation in the Form of Joint Ventures Brings Prosperity and Growth for Both Partners

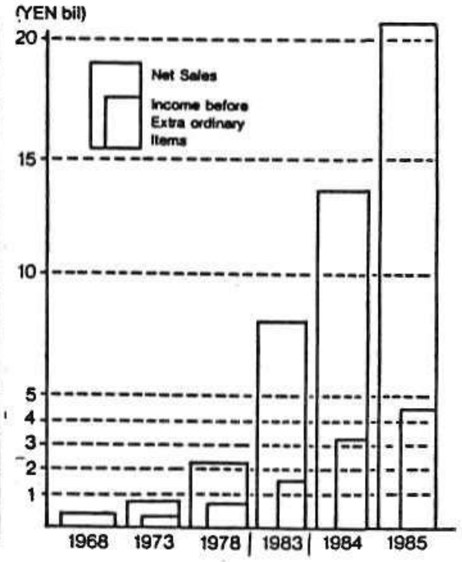


Advantages for Both Sides

1. They receive 5% of sales of the joint venture royalties.
2. They receive half of the joint venture's profit (Capital gains).
3. The joint venture system compensates for weaknesses of both parties.
4. Perfect cooperation means trade frictions will not occur.

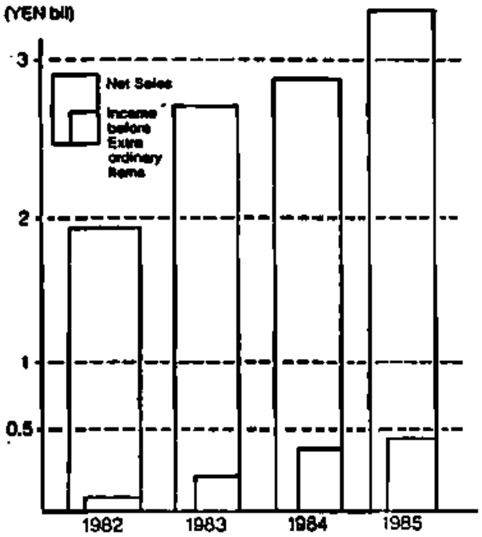
TEL–THRMCO ENGINEERING CO., LTD.

U.S Partner	Thermo Products Co.
Establishment	Feb. 1968
Products to Manufucture	Diffusion Furnace Low-Pressure CVD High-Pressure Oxidation Furnace Epitaxial Furnace Lamp-Annealer. etc
Paid-in Capital	¥73.5 mil (50%–50%)
Directors	TEL : 4 Thermco : 3
Royalties	5% of Net Sales
Sales to Enduser	100% by TEL in Japan
Employees (9/30/85)	400



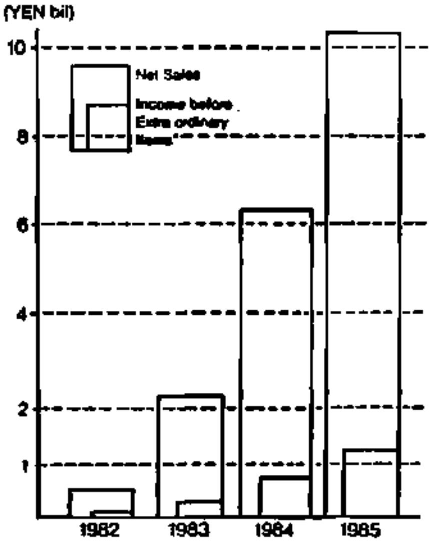
TEL GENRAD LTD.

U.S Partner	Gen Rad Inc.
Establishment	Sept. 1981
Products to Manufacture	Board Tester VLSI Tester
Paid-in Capital	¥50 mil (50%–50%)
Directors	TEL : 5 Gen Rad: 5
Royalties	5% of Net Sales
Sales to Enduser	100% by TEL in Japan
Employees (9/30/85)	56



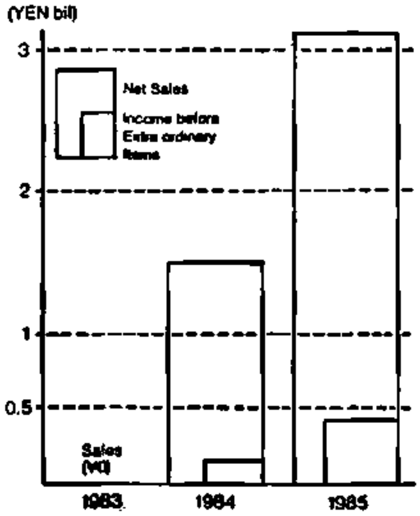
TEL VARIAN LTD.

U.S Partner	Varian Associates Inc.
Establishment	March 1982
Products to Manufacture	Ion Implater
Paid in Capital	¥100 mil (50%–50%)
Directors	TEL : 4 Varian: 4
Royalties	5% of Net Sales
Sales to Enduser	100% by TEL in Japan
Employees (9/30/85)	158



TEL–LAM LTD.

U.S Partner	Lam Research*Corp.
Establishment	July 1983
Products to Manufacture	Plasma Etching System
Paid in Capital	¥50 mil (9/30/85)
Directors	TEL: 3 Lam: 3
Royalties	5% of Net Sales
Sales to Enduser	100% by TEL in Japan
Employees (9/30/85)	74



——Towards Japanese-American Cooperation and Prosperity——

TOKYO ELECTRON LIMITED

本日、私の頂きましたテーマが「ハイテック業界に於ける日本のイニシアティブと協力」という事でございますが、ハイテック産業の中核である半導体、とりわけ現在日米間で大きな問題となっております半導体貿易摩擦に絞って、大変僭越ではございますが、私見を述べさせていただきます。

振り返ってみますと、過去、日米間では貿易摩擦という形でいろいろな日本の製品が次々とクローズアップされました。1969年の繊維に始まり、鉄鋼、カラーテレビ、自動車がつぎつぎと問題化し、そして、現在、半導体貿易摩擦が表面化し、何らかの解決を迫られているわけです。折しも昨日、レーガン大統領と中曽根首相がアメリカにおきまして貿易摩擦問題について話し合っております。

これらの貿易摩擦が起きる背景には共通の要因がかくされていることがうかがえます。それは、ある特定製品の市場規模が大きくなり、量産する段階で、米国製品に比較すると、日本商品の方が品質、信頼性ともに高く、さらにコストが安いために、日本から米国にどっと商品が流れ込む。摩擦は必ずこういうパターンで始まります。そして、その商品が米国で高いシェアを握り、貿易摩擦となるわけです。

つまるところ、次々と起きる貿易摩擦の原因は日本商品が量産の段階で強いという事に他ならないのですが、この理由にかかわる日米それぞれの強さの違いをここで対比してみたいと思います。

まず、米国の強さとは、

(1)優れたシステム思考力
(2)米国の教育制度は特定の分野に極めて優れた能力の人間が育つ
(3)人材の流動性が豊かであり、必要とする人間が短期間に集められる
(4)トップクラスの技術者のほとんどが開発業務に従事する

となります。

これらの米国の強さは、独創的な商品開発、システム開発に極めて有利であり、事実、米国は先端技術分野の開発面では世界をリードしています。

これに対して日本の強さとは、

(1)従業員の企業に対するロイヤルティが高く、仕事、作業の質が高い

(2)日本の教育制度は平均的人間がより多く育つ

(3)企業の評価が比較的ロングタームで行われるため、先行投資を行い易い

(4)トップクラスの技術者が社命によって製造技術の仕事にも従事する

(5)終身雇用制によって、人材の流動性が少なく、作業の質や能率を継続的に高めることができる

となります。

これらの日本の強さは、すべてが高品質、高信頼性を持つ商品の生産に極めて有利なのは明らかです。

これらの、米国と日本の強さの相違は、歴史的な要素および文化の違いに起因しているものであり、短期間にこれを変えることは不可能と思われます。従って、これからも当分の間は、量産段階における日本製品の高い競争力は維持、持続されることになります。さらに、米国のマーケットサイズは日本市場に比べてはるかに大きいことから、両国間の貿易不均衡、貿易摩擦は常に存在し、５年あるいは１０年といった年月でそれを解決することは非常に困難であります。

一方、日本の立場について少し考えてみたいと思います。

日本は国土も小さく、天然資源にも恵まれておりません。また、食料ですら 50%以上を輸入に頼っている状態で、米国を中心とする外国との貿易なしには成り立たない国であります。これは、日本がいかに米国その他の外国の国々を必要としているかということに他なりません。それに対して、外国の国々にとって日本は必要な国なのかどうか考えさせられるところであります。

このような背景を考え合わせますと、日本にとって貿易摩擦の問題を単に「良くて安いものは売れるんだ」とか、「強いものが勝つ」と言った経済原則だけで割り切るわけにはいかないという事を痛切に感じるわけです。

従いまして、諸外国に比べてはるかに大きく外国との貿易を必要としている日本がイニシアティブをとって、協調をベースとし、共に繁栄、成長していく道を探し、一歩一歩実現していく事が非常に重要であると確信いたします。

さて、具体的に日米の摩擦をいかに解決していくかは、先程みてきたように米国と日本の強さが異なっているという前提にまず立たなければなりません。異なっている故にお互いの弱点を補完し、協調しながら共に繁栄するという事が可能であり、お互いに大変メリットがあると思います。

これには、既にいくつかの例に見られるような合弁会社の設立、および相互乗り入れといった手段が非常に有効だと思います。

ここで、今話題となっているＤＲＡＭとマイクロプロセッサーを例にとって、合弁会社設立による協調のメカニズムを仮想してみました。

左側は日本の半導体メーカーＪ社、右側は米国の半導体メーカーＡ社となっています。この両社が日本および米国の両市場で協調していくパターンを図にしてあります。日本のＪ社および米国のＡ社が日米両国において、それぞれ資本比率 50%−50% の合弁会社を設立します。日本に設立するものをＪＡ社、米国に設立するものをＡＪ社とします。Ｊ社は米国に設立したＡＪ社とＤＲＡＭに関するライセンス契約を結び、ＡＪ社が生産したＤＲＡＭは、Ａ社ブランドでＡ社を通して米国市場で販売する。

一方、Ａ社は日本に設立したＪＡ社とマイクロプロセッサーに関するライセンス契約を結び、ＪＡ社は、Ｊ社を通じて日本市場でＪ社ブランドのマイクロプロセッサーを販売することになります。

この仮想においてＪ社およびＡ社共に次のメリットを得られることになります。考えられるメリットは　①ロイヤルティーとして合弁会社の売上高の５％　②合弁会社の利益から半分を還元（あるいはキャピタルゲイン）　③Ａ社およびＪ社の弱点を補完し、強みを生かすことができる　④完全な協調であり、貿易摩擦が生じることはない ―― となります。

東京エレクトロンでは、半導体デバイスの生産は行っておりませんが、半導体製造装置の製造販売について、日本でＪＡ社に相当する合弁会社を４社設立し、順調に運営しております。４社全てが資本比率50% - 50%でございます。

合弁会社の資本比率につきまして、我々は50 / 50が最も良いと思います。どちらかがMAJORITYを持っておりますと、どうしても多く持っている会社のONE WAY OPERATIONとなり協調路線が崩れてしまいます。昨今の様に長いRECESSIONとなりますと、いろいろの問題がクローズアップされます。お互いに家庭の事情がありますのでその問題の解決は、決して楽ではありませんが50 / 50だと先ず徹底的に議論し、そしてお互いに譲り合う事により解決する以外に方法がない訳で、時間が要る事もありますが、その間に真の協調理解が生まれます。

当社が合弁会社を初めて設立したのは、1968年までさかのぼります。この年、米国トップのDIFFUSION FURNACE CVDメーカーであるサームコプロダクツ社と50%−50%出資によるテルサームコ㈱を設立、拡散炉の生産を開始致しました。半導体産業の伸長などの好環境も影響して、日本のお客様の大変なご愛顧によりテルサームコは順調に日本市場でシェアを伸ばし、グラフでおわかりのように飛躍的に業績を伸ばしました。拡散炉ではもちろん日本でトップシェアを持っているほか、減圧ＣＶＤ高圧酸化炉、エピタキシャル成長炉、ランプアニーラでも高い販売実績を誇っています。

この成功に続いて設立したテルジェンラッド㈱では、インサーキットボードテスタの生産を目的にしています。米国ジェンラッド社との合弁で、1981年に設立され、出資比率はもちろん50%−50%です。米国の優れたソフトウェア開発力をベースに日本でハードを生産することにより、マーケットでシェアを取っていこうという考えは見事に達成され、現在、日本のインサーキットボードテスタ市場では70%という高いシェアを持っています。

APPLICATION STRATEGIES FOR SUCCESS

Noriaki Shimura
Managing Director and Group Executive
Development Division
Casio Computer Company, Limited

Mr. Shimura is Managing Director and Group Executive of the Development Division of Casio Computer Company, Limited. He joined the company in 1964 and is in charge of new original products. Mr. Shimura received a Bachelor of Engineering degree from the College of Science and Technology at Nihon University.

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Casio Incorporated in 1957 had an annual sales of 1 billion yen only in 1965 when the electronic calculator gradually began to be used widely. Casio has attained , nevertheless, a phenomenal growth since then by giving birth to numerous hit products succeedingly and creating their markets on the basis of its advanced electronic technology and through development of a wide variety of original products. Casio's current annual sales exceeds 200 billion yen, thus achieving a high growth of over 200 times as much in such a short span of mere 20 years. What is then, Casio's electronic technology as the primary factor that has contributed to such a marvelous growth? It is evolution by Casio of applications of the electronic technology rapidly advancing , namely application of the transistor to that of the IC, LSI, and , then, VLSI. It is not going too far to say that the digital technology among others is virtually Casio's " key " technology.

I would like to describe, today, the LSI strategies Casio has so far unfolded pertaining to the LSI, which composes the core of this digital technology, and how Casio intends to cope with the issue of VLSI hereafter.

1. Casio's LSI consumption
2. Casio's LSI strategies
3. Casio's advance toward VLSI applications

- 90% custom LSI
- LSI strategies:
  1. Outpacing others
  2. Low cost products
  3. Innovative functions
  4. Speed up development
  6. Eliminate waste
- Digital watch → info processing
- "Zero miss" - goal w/ IC vendors.
- Tie w/
  1) Outpace others
  ~~2~~)
  3) Engineer exchange
- Technical meetings

1 Casio's LSI consumption

1-1 Growth of Casio's LSI consumption

1985 – 50 MU

As shown in Fig-1, LSI consumption by Casio has continued to show a sharp increase since 1972 when its " CASIO MINI " was initially put on the market. The increase in its LSI consumption marked during the period from 1972 to 1979 was attributable to increase in the production output of electronic calculators , and the further increase in Casio's LSI consumption observed in 1980 and thereafter was due to expansion of the production output of electronics watches. Besides, since 1982, its additional LSI consumption for their application in the new fields of produciton of electronic musical instruments and liquid crystal televisions served to elevate the above LSI consumption figure. The majority of LSIs procured by Casio during the period from 1972 to 1977 was occupied by P-MOS process LSIs for production of electronic calculators, while consumption of C-MOS process LSIs merely grew slightly since 1974 as used for production of digital watches. The total production output of electronic calculators in Japan during these six years was approximately 130 million sets, a figure which corresponded to the majority of production output of the P-MOS process LSIs during said period. It can be said, accordingly, that the advancement of LSIs owing to miniaturization as well as diversification of functions of electronic calculators occurred in the course of this period contributed largely to progress of the Japanese semiconductor industry.

Casio's LSI consumption is outstanding in the world and the current monthly LSI consumption by Casio has reached the level exceeding 10 million pieces. Approximately 90 % out of this consumption figure is occupied by custom LSIs, and one third of these custom LSIs is based on Casio's own designs. While procurement of remaining two third is conducted by a system of consigning its production to LSI makers in conformity with Casio's custom specifications. Accordingly, Casio's LSI consumption is outstanding in the world. However, it can also be said that the quanitity of custom LSIs developed by Casio annually is also outstanding in the world.

1-2 Product-wise LSI consumption

Fig-2 presents a matrix indicating how LSIs are currently used by Casio. The custom LSIs occupy an important percentage in case of electronic calculators and watches. However, not only the custom LSIs but also the standard LSIs for microprocessors and memories also occupy a substantial percentage in case of electronic musical instruments, liquid crystal televisions and electronic office equipment. In the graph showing the LSI consumption presented in Fig-1 also, electronic calculators and watches occupied the major percentage of products using LSIs until around 1980, and their consumption figure exactly reflects respective quantity of products usig these LSIs. However, in case of new products marketed since 1980, the percentage of products, each using plural LSIs is becoming large.

It is assumed that this tendency would gain force for new products that will be developed hereafter, also, and the percentage occupied by the standard and semi-custom LSIs in the total LSI consumption would all the more increase as a consequence. Nevertheless, this percentage may undergo transitions in its growth in the event it will have finally become possible to compose a system using one chip only as an outcome of further advancement of the VLSI technology in future.

2 Casio's LSI strategies

2-1 Casio's LSI strategies - with the LSI as its "magic wand"

1 Outpacing others in development of the LSI technology

2 Planning of drastically low cost products

3 Planning of products with innovative functions
only feasible by application of the LSI

4 Speeding up of development

5 Elimination of wasteful searches

2-2 Relationship with the LSI makers - "joint development system under collaboration with 1 or 2 LSI makers"

Casio's current monthly consumption of LSIs exceeds 10 million peices. However, Casio is not doing its own LSI production at all. This is for the reason that Casio finds it as an ideal setup that LSI design by Casio are put into product LSIs in an optimum form by world's leading semiconductor makers. Thus, Casio maintains very good relationship with respective LSI makers on the basis of the following points.

(1) Outpacing others in development of the LSI technology

This subject corresponds to the theme described under the title of the Casio's LSI strategies, and it is realizable through precise identification of themes requiring clarification jointly made by engineers of the LSI makers and Casio and their constant challenge for building up mutual tecyhnological potency.

(2) Achievement of continuous business

As shown in Fig-3, the joint technological development system by the LSI makers and Casio has been organized into a flow comprising three steps of (1) Setting of themes, (2) Technological development and (3) Mass production,and is a system in which these technological themes and amounts of business transactions are jointly checked periodically by both parties.

(3) Personal interchange

You may call this a Japanese-like conception. However, Casio deems it important to maintain a close personal interchange between respective enginners of the LSI makers and Casio. This indicates that the relationship between engineers of Casio and those of the LSI makers is clarified in the form of a matrix, thereby assuring that technological interchange between both parties is performed smoothly and, at the same time, engineers of both parties collaborate mutually in challenging creation of new products through full utilization of the latest technology.

3. Casio's advance towards VLSI applications

It is assumed that the LSI would hereafter continue to follow pattern of becoming all the more larger in scale, having multiple functions and begin well diversified. Then, how Casio is going to cope with such a rapid advancement of the LSI technology. I would like to discuss here varied problems involved and Casio's stance in coping with these problems.

3-1 Problems involved in application of VLSI

As problems existing on the part of product set makers, we can enumerate further prolongation of the period in requirement for product development and further complication of system designing of product sets. Further analysis of these problems in the light of the LSI technology points to the following issues.

(1) Engineering techniques

* Increase in the sizes and diversification of circuit designs and problem of testing accompanying these factors
* Elongation of the period required for TAT
* Management of the "zero mistake" system

(2) Packaging techniques

* How to package the VLSI compactly

(3) Form of split of work between the LSI makers and product unit makers
  * Problem of the split of work in development of the VLSI

3-2 Casio's VLSI strategies

(1) Aggressive challenge to adoption of most advanced process

As regards the issue of the engineering techniques, Casio intends to continue promoting development and adoption of most advanced processes through elevation of the level of work stations and enhancement of innovative engineering techniques. The reason for this stance taken by Casio is that this challenge eventually serves to promote the process development by LSI makers, and establishment of relevant technology based on which eventually enables Casio to make its succeeding challenges.

(2) Realization of an one-chip total system

Conversion of a total system into a one-chip system would consequently make it possible to realize such a package as would serve to accomplish more compact equipment sizes.
Casio challenges achievement of the goal of converting a system currently incorporating plural LSIs into a one chip system.

(3) Development of an innovative packaging system

So far the LSI chip has been deemed important. However,the problem of how the chip itself should be mounted will hereafter loom up as a large issued yet to be resolved. Casio intends to develop an innovative packaging system fit for packaging the VLSI in place of the conventional packaging system hitherto employed.

(4) Construction of an integrated CAD system

Casio plans to build up an integrated CAD system between the LSI makers and Casio for coping with the issues of elevation of the engineering techniques and split of work between the parties.

Casio intends to evolve hereafter the five principal themes of its LSI strategies at the present stage where the industry is on the threshold of entering the "VLSI Age" as described above, while promoting concurrently its new technology which will be well in harmony with the VLSI.
The unlimited progress of semiconductors enhances unlimited creation of new functions and creation of new product categories.
Casio continues its untiring challenge against unlimited development so as to always be the "top batter".

SUPPORTING THE TRANSITION TO VLSI FABRICATION

James C. Morgan
President and Chief Executive Officer
Applied Materials Incorporated

Mr. Morgan is President and Chief Executive Officer of Applied Materials Inc. He was previously a senior partner with Westven Management, a private venture capital partnership affiliated with the Bank of America Corporation. Prior to Westven, Mr. Morgan was on the corporate staff at Textron, a diversified manufacturing company, and held executive positions in two of its high-technology divisions. Mr. Morgan received B.M.E. and M.B.A. degrees from Cornell University. He is also on the board and is an officer and past president of the Semiconductor Equipment and Materials Institute (SEMI).

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THIS PRESENTATION WAS NOT AVAILABLE
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SILICON AND SEMICONDUCTORS--PARTNERS IN THE '80s

James E. Springgate
President
Monsanto Electronic Materials Company

Mr. Springgate is President of Monsanto Electronic Materials Company, an operating unit of the Monsanto Company. He joined Monsanto as an engineer in St. Louis and served in various engineering and manufacturing positions. He has been plant manager of the Nitro, West Virginia, facility and general manager for several Monsanto Divisions. He later assumed the position of General Manager, Electronics Division. Mr. Springgate received a B.A. degree in Chemical Engineering from the University of Missouri and an M.S. degree in Chemical Engineering from Washington University. He is licensed as a Registered Professional Engineer and is a member of the American Institute for Chemical Engineers and the California Manufacturers' Association.

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SILICON AND SEMICONDUCTORS: PARTNERS IN THE LATE 1980'S

J.E. Springgate, President
Monsanto Electronic Materials Company

INTRO SLIDE

THANK YOU FOR INVITING ME TO SHARE OUR VIEW OF THE FUTURE WITH YOU. MONSANTO HAS BEEN IN THE SILICON BUSINESS FOR MORE THAN 25 YEARS AND WE HAVE SEEN, AND CONTRIBUTED TO, MANY DRAMATIC CHANGES IN THE SEMICONDUCTOR INDUSTRY. HOWEVER, WE ANTICIPATE THAT CHANGES WILL BE EVEN MORE SIGNIFICANT IN THE NEXT FEW YEARS. MUCH OF THE REASON FOR THE CHANGES WILL TRACE TO THE JAPANESE MARKET.

WE HAVE BEEN MARKETING SILICON IN THE JAPANESE MARKET FOR 18 YEARS AND ARE PLEASED THAT WE HAVE BEEN ABLE TO PARTICIPATE IN HELPING THE JAPANESE SEMICONDUCTOR INDUSTRY BECOME A WORLD CLASS COMPETITOR. WE HAVE LED THE WORLD IN DEVELOPMENT OF WAFER POLISHING TECHNOLOGY AND WAFER FLATNESS.

SLIDE - PLANT SITE

1986 IS A SPECIAL YEAR FOR MONSANTO ELECTRONIC MATERIALS COMPANY BECAUSE WE WILL BEGIN PRODUCING FINISHED POLISHED WAFERS AT A NEW PLANT IN THE KIYOHARA INDUSTRIAL PARK, NEAR UTSUNOMIYA, TOCHIGI. INITIAL CAPACITY WILL BE FOR 1 MILLION 5 INCH WAFERS, WHICH WILL BE EXPANDED TO 5 MILLION 5 INCH WAFERS. OVER 700 PEOPLE WILL WORK AT THE FACILITY AT FULL CAPACITY.

THERE ARE SEVERAL REASONS WE ARE BUILDING A PLANT IN JAPAN. WE HAVE LEARNED OVER THE MANY YEARS OF OUR DOING BUSINESS IN JAPAN THAT OUR CUSTOMERS EXPECT US TO WORK VERY CLOSELY WITH THEM IN A TEAMWORK APPROACH TO PROBLEM SOLVING. THIS REQUIRES THAT WE HAVE APPLICATION ENGINEERING, TECHNOLOGY AND MANUFACTURING PERSONNEL NEAR OUR CUSTOMERS SO THAT WE CAN REACT QUICKLY AND POSITIVELY TO THEIR NEEDS.

ALSO, THE JAPANESE SEMICONDUCTOR INDUSTRY HAS GROWN TREMENDOUSLY THE PAST 10 YEARS, ESPECIALLY THE PAST 5 YEARS, AND IS PROJECTED TO ROUGHLY EQUAL THE U.S. MARKET TODAY. WE HAVE PARTICIPATED IN THIS GROWTH AND HAVE BEEN STRENGTHENING OUR ABILITY TO SERVE THE VERY RIGOROUS DEMANDS OF OUR JAPANESE CUSTOMERS. WE OPENED A TECHNOLOGY SERVICE CENTER IN TOKYO IN 1982 AND HAVE BEEN PLANNING OUR UTSUNOMIYA PLANT SINCE 1983.

OUR JAPANESE CUSTOMERS HAVE APPRECIATED OUR CAPABILITIES TO PRODUCE ADVANCED SILICON PRODUCTS AND HAVE ENCOURAGED US TO BUILD A PLANT IN JAPAN THAT IS EQUIPPED WITH THE BEST TECHNOLOGY, SERVICE AND EQUIPMENT IN THE WORLD.

THE JAPANESE SEMICONDUCTOR INDUSTRY IS THE MOST INTENSELY COMPETITIVE MARKET IN THE WORLD. WE KNOW WE CAN COMPETE AND EARN A SUBSTANTIAL SHARE OF THE MARKET BECAUSE WE HAVE DEMONSTRATED OUR LEADERSHIP ABILITIES IN EVERY WORLD AREA. WE HAVE PAID ATTENTION TO THE SPECIAL NEEDS OF THE JAPANESE MARKET, HAVE TAKEN THE TIME TO LEARN HOW TO SERVE THE MARKET, AND HAVE INVESTED IN THE BEST PEOPLE AND EQUIPMENT. THE CHALLENGE FACING ALL OF THE SEMICONDUCTOR INDUSTRY IS TO MANAGE THE RAPID PACE OF CHANGE IN THE INDUSTRY AND TO SUCCESSFULLY COMPETE IN A GLOBAL MARKET.

OUR ANSWER TO THESE CHALLENGES IN THE SILICON MARKET IS TO CONTINUE TO PROVIDE INNOVATIVE PRODUCTS USING THE MOST ADVANCED TECHNOLOGY, AND TO BUILD PARTNERSHIPS WITH OUR CUSTOMERS THAT FOCUS ATTENTION ON ANTICIPATING THEIR NEEDS AND PROVIDING SOLUTIONS TAILORED TO THEIR REQUIREMENTS.

OUR JAPANESE CUSTOMERS TELL US THE CHALLENGES THAT HAVE THE GREATEST IMPACT ON THEIR BUSINESS, AND WHERE WE CAN BEST WORK TOGETHER TO LEVERAGE OUR JOINT RESOURCES IN THE LATE 1980'S, ARE THE DEVELOPMENT OF APPLICATION-SPECIFIC IC'S, SHRINKING DESIGN RULES, THE INEXORABLE MOVE TO LARGER DIAMETER WAFERS, AND WORLDWIDE COMPETITION. global marketing

SLIDE -
WAFER ZONE

THESE NEEDS HAVE DRIVEN OUR PLANNING THE PAST FEW YEARS AND WE ARE READY TO MEET THEM WITH APPLICATION-SPECIFIC WAFER ZONE ENGINEERING, A TECHNIQUE WE USE TO TAILOR WAFER CHARACTERISTICS TO CIRCUIT REQUIREMENTS (THIS IS SIMILAR IN CONCEPT TO THE APPLICATION-SPECIFIC IC APPROACH). WE ARE DEVELOPING ADVANCED WAFERS SPECIFICALLY DESIGNED FOR THE YIELD AND PERFORMANCE DEMANDS OF ADVANCED VERY LARGE SCALE AND ULTRA LARGE SCALE INTEGRATION IC'S. AND, WE ARE ACTIVELY WORKING ON LARGER DIAMETER WAFERS SUCH AS 200 AND 250MM WAFERS.

TO COMPETE ON A GLOBAL BASIS WE ARE OPENING MANUFACTURING FACILITIES HERE IN JAPAN AS WELL AS ENGLAND AND KOREA TO BUILD CLOSER WORKING RELATIONSHIPS WITH CUSTOMERS IN THESE MARKET AREAS.

SLIDE -
DRAM
DENSITY

MEMC SCIENTISTS AND ENGINEERS, WORKING WITH OUR CUSTOMERS, HAVE FOCUSED MANY TECHNICAL PROGRAMS AND WAFER ENGINEERING EFFORTS ON THE CHALLENGES INHERENT TO THE EVER-SHRINKING IC DESIGN RULES. THIS DIAGRAM OF DRAM FEATURE SIZE SCHEMATICALLY DEMONSTRATES THE SYMBIOTIC RELATIONSHIP OF WAFER FLATNESS AND FEATURE SIZE - REDUCED FEATURE SIZES CANNOT BE PRODUCED WITHOUT IMPROVED WAFER FLATNESS. A SIMILAR RELATIONSHIP EXISTS ACROSS ALL WAFER PARAMETERS, ESPECIALLY TOWARDS IMPROVED TOLERANCES.

THE CONCEPT BEHIND WAFER ZONE ENGINEERING IS THAT A ULSI CIRCUIT REQUIRES DIFFERENT WAFER CHARACTERISTICS THAN A VLSI CIRCUIT, WHICH IS ALSO DIFFERENT FROM AN LSI OR MSI CIRCUIT. THESE DIFFERENT APPLICATIONS, AND THE WAFER PARAMETERS OUR CUSTOMERS REQUIRE TO MAKE EACH TYPE OF CIRCUIT, DICTATE HOW WE ENGINEER THE WAFER ZONES. OUR SCIENTISTS USE THE NEXT 3 SLIDES TO REPRESENT THE WAFER ZONE ENGINEERING CONCEPT.

SLIDE -
LSI/MSI

THIS SLIDE DEPICTS AN LSI/MSI WAFER. THE TOP AREA IS THE CIRCUIT ACTIVE ZONE. FLATNESS IN THIS ZONE IS CRITICAL TO THE PHOTOGRAPHIC DEPTH OF FOCUS REQUIRED FOR FEATURE SIZE RESOLUTION. SURFACE CONTAMINATION SUCH AS HAZE AND DEFECT ARTIFACTS MUST ALSO BE CONTROLLED IN THIS ZONE. THE SURFACE MAY BE EITHER A POLISHED SURFACE OR AN EPITAXIAL SURFACE, DEPENDING UPON THE APPLICATION. THE DEFECT FREE DENUDED ZONE, WHICH IS JUST BELOW THE CIRCUIT ACTIVE ZONE, IS DEVELOPED DURING THERMAL PROCESSING THAT ACCOMPANIES THE FORMATION OF THE INTERNAL GETTERING ZONE.

THE LATTER ZONE GETTERS PROCESS-INDUCED METAL CONTAMINANTS FROM THE CIRCUIT ACTIVE REGION DURING IC FABRICATION. IT APPARENTLY HAS NOT PLAYED A MAJOR ROLE DURING LSI OR MSI CIRCUIT FABRICATION, WHERE BACK-SURFACE MECHANICAL DAMAGE GETTERING HAS BEEN MORE PREVALENT. BUT INTERNAL GETTERING IS A KEY TO VLSI DEVICE FABRICATION, WHERE LOW LEVELS OF SURFACE CONTAMINATION ARE ESSENTIAL.

SLIDE -
VLSI

AS WE MOVE INTO FINER LINE GEOMETRIES AND MORE DENSE CIRCUITRY IN VLSI DEVICES, CHANNEL LENGTH IS REDUCED, JUNCTION DEPTHS ARE SHALLOWER AND GATE OXIDES ARE THINNER.

FOR THIS TYPE OF DEVICE, THE BACKSIDE CLEANLINESS OF THE WAFER BECOMES MORE CRITICAL AND MUST BE REDUCED IN PARTICLE COUNT. MONSANTO HAS PATENTED AN ENHANCED GETTERING PROCESS THAT INCORPORATES A THIN POLYSILICON LAYER ON THE BACKSURFACE. THIS CREATES NUMEROUS EXTERNAL GETTERING SITES WHICH GETTER PROCESS INDUCED CONTAMINANTS AWAY FROM THE CIRCUIT ACTIVE REGION. ENHANCED GETTERED WAFERS TEND TO EXHIBIT LONGER LASTING GETTERING THAN MECHANICAL BACKSIDE GETTERING THROUGH SEVERAL IC PROCESSING STEPS.

THE SCHEMATIC ALSO INCLUDES AN EPI LAYER, WHICH IS TYPICALLY USED IN CMOS APPLICATIONS TO REDUCE LATCH-UP MALFUNCTIONS. THE SUBSTRATE SINKS THE TRANSIENT CURRENTS RESPONSIBLE FOR INITIATING LATCH-UP. BY ENGINEERING THE EPITAXIAL SUBSTRATE INTERFACE, DEFECT DENSITIES HAVE BEEN SIGNIFICANTLY REDUCED IN THE EPITAXIAL LAYER. FOR EPI WAFERS, AN OXIDE SEAL IS INCORPORATED ON THE WAFER BACK SURFACE TO MINIMIZE AUTO DOPING.

SLIDE -
ULSI

THIS ULSI WAFER SHOWS THE CONTINUED EVOLUTION TO REDUCED CHANNEL CHANNEL LENGTHS, SHALLOWER JUNCTIONS AND THINNER GATE OXIDES OXIDES. TRENCH STRUCTURES FURTHER PREVENT LATCH-UP MALFUNCTIONS. P/P+ IS SHOWN, BUT N/N+ IS CONSIDERED BY SOME TO BECOME MORE CRITICAL FOR SUBMICRON APPLICATIONS. PROBABLY BOTH P/P+ AND N/N+ WILL BE USED. WHICH CHOICE IS APPROPRIATE WILL DEPEND UPON THE THE CIRCUIT APPLICATION. ACCORDING TO OUR SCIENTISTS, THIS IS STILL A STATE OF THE ART RESEARCH QUESTION.

THE MULTI-ZONE WAFER PRODUCTS HAVE BEEN DESIGNED WITH SPECIFIC MECHANICAL, CHEMICAL, AND STRUCTURAL CHARACTERISTICS NECESSARY TO DEVELOP THE ELECTRICAL CHARACTERISTICS THAT SUPPORT THE IC DENSITY AND ELECTRONIC PERFORMANCE GOALS OF EACH LEVEL OF IC INTEGRATION.

SLIDE -
MECHANICAL

NOW I'M GOING TO TAKE A FEW MINUTES TO DESCRIBE OUR VIEW OF THE WAFER CHARACTERISTICS NECESSARY TO MEET THESE VARYING NEEDS. THESE CHARACTERISTICS REPRESENT THE COLLECTIVE JUDGEMENT OF OUR SCIENTISTS AND ENGINEERS, AND HAVE BEEN DEVELOPED AFTER EXTENSIVE CUSTOMER CONSULTATION.

FOR EXAMPLE, MECHANICAL CHARACTERISTICS ARE MORE IMPORTANT THAN EVER FOR LEADING EDGE IC'S. OUR MOST ADVANCED 150MM ULSI WAFERS PROVIDE EXTREMELY TIGHT DIAMETER, ORIENTATION FLAT LENGTH AND THICKNESS TOLERANCES. THEY MUST BE TIGHT TO ACCOMMODATE THE AUTOMATED WAFER HANDLING EQUIPMENT BEING INSTALLED.

SLIDE -
MECHANICAL
(CON'T)

FLATNESS IS ALSO A CRITICAL PARAMETER, ESPECIALLY WITH THE ONSET OF MIX AND MATCH APPLICATIONS, UTILIZING STEPPERS AND PROJECTION PRINTERS. USING OUR 150MM ULSI WAFER EXAMPLE, GLOBAL FLATNESS OF LESS THAN OR EQUAL TO 3 MICRONS WILL BE REQUIRED FOR TODAY'S STATE OF THE ART DESIGN RULES TO ENABLE CIRCUIT DESIGNS TO ACHIEVE SUB- MICRON FEATURE SIZE. LOCAL SITE FLATNESS OF LESS THAN OR EQUAL TO 1 MICRON ACROSS A 20 BY 20 SQUARE MILLIMETER FIELD IS ALSO ESSENTIAL. BOW, WARP, WAFER CURVATURE, EDGE CONTOUR AND ESPECIALLY TAPER IN BACK-SURFACE REFERENCED STEPPER APPLICATIONS ARE ALL KEY PARAMETERS FOR OPTIMAL WAFER HANDLING AND LITHOGRAPHIC PROCESSING.

SLIDE -
CHEMICAL

WAFER CLEANLINESS BECOMES CRITICAL AS FEATURE SIZES BECOME COMPARABLE TO PARTICLE SIZES AND THE DISTRIBUTION OF PARTICLE SIZES BECOMES MORE IMPORTANT. BOTH FRONT SURFACE AND BACK SURFACE PARTICLES MUST BE REDUCED IN BOTH SIZE AND NUMBER BECAUSE THEY MAY INTERFERE WITH EFFECTIVE ALIGNMENT AND RESOLUTION.

SLIDE -
CHEMICAL
(CON'T)

OXYGEN IS A MAJOR IMPURITY AND CARBON A SUBSIDIARY IMPURITY INFLUENCING SILICON'S MECHANICAL STRENGTH AS WELL AS THE NUCLEATION AND GROWTH OF BULK OXYGEN PRECIPITATES FOR INTERNAL GETTERING. AT THE SAME TIME IT IS ESSENTIAL THE BULK OXYGEN PRECIPITATE IS CONTROLLED TO MINIMIZE IN-PROCESS WARPAGE AND MAINTAIN THE DESIRED WAFER FLATNESS. THE OXYGEN TOLERANCE IS CUSTOMER SPECIFIED. CARBON IS SPECIFIED WITHIN LESS THAN OR EQUAL TO THREE TENTHS PARTS PER MILLION.

SLIDE -
STRUCTURAL

CRYSTALLOGRAPHIC PERFECTION NEAR THE CIRCUIT ACTIVE REGION IS IMPORTANT TO REDUCE EXCESS LEAKAGE CURRENT. THE 150MM WAFER DEVELOPED FOR ULSI APPLICATIONS IS DISLOCATION-FREE AND CHARACTERIZED TO DEVELOP OXIDATION INDUCED STACKING FAULTS LESS THAN OR EQUAL TO 3 PER SQUARE CENTIMETER WITH MICRO-DEFECTS SUCH AS SAUCER PITS LESS THAN OR EQUAL TO 100 SQUARE CENTIMETERS, AND EVEN LESS.

SLIDE -
STRUCTURE
(CON'T)

AS MENTIONED EARLIER, AN EXTERNAL GETTERING PROCESS - ENHANCED GETTERING - IS RECOMMENDED TO REMOVE PROCESS INDUCED METALLIC CONTAMINANTS FROM THE CIRCUIT ACTIVE ZONE. AN EPITAXIAL LAYER IS RECOMMENDED FOR CMOS AND SELECTED NMOS CIRCUITS TO REDUCE CMOS LATCH-UP AND PROVIDE LOWER DEFECT DENSITIES. THE USE OF THIS EPI LAYER IS MUCH MORE PREVALENT IN THE UNITED STATES THAN IN JAPAN.

WAFER STRUCTURAL CHARACTERISTICS MUST ALSO BE REPRODUCIBLE WITHIN EACH WAFER, FROM WAFER TO WAFER, AND FROM CRYSTAL TO CRYSTAL TO ACHIEVE CONSISTENT RESULTS IN IC FABRICATION.

SLIDE -
DIAMETER

THE ECONOMIC FACTORS THAT CREATED THE NEED FOR THE 150MM DIAMETER WAFER WILL DRIVE THE INDUSTRY TO 200MM WAFERS BY THE END OF THIS DECADE. HOWEVER, THE SPEED OF THIS TRANSITION WILL DEPEND TO A LARGE EXTENT ON THE ECONOMIC HEALTH OF THE INDUSTRY. WE HAVE ALREADY SEEN THE DELAY OF A NUMBER OF 150MM FAB LINES DUE TO THE RECENT MARKET DOWNTURN, AND 1986 CAPITAL EXPENDITURE PLANS FOR THE INDUSTRY REMAIN CAUTIOUS. THIS ECONOMIC SLOWDOWN COULD DELAY GROWTH OF LARGER DIAMETER WAFERS. ✓

150mm
↓
200mm
↓
250mm

THE 150MM DIAMETER IS JUST REACHING PRODUCTION VOLUMES. IT ACCOUNTED FOR ONLY 5% OF WORLDWIDE VOLUME IN 1985, ALTHOUGH IT ACCOUNTED FOR 10% OF THE JAPANESE MARKET. IN 1995 WE ARE ANTICIPATING A WHOLESALE CHANGE IN DIAMETER COMPOSITION, AS THE 150MM WILL BE THE SMALLEST SIZE, ACCOUNTING FOR 35% OF THE MARKET. 200MM WILL BE THE WORKHORSE, WITH 45% OF THE MARKET, AND THE 250MM WILL ACCOUNT FOR THE BALANCE OF THE MARKET.

THIS CHANGE WILL OCCUR CONCURRENT WITH THE ADVANCES IN CIRCUIT DESIGN, THE ONGOING THRUST TO CMOS AND ADVANCES IN FABRICATION TECHNOLOGY. TREMENDOUS CAPITAL WILL BE REQUIRED BY BOTH SEMICONDUCTOR PRODUCERS AND EQUIPMENT AND MATERIAL PRODUCERS TO IMPLEMENT THESE ADVANCES. TO ACCOMPLISH THIS MAGNITUDE OF CHANGE WE MUST UTILIZE NEW FORMS OF COOPERATION AMONG EQUIPMENT VENDORS AND SEMICONDUCTOR MANUFACTURERS.

SLIDE -
CUSTOMER
PARTNER

WE SPENT OVER 2 YEARS WORKING CLOSELY WITH SEMICONDUCTOR CUSTOMERS AND EQUIPMENT SUPPLIERS TO DEVELOP THE 150MM WAFER. WE WERE FIRST TO MARKET WITH IT AND, MORE IMPORTANTLY, OUR CUSTOMERS HAVE HAD FEWER 150MM START UP PROBLEMS DUE TO THE PROVEN PRODUCTION QUALITY WE CAN PROVIDE AS A RESULT OF OUR EARLY JOINT EFFORTS.

EVEN GREATER COOPERATIVE EFFORTS ARE NECESSARY IN THE FUTURE. THE JAPANESE INDUSTRY HAS PRACTICED THIS KIND OF COOPERATION FOR YEARS, AND OUR ENTIRE EFFORT IN JAPAN IS DESIGNED TO ENABLE US TO WORK CLOSELY WITH OUR CUSTOMERS TO UNDERSTAND THEIR NEEDS AND HELP THEM SOLVE THEIR PROBLEMS. BUT NO COMPANY CAN KEEP UP WITH ALL THE TECHNICAL DEVELOPMENTS THAT WILL IMPACT IC FABRICATION IN THE FUTURE, YET YIELD OPTIMIZATION REQUIRES SQUEEZING EVERY EFFICIENCY OUT OF AVAILABLE TECHNOLOGIES. THE ANSWER IS FOR MANUFACTURERS AND THEIR SUPPLIERS TO WORK CLOSELY TO SHARE INFORMATION, TECHNOLOGY AND RESOURCES.

WE EXPECT THIS TREND TO CLOSER SUPPLIER-CUSTOMER RELATIONS WILL ACCELERATE IN THE FUTURE. TECHNOLOGY EXCHANGES, JUST IN-TIME INVENTORY & DELIVERY AGREEMENTS, SHARING OF QUALITY CONTROL DATA DESIGNED TO HELP ELIMINATE INCOMING INSPECTION AT IC FABS AND GROWING USE OF APPLICATION ENGINEERING SPECIALISTS ARE BECOMING STANDARD OPERATING PROCEDURE.

SLIDE -
MAP

EARLIER I SAID WE SEE THE FUTURE AS A GLOBAL MARKET. WE ARE ACTIVELY ENGAGED IN BUILDING PLANTS IN VARIOUS WORLD AREAS, NOT ONLY IN JAPAN BUT ALSO IN KOREA AND ENGLAND, SO WE CAN BUILD STRONG CUSTOMER PARTNERSHIPS IN THESE IMPORTANT MARKETS. TO BE SUCCESSFUL IN ALL WORLD MARKETS IN THE FUTURE WE BELIEVE IT WILL BE ESSENTIAL TO HAVE CLOSE CONTACT WITH CUSTOMERS - TO HAVE SUPPORT FACILITIES CLOSE TO THE MARKET AND BE ABLE TO WORK CLOSELY WITH CUSTOMERS IN THESE MARKETS. A NUMBER OF OUR JAPANESE CUSTOMERS HAVE RECOGNIZED THIS AND OPENED PLANTS IN THE UNITED STATES AND EUROPE TO SERVE THESE MARKET NEEDS.

GaAs - Mitsubishi
Monsanto

THE REALITIES OF A GLOBAL MARKET ALSO DICTATE BUILDING INTERNATIONAL PARTNERSHIPS. FOR EXAMPLE, MONSANTO HAS BEEN A JOINT VENTURE PARTNER WITH MITSUBISHI CHEMICAL IN JAPAN FOR OVER 34 YEARS. THE COMPANY, MITSUBISHI MONSANTO KASEI OF JAPAN, HAS JUST SIGNED AN AGREEMENT WITH MEMC IN WHICH WE WILL HELP INTRODUCE III-V COMPOUNDS (PRINCIPALLY GALLIUM ARSENIDE) IN THE U.S. MARKET. WE WILL CONTINUE TO LEVERAGE OUR CAPABILITIES VIA A PARTNER WHEREVER IT WILL HELP OUR BUSINESS RESULTS.

SLIDE -
CONCLUSION

WE HAVE SEEN DRAMATIC CHANGES IN THE SILICON AND SEMICONDUCTOR INDUSTRIES THE PAST FEW YEARS, AND WE ANTICIPATE EQUALLY SIGNIFICANT CHANGES IN THE NEXT 5 YEARS. 200 AND 250 MM DIAMETER WAFERS, WAFERS TAILORED TO SPECIFIC IC APPLICATIONS, WAFERS DESIGNED SPECIFICALLY FOR EMERGING ULSI APPLICATIONS AND ADVANCED EPITAXIAL WAFERS ARE AMONG THE MORE SIGNIFICANT TRENDS WE FORSEE.

CUSTOMER PARTNERSHIPS, A GLOBAL MARKETING PERSPECTIVE, AND MANUFACTURING PLANTS IN ALL WORLD AREAS ARE THREE INCREASINGLY IMPORTANT TRENDS THAT WILL DRIVE THE BUSINESS AND TECHNOLOGICAL DIRECTION WE TAKE BECAUSE ULTIMATELY WE MUST LOOK FIRST TO WHAT OUR CUSTOMER NEEDS, THEN MAKE SURE WE CAN MEET THE NEED BETTER THAN ANY COMPETITOR. THANK YOU FOR INVITING ME TO SHARE MY THOUGHTS ON THE FUTURE. I HOPE MY TECHNOLOGY FORECAST PROVES TO BE MORE ACCURATE THAN WHAT MY GOLF PRO TOLD ME I SHOULD EXPECT FROM MY GOLF GAME.

Larger diameter wafers
Application-specific wafers
Advanced EPI (200-250 mm)
Customer partnerships
Global marketing

SILICON AND SEMICONDUCTORS:

PARTNERS IN THE LATE 1980'S

J.E. Springgate
President
Monsanto Electronic Materials Company

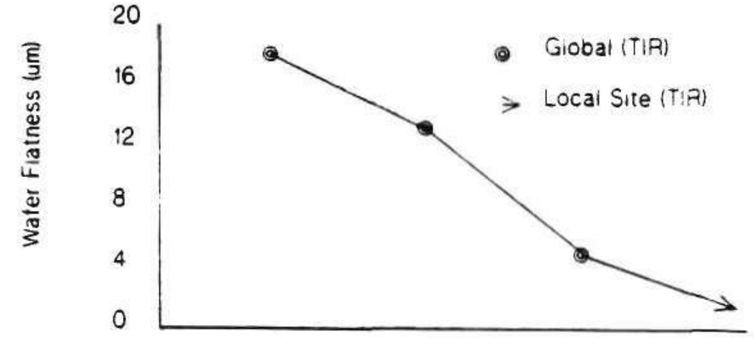
Wafer Zone Engineering

ULSI Designed Wafers

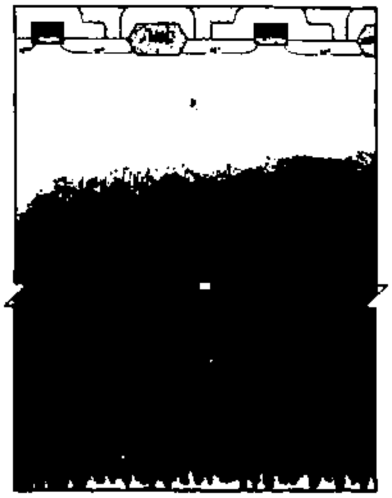
Larger Diameters

Global Marketing

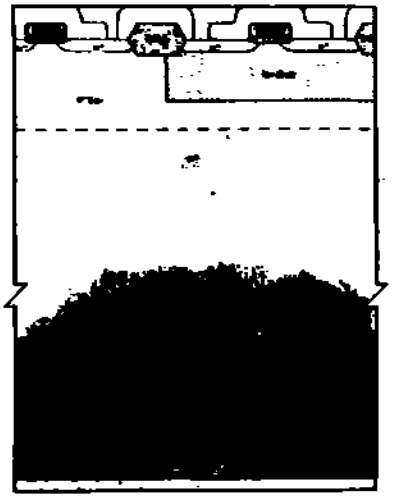
WAFER FLATNESS EVOLUTION



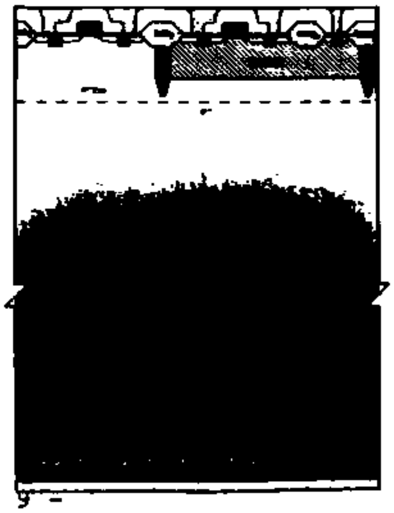
Year	1970	1975	1980	1985
Circuit Complexity	MSI	LSI	VLSI	ULSI
Feature Size (um)	10	5	3	<1
Wafer Diameter (mm)	50	75	100	150



LSI/MSI APPLICATION
SERIES WAFER
SCHEMATIC



VLSI APPLICATION
SERIES WAFER
SCHEMATIC



ULSI APPLICATION
SERIES WAFER
SCHEMATIC

MECHANICAL CHARACTERISTICS

PARAMETER	VALUE
- Diameter	150 mm
Tolerance	≤ ±0.2 mm
- Orientation Flat	
Tolerance	≤ ±1.5 mm
- Thickness	625, 675 µm
Tolerance	≤ ± 10 µm
- Taper	≤ 10 µm
- Global Flatness	≤ 3 µm

MECHANICAL CHARACTERISTICS
Cont'd

PARAMETER	VALUE
- Local Site Flatness	≤1.0 µm across a 20 x 20 mm^2 Field
- Wafer Curvature (Polished Surface)	Convex or Concave Specified by Customer
- Bow	≤10 µm
- Warp	≤10 µm
- Edge Contour	Chip-Free

CHEMICAL CHARACTERISTICS

PARAMETER	VALUE
- Cleanliness	
Front-Surface Particles	$\leq 0.03/cm^2$ (≤ 0.5 µm)
Back-Surface Particles	$\leq 0.06/cm^2$ (≤ 1 µm)
Back-Surface Stain/ Residues	None
Front-Surface Chemical (Native) Oxide	Hydrophilic

CHEMICAL CHARACTERISTICS
Cont'd

PARAMETER	VALUE
- Oxygen	Customer Specified
Tolerance	±2 ppma
Precipitation	Controlled, Reproducibl
Radial Gradient	≤3%
- Carbon	≤0.3 ppma
- Metallics	
Bulk	<0.01 ppba for Specific Metallics
Surface	$\leq 10^{10}/cm^2$

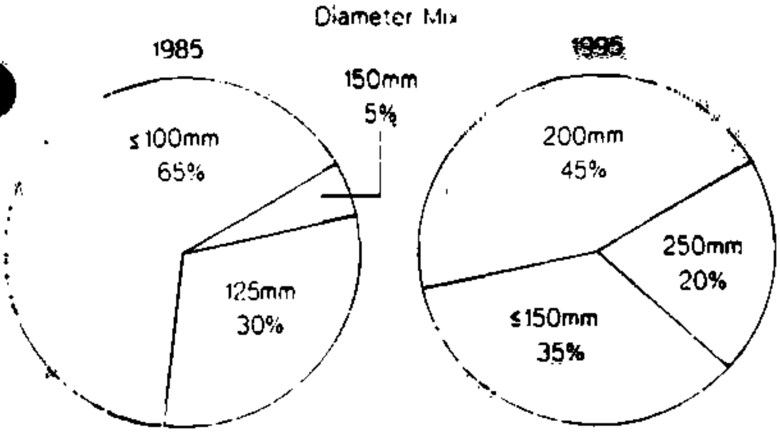
STRUCTURAL CHARACTERISTICS

PARAMETER	VALUE
- Wafer Perfection	No X-Ray Resolved Bulk Structural Defects
- Grown-In Dislocations (Etch Pits)	0 cm^{-2}
- Oxidation-Induced Stacking Faults (OISF)	≤ 3 cm^{-2}
- Micro-Defects (S-Pits)	≤ 100 cm^{-2}

STRUCTURAL CHARACTERISTICS
Cont'd

PARAMETER	VALUE
- External Gettering (Recommended)	Back-Surface Polysilicon
- Wafer Uniformity	Reproducibility Within Wafer, Wafer to Wafer, and Crystal to Crystal
- Epitaxial Layer (Recommended for CMOS and Selected NMOS Circuits)	Customer Specified Resistivity and Thickness ≤ 3 OISF cm^{-2}

THE SILICON WAFER MARKET



DIAMETER WILL CONTINUE TO INCREASE

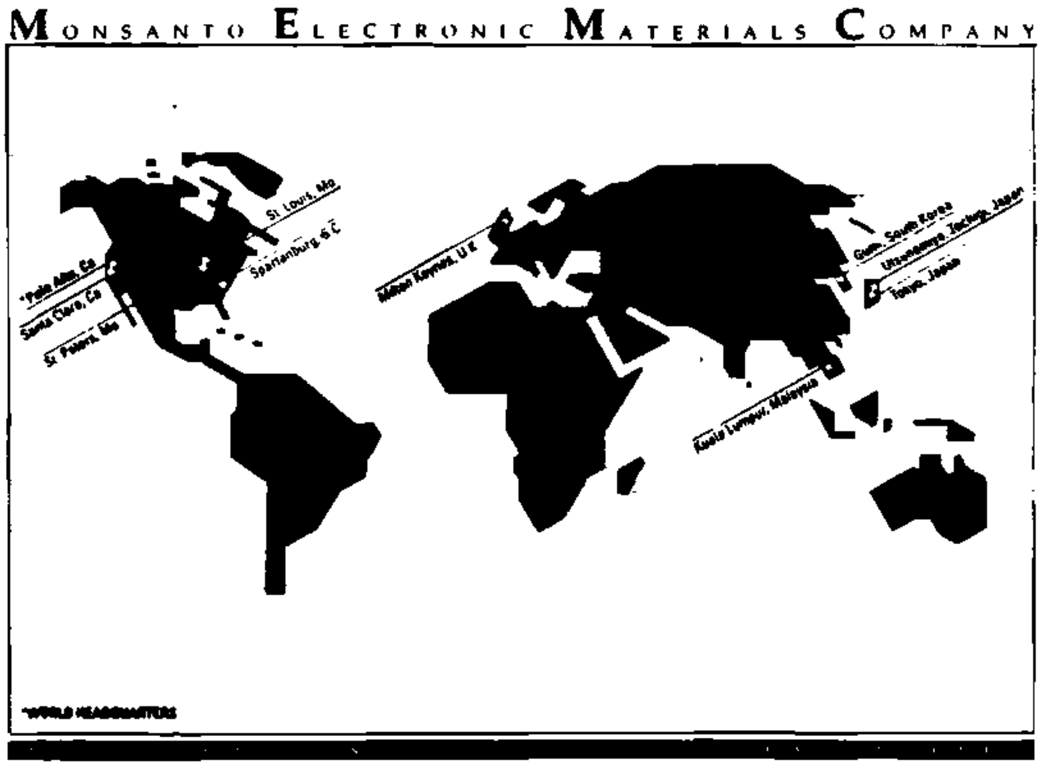
CUSTOMER PARTNERSHIP

Technology Exchanges

Just-In-Time

Joint Quality Control

Application Engineering



CONCLUSION

Larger Diameter Wafers

Application Specific Wafers

Advanced EPI

Customer Partnership

Global Marketing

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CORPORATE ALLIANCES

Keiske Yawata
Chief Executive Officer
LSI Logic K.K.

Mr. Yawata is Chief Executive Officer of LSI Logic K.K., an affiliate of LSI Logic Corporation. Previously, he was President and Chief Executive Officer of NEC Electronics Inc., and prior to that, he was General Manager of the International Electron Devices Division of NEC Corporation. He served in the semiconductor group of NEC Corporation for 13 years. Mr. Yawata received a B.E. degree in Electrical Communication Engineering from Osaka University and an M.E.E. degree from the Electrical Engineering School of Syracuse University.

Dataquest Incorporated
JAPANESE SEMICONDUCTOR INDUSTRY CONFERENCE
April 13-15, 1986
Hakone, Japan

Japanese Creativity in applications

1. Consumer electronics
2. More compact (Kei-haku-tan-sho)
3. Lower power consumption
4. Flat package
5. Short pitch leads
6. Perfectionism → high reliability

American creativity

1. Fundamental research
2. Systems development
3. User-friendly software

CORPORATE ALLIANCE

ASICs Require Enormous Resources

Keiske Yawata
President and Chief Executive Officer
LSI Logic Co. Ltd.

Rapidly growing ASIC market and evolving technology requires enormous resources. Discussed in this talk are; current applications of ASICs, new applications, what is going on in the ASIC industry, and what roles Japan and the U.S.A. should play.

Applications for ASICs today are largely replacement of standard logic curcuits reducing the physical size of equipment and power consumption. Examples are; computer terminals, main frame CPU, telecommunication terminals, instrumentation, medical electronics, etc. As the scale of integration increases, new applications are emerging in the area of graphic processing, artificial intelligence, digital signal processing, automotive, and consumer electronics. These new applications emerge largely due to the increase in gate density, speed performance, design security and design automation. It should also be noted that the user's needs are diversifying and ASICs can fulfil the needs with short turn around time. Diverse applications often requires low volume production which few ASICs suppliers can meet. Emerging technologies in the semiconductor industry are silicon compilation, design tool which simmulates system architecture as well as circuits and three dimensional circuits in silicon further increasing integration density.

The applications which are of particular importance to the ASICs industry are graphic processors for type-setting, fabric pattern design and automated graphic design tool. As the sensing technology improves, pattern recognition and automated three dimensimal design tool will enable fully automated grader for fruits, vegetables, etc. and artificial intelligence in a true sense.

The Japanese creativity has been primarily demonstrated in applications area, particularly in consumer electronics. Perfectionism is perhaps the key for Japanese success in manufacturing high quality and reliability product. It is characteristic that Japanese electronic equipment is user friendly, e.g., thinner refrigerator which can be installed directly against the wall of a small kitchen, auto reverse mechanism of cassette tape recorder, low power comsumption for energy conservation, etc. High density packaging using surface mount technology requires high pin count flat package and leadless chip carriers with short pitch leads. The Japanese skillfulness may be useful in developing such packages. The strength of U.S. companies is in fundamental research, systems development and user friendly software development. If the weakness of a company is offset with the strength of another company, a complementary relationship may be achieved. An ideal corporate alliance is a perfectly complementary relation without conflict of interest.

1. Shortage of human resources

Evolving Technology

1. Array technology
2. Cell " — 40K gates
3. Silicon compilation
4. Design automation
5. Flexible automated mfg.
6. Packaging

Hot End User

1. Typesetting
2. Fabric pattern design
3. 3-D pattern recognition
4. Fruit/vegetable grading machines

競争下の企業間協力

ＬＳＩロジック株式会社
代表取締役社長　八幡惠介

急速に成長するＡＳＩＣの市場は技術革新のテンポの速さと相俟って莫大な資源を必要とする。本稿ではＡＳＩＣの現在と将来の用途、ＡＳＩＣ産業に何が起ころうとしているか、日本と米国がどのような役割を果たすべきかについて論ずる。

今日までのＡＳＩＣの用途は主として標準ロジックＩＣを使った回路の置換えであり、これによって機器の小型化と低電力化を実現してきた。例えば、コンピューター端末、大型コンピューターのＣＰＵ、通信用端末、計測機、医用エレクトロニクスなどが上げられる。集積規模が更に大きくなれば、画像処理、人工知能、デジタル信号処理、車載機器、民生用電子機器等にも新しい用途が拡がろう。これらの新しい用途が出てくるのは主として、ゲート規模の増大、応答速度の向上、設計の機密保持、あるいは設計の自動化のゆえであろう。また、ユーザーの要求は多様化しており、ＡＳＩＣがこの要求を短納期で満たせるということも見逃がしてはならない。多様な応用は多くの場合において少量生産にならざるを得ないが、これを得意とするＡＳＩＣメーカーは多くない。半導体産業の中で出現しつつある技術の中でもシリコンコンパイレーション、三次元ＬＳＩ及びシステムアーキテクチャと回路シミュレーションを連続的に行なえる設計システムは集積密度を更に増大させる。

ＡＳＩＣ産業にとって特に重要な用途は印刷用組版、布地パターン設計、その他の自動化画像設計システムに使われる画像処理システムがある。またセンサー技術の改良に伴い、パターン認識、三次元設計システムなどが、完全自動果物（野菜）選別機や真の人工知能を実現させることになるのであろう。

日本人の独創性は主として応用技術、中でも民生用機器において発揮されてきた。完全主義もまた品質と信頼性の高い製造で日本が成功をかち得た鍵であろう。日本の電子機器は使い勝手がよいということも注目すべきことである。すなわち、狭い台所で直接壁に接して設置できる冷蔵庫、カセットプレーヤーのオートリバース機構、省エネ化の低電力消費などがそれである。高密度実装をサーフェスマウント技術を使って実現するためには、ピン数の多いフラットパッケージかピン間隔の狭いリードレスチップキャリヤが必要となる。このような分野では日本人の器用さが貴重ではなかろうか。一方米国の強みは基礎研究、システム開発力、ユーザーフレンドリーなソフトウエアの開発力にある。ある会社の弱点が他の会社の強みで補なわれれば、補完的関係が成立する。理想的な企業間協力は利害が競合しない完全補完関係が存在する時に成立するが、勿論このようなことは望むべくもなく競争下の協力となり補完的関係が強い程協力関係は永続きするのである。

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PERSPECTIVE FOR THE 90s

Kimio Sato
Senior Managing Director
General Manager, Electronic Devices Group
Mitsubishi Electric Corporation

Mr. Sato is Senior Managing Director and General Manager of the Electronic Devices Group of Mitsubishi Electric Corporation. Previous positions at Mitsubishi have included General Manager of the Osaka Industry Product Sales Branch, and General Manager of the Semiconductor Marketing Division in the company's headquarters. In 1981, he was elected to the Corporate Board as a Director, and was later promoted to his present position. He is a graduate of Fukushima National Commercial College.

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Perspective for the 1990s

Kimio Sato

Senior Managing Director

Electronic Devices Group

Mitsubishi Electric Corp.

April 15, 1986

1. Preface

In less than four years we will reach the 1990s. Four years ahead is rather a difficult length of time to forecast. We can anticipate one or two years ahead with a high degree of accuracy, while anything for ten years ahead can only be predicted irresponsibly. Four to five years ahead fall somewhere between dreams and reality and as such are very hard to forecast.

I will, however, boldly take just such a forward view of - mainly - the application group of products of semi-conductors.

2. Social Trends

I will highlight five social trends which will greatly influence electronics in Japan.

5 trends

These are: informationization, internationalization, labour-saving, entertaining (goraku-ka) and the elevation of the average age. Let us consider how these five trends are related to electronics.

2.1 Informationization is dealt with first as follows.

There are many kinds of information journals on sale, such as the "Daily News on Side Jobs" and "Pia", etc., all aimed at the younger generation. These journals have been electrified of late and have changed into the "B-Box" and "Ticket Pia", etc. It is therefore quite natural that these journals in turn will be replaced by on-line electronics publications because the information contained in them becomes old even at the moment of their printing and subsequent display in the shops.

Many information will likewise be electrified in the future easy to be utilized and informationization of society will be accelerated rapidly.

2.2 Internationalization is dealt with next.

Nowadays, CNN's American television programmes are broadcast everyday here in Japan, and the American newspaper "USA Today" is printed and sold in Japan. On the other hand, the "Asahi Japanese newspaper" is printed and delivered to subscribers' homes every morning in London. The money markets of London, New York, Sydney, Tokyo and Hong Kong are altogether working 24 hours a day in relays.

Such internationalization will continue to take place for more items in more countries.

Electronics, especially advanced technology such as artificial satellites, will play an increasingly important role in this.

By 1990 it will not be impossible to join a meeting where each participant is in a different country, via "video conference".

2.3 The third trend is (shoryoku-ka) labour saving

In Japan since the war we have had markedly fewer children in each home. Japan's population was previously believed as being the source of national power and a policy of "the more, the stronger" was practised, but after the war there was a turnabout change to "the fewer children, the better-educated".

As a result, the numbers receiving higher education increased and those who became technicians decreased sharply. In this way automative equipment was introduced into factories in place of technicians.

Numerical control machines, transfer machines, machining centers and finally robots, were adopted. Robots were warmly welcomed by labours as competent juniors came to help them.

Robots and unmanned hansōsha trucks were combined to make flexible manufacturing systems (FMS).

Not only manufacturing, but also the new designing on computer aided design (CAD) was introduced, which contributed for a high-reliability in design as well as a noticeable speed-up.

Such factory automation (FA) will be prevailing into much diversified fields in the future.

2.4 The fourth trend is entertaining

About fifty years ago, radio was the only home entertainment utilizing electronics. Record players were not related to electronics at that time, and were driven by springs. We played with spinning tops and made bamboo toys.

Nowadays, it is very difficult to find a toy not related to electronics; games and watches, radio-controlled cars, game centers, family computers, transceivers, stereo sets, electric guitars, electronic music instruments, televisions, video cassette recorders, compact disks, video disks, music tape minus ones, and lots of others.

Even chess, Shohgi (Japanese chess) and Go are now electronicised. Electronics produced a new type of game, such as space invaders, which ruled the games world of Japan for a year some years ago. The game of Pachinko must be the biggest and longest-lived leisure industry in Japan, with millions of deep-rooted fans, but it can not do without electronics nowadays.

New electronics leisure equipment will be realized in the future to make our lives even more comfortable and enjoyable.

2.5 Finally let's consider the trend of the elevation of the average age. aging

The Japanese society is progressing into a higher age bracket at four times the rate of that of Europe, i.e. the time it takes for the percentage of people over 65 years old to rise from 8% of the total population to 18% took 160 years in Europe, but will take only 40 years in Japan.

The Fig.1 shows demography of Japan made by Mr. Kazuo Takenaka of the Population Research Laboratory, Ministry of Welfare, Japan.

We used to say "Life is fifty years". Only 15% of population was over 50 years old in 1920, but now 27% and will be 35% in 2000.

This means younger generation in the society become relatively less than now. And it is feared that social dynamism will be lost. But electronics can keep aged people to continue working and society can be kept active.

Aged people pay more attention to their health which is made possible by medical electronics.

Aged people have longer leisure periods than young people to spend on hobbies and amusements. When they need attendance for easy movement, they prefer playing Go over the telephone, or watching TV university programms at home. It is a great joy for them to receive letters and picture from their grandchildren.

These are my views of electronics application in our lives, which I am convinced will continue developing in the 1990s.

3. Industrial Trends

3.1 The table 1 is cited from Mr. Mikio Goto "New Media" in "In Search of Vision for Industrial Structure in the 21st Century – Metamorphosis of Industrial Society by Innovation in Advanced Technology" published by the Japan Committee for Economic Development of Japan.

If one compares macroscopically the production of electronic in both electronic communications systems and non-electronic communications systems for the years 1980 and 2000, the former showed an increase of 5.8 times whereas the latter is only 1.7 times as big, respectively.

In the electronic communications system field it is estimated that the electronic communications-related industry will increase 6.9 times, the electronic communications industry itself 3.5 times and broadcasting 2.1 times during these 20 years.

3.2 The Demand for Semiconductors and its growth

The Demand for semiconductors and its growth from 1984 to 1990 are shown in Fig.2 which is based on "New Trends in a Highly Advanced Electronic Society and Electronic Devices" (1985) published by the Japan Electronic Industry's Association.

It is quite obvious that no items in both home use and industrial use show a decrease during these six years. Although cameras and television receivers will grow less than 5%, video cassette recorders and music instruments will grow 5 to 10% and home appliances will grow 20% which is the highest rate in home-use electronics.

Industrial use electronics will show a relatively higher growth rate than home use ones.

Personal computers, word processors, computers and their peripherals, facsimil machine and robots will grow approximately 25%. Even the lowest growth product (office computers) shows a 10% growth rate.

3.3 The birth of new products for home use and industrial use, and the demand for related semiconductor devices in 1990.

Figure 3 is also based on information from the Electronic Industries Association of Japan.

The biggest sale of new products in 1990 will be business machines for office use which will total more than ¥900B and use an additional ¥150B of semiconductor devices.

The second largest sale will be of new audio visual equipment and terminals for information and communications equipment for office use. Each of them will sell as much as ¥400B and use about ¥80B of semiconductor devices.

Information and communications equipment for home use and other industrial equipment will sell for a little under ¥300B but will use quite a lot of semiconductor devices.

3.4 The Development of Electronic Equipment and New Semiconductor Devices.

Now let's consider the development of electronic equipment and new semiconductor devices. (Table 2)

Among the existing equipment, those for home use such as TV, VCR, audio and home appliances will add new functions and mechanisms in order to achieve automation, be of higher performance and of greater convenience, and this development will require the use of new systems and circuits and new semiconductor devices.

This can also apply to industrial equipment such as personal computers, word processors, computers, peripherals and terminals, communications equipments and automobiles.

New equipment and new systems such as videotex, home automation, business information equipment for office use, high definition TVs, IC cards and engineering work stations, require high speed random logic ICs, and EEPROM with built-in microprocessors.

3.5 A Forecast of the Demand for Semiconductor Devices.

A forecast of the demand for semiconductor device in 1990 is shown in Fig 4.

Among the total estimated demand of ¥4,900B, those related to existing equipment occupy about 60% of ¥2900B. Semiconductor demand related to new functions and mechanisms occupies about 30% of ¥1500B and those installed in new equipment and systems are about 10%.

3.6 The Percentage Demand for Each Semiconductor Device

Let's see the percentage demand for each semiconductor device (Fig.5).

The biggest change between 1984 and 1990 is the decrease of discrete semiconductors from 23.8% in 1984 to 16.4% in 1990. On the contrary, MOS logic microprocessors and MOS memories of 24.0% and 21.7%, respectively, in 1984 will show an increase of up to 28.4% and 25.6%, respectively, in 1990.

The main cause of these changes is the increased use of MOS logic micro-processors and MOS memories in new equipment with new functions and mechanisms which will become 51.3% and 30.7%, respectively, in 1990.

The percentage in existing equipment is 1/3 for MOS micro processors and 2/3 for MOS memories compared with new equipment.

4. New Electronic Equipment

The above-mentioned will encompass macrosopic view for 1990. Now let's see the details of some new electronic equipment.

4.1 Electronic Files.

In the previous chapter we saw that business information equipment for office use will be the best-seller in 1990.

Out of this, electronic files may be one of the most promising items to be developed. My own office is located in front of Tokyo station, where the center of the Tokyo business world is located, as it is very convenient both to do business and for transportation.

The demand for office space here is very strong and rents are very expensive. Therefore, the space for document-storage is limited. It is a compulsion to throw old documents away at least once a year, which raises problems sometimes of missing documents.

In the future there could be a paperless office, but that concept is rather difficult to envisage at present. The compromise is to move documents from their shelves into electronic files. We would then be very comfortable with wider rooms and the convenience of accessing the documents quicker. In the case of a transfer, one can carry a disk or two far easier than boxes.

The electronic file is a very serious item to be considered especially for Japan because here we have a very small apartment area.

If we remember that a Japanese word processor went from ¥6,300,000 to ¥40,000 in eight years, and apply a similar experience curve on the electronic file business, we can expect that it will become a home use item in the 1990S.

The memory media will be via optical disks rather than magnetic disks. Besides, we can use one disk many times by erasing it, rather than the add-on type which can be used only once.

There will be no recording media of a higher density than the optical disk developed in the 1990S. It will be later than the year 2000 when molecular memories appear.

4.2 The Electronic Secretary

Personally, my secretary arranges all of my schedules. Meetings with newspaper reporters, dining with customers, presentations for Data quest, etc. are all fixed by her.

I cannot make my own appointments at will without consulting with her in order to make a commitment with my friend.

However, If I had an electronic secretary in my wristwatch, and both I and my secretary could fix my schedule remotely, it would be very convenient. If I may be allowed to hope for even more, my schedule would be displayed on the boards of my staff as well as to my wife.

4.3 Computer Conferences

The more multi-national companies, there are, the more international conferences too. If the number of the companies involved reaches 10 or 20, it becomes very difficult to arrange a schedule, and travel and hotel expenses amount to a very large sum of money. Although in this way all the members are able to meet in one room together, the conference can function fully if some of them are sleepy or suffering from jet lag.

If personal computers spread widely and a communications network is available all over the world at a lower cost, members of a meeting in a multi-national company would be able to a meeting at their office or even their home, in their own country.

They would see the subject of the meeting on the display, type in their opinions, agree or disagree with the opinions of others.

Computer conferences can bring about a decision in less time than it takes to arrange the timetable for a normal conference. There is also no need to have a secretariat nor to take minutes.

4.4 Video Conferences

If you are not satisfied with computer conferences because you cannot see the faces of the people present, you would then prefer a video conference. We can hold a video conference from any corner of the world with a minimum of three communications satellites. We can have face-to-face communications and can explain showing figures, tables and photos to arrive at a better understanding, although it is day in some countries and night in other countries.

Although it necessarily costs more than a computer conference and some member somewhere must be sleepy due to the time differences, enough merits can be achieved by face-to-face communication. Now, thanks to the new technology of the band compression and quantization, the cost is remarkably reduced. But unfortunately, the joy of a business trip free from office duties, and the pleasure of chatting at the post-meeting party no longer would exist.

4.5 Teleworking

Before the industrial revolution in the 18th century, small household industries were popular and industry employees worked at home or near their homes.

After the revolution, factory workers increased. The bigger the factory, the farther their home became from factory.

Nowadays, those who can commute within an hour become the targets of envy from their colleagues in Tokyo. Quite a few people commute for one hour and a half, or sometimes for more than two hours. They are tired even before they arrive at their office, and are forced to live inhuman lives of going home only to sleep.

Dr. Alvin Toffler proposed the concept of an "electronic cottage" in his "The Third Wave".

He introduced the idea of a life in a mountain cottage provided with sufficient electronic equipments to allow a businessman to work without having to live in a city.

A British software house named "F International" has 850 employees, out of which 750 programmers are working at home. About 40 companies have employee working at home in Japan. The Equal Employment Act for women is enforced this year in Japan which will result in more lady workers, who will continue working also after marriage. At present, most of the women who have babies must resign their office due to the lack of a social infrastructure such as a day-care center.

If teleworking become popular, one or both of the married couple could work at home. This would enable women with a higher education to work for move years and save wasting human resources.

If both a husband and wife can work at home, they would be no more forced to live in the suburbs of a big city. Instead they could live in a rural area with a good natural environment and could live in a spacious house, enjoying a substantial lifestyle with plenty of leisure time.

Teleworking is possible electronically if labors systems can be changed. Engineering workstations are an ideal equipment for teleworking.

4.6 Artificial Intelligence

For those areas which require extraordinary degree of safety such as nuclear reactors and aircraft, sufficient education and training for safety measures must be given to their operators.

But when an emergency occurs, say once in ten years, the operators take fright and become incapable of judging correctly or operating, only making the accident even worse.

In such a case electronics can judge more accurately because it has no sentiment. But there are so many factors to judge, that it is difficult to teach the logic to the computer.

Artificial intelligence, especially expert systems, can judge just like an expert but calmly and without emotion.

Expert systems can choose medecines judging from the symptoms of patient or can point out part-failures judging from the sound of a car.

Much more advanced judgement functions will be provided in this field to avoid such mistakes as the break-out of a Third World War by mistakenly judging a meteorite to be an enemy missile.

4.7 Automatic Translators

In Japan 3.5 billion copies of books are sold every year. Japan is one of the best book-loving nations. The intellectural curiosity of the Japanese is full of vigour and books originally written in almost every language in the world are translated. So many experts translate a book cooperatively, that it may happen sometimes that the translation is published earlier than the original book.

Recently the international business has increased and the translation of specifications for bids and instruction manuals for products has increased enormously, so that it is now necessary to improve translations in cost as well as in time.

Therefore, the possibility of automatic translations has been discussed for a long time. Recently high quality automatic translations became realized between Japanese and English at a lower cost. It will not be long before practical documents excluding literature can be translated electronically to make one understood.

Nevertheless, automatic interpreting is not so easy. It is very difficult to recognize the speech of a non-specific speaker therefore, it is forecasted that automatic interpreters will be realized only in the 21st century.

4.8 Automatic Readers

Nowadays if a blind man wants to read a book he must ask someone to make a translation into Braille and then read this version or ask someone to read aloud to him. In most cases, volunteers do the job and the blind man is subsequently restricted in his requests to that person.

However, the present optical character recognition technology can recognize the alphabet and numerical figures with a rather high degree of accuracy. If this is improved to read Japanese and Chinese letters, Japanese books could be read. This book reader is a benefit not only for blind people but also for aged people with presbyopia or for car-drivers.

If the voice quality could also be chosen, it would certainly be a lot of fun to choose one's favourite voice to read to you.

4.9 IC Cards

Credit cards have prevailed remarkably as they are much safer and more convenient than cash. However, many problems have occured recently and real security is doubted for credit cards with magnetic stripes.

IC cards are thought to be better than magnetic cards and may replace them. They have 100 times more memory capacity than magnetic credit cards, so that much more complicated passwords can be adopted, and they are practically impossible to gorge.

This IC card can be used not only in commercial transactions like the present credit card, but also as an identification card, a case history card for a patient, game software, a memory for word processors, job instructions for robots and in infinite other application fields.

At the moment the biggest bottleneck is the cost, which will be sharply reduced in 1990, resulting in its adoption into many fields at that time.

4.10 Robot

Skilled labor are getting older and young labor to succeed them are decreasing, therefore, it is quite natural robots will be increased in factories.

Traditional robots do preprogrammed jobs royally and accurately, while robots in 1990s may be intelligent robots. They have eyes and/or touch sensors and artificial brains to judge from information obtained by the sensors, and behave by themselves.

Chinō

They will be able to check and repair in a highly radioactive area in nuclear power plant where no human being can walk in. Robots will be also available to survey and collect natural resources under deep sea where pressure is high and divers can not work.

In case of earthquake or fire, robots can rescue people in a crushed or burning building.

It is obvious that such highly intelligent robots have fairly high performance computer in them.

5. Conclusion

As I mentioned above, these are many jobs yet to be done in the semiconductor industry, which will keep growing as the basis of all industries.

I don't believe that we will see the appearance of either substitutes of functional devices for semi-conductors or of circuits for electronics in the 1990s.

Table 1 Infomation Communications Business

11
Unit ¥10 ,Price in 1980

	1980		1990		2000		1990/1980	2000/1980	1990/1980	2000/1980
	Amount	%	Amount	%	Amount	%	factor	factor	Average annual growth	
(Electric communication)	22,6	4.07	63.2	8.00	131,1	12.40	2.8	5.8	10.8	9.2 %
(Electric communications business)	5,5	1.00	10,4	1.32	18,1	1.88	1,8	3.5	6.6	6.4
· A class electric communications business	4,0	0.73	6.9	0.88	11,8	1.12	1.7	2.9	5.5	5.5
· B class electric communications business	1,4	0.26	3,4	0.44	7.2	0.68	2.4	5.0	9.1	8.4
(Broadcasting business)	1,2	0.23	1,8	0.23	2.6	0.25	1.6	2.1	3.8	3.9
(Electric communications related business)	15,8	2.85	51.0	6.45	109,3	10.34	3.2	6.9	12.4	10.1
· Infomation communications equipment	13,6	2.46	45.2	5.72	88.9	8.35	3,3	7.3	12,7	10.4
· Cable and wire	1,4	0.25	2,0	0.25	2,9	0.28	1.4	2.1	3.6	3.8
· Electric communications construction	6	0.11	1,5	0.20	3,0	0.29	2.4	4.8	8.3	8,2
· Software	1	0.03	2.2	0.28	4.4	0.42	15.6	31.2	31.6	18.8
(Non-Electric communication)	23,6	4.26	34,0	4.31	39,3	3.72	1.4	1.7	3.7	2.6
· Mail service	8	0.15	9	0.12	1,0	0.10	1.1	1.3	1.2	1.2
· Newspaper	1,3	0.25	1,8	0.24	2,5	0.24	1.4	1.9	3,1	3.1
· Printing pubulishing	4,9	0.88	6,5	0.83	8,8	0.85	1.3	1.8	2.8	3.0
· Education	11,5	2.08	16,7	2.12	16,2	1.53	1.5	1.4	3.8	1.7
· Movie & Theatre	3	0.07	4	0.05	4	0.04	1.1	1.3	1.2	1.2
· Survey & Research	1,7	0.31	3,3	0.43	4,4	0.42	2,0	2.6	7.0	4.9
· Advertising	2,8	0.50	4,0	0.52	5,6	0.54	1.6	2,0	3.4	3,6
Infomation communication	46,2	8.33	97,3	12.30	170.5	16.12	2.1	3.7	7.7	6.7
Gross domestic product	555,0	100.00	790,9	100.00	1,057,0	100.00	1.4	1.9	3.6	3.3

Table 2 Development in Electronics and New Semiconductor Devices (1/3)

		Equipment System	New function New mechanism to be added	Necessary system circuit	New semiconductor to be needed
EXISTING EQUIPMENT	HOME USE EQUIPMENT	1 TV	Image processing Satellite broadcasting receiving	Memory Control A/D converter D/A converter	16 bit microprocessor 1M video RAM GaAs FET
		2 VCR	Random access Hi-fi	Memory Control A/D converter D/A converter	Digital processing LSI 1M video RAM High speed A/D converter IC
		3 Audio	Hi-fi Automatic performance Compact disk	Pulse code modulation type recording and playing memory	Microprocessor with tuning function FM DEMOS linear IC Laser diode
		4 Home appliance	Fully automatic washer Food temperature controlling electronic oven	Control system	One chip microprocessor

Table 2 Development in Electronics and New Semiconductor Devices (2/3)

		Equipment System	New function New mechanism to be added	Necessary system circuit	New semiconductor to be needed.
EXISTING EQUIPMENT	INDUSTRIAL USE EQUIPMENT	5. Personal computer Word processor	Communication Handwriting input Voice data input	Pattern recognition circuit High speed signal processing	32 bit microprocessor 1M bit video RAM 4M RAM
		6. Computer, peripheral & terminal	Pattern recognition Wireless Communication	Multi-processor High speed More memory capacity	1 MDRAM ECL gate array
		7. Communications equipment	Multifunction telephone Wireless PBX	Voice input dialling Calculation by built-in personal computer	16 bit microprocessor 36 bit microprocessor High speed D/A converter IC
		8. Automobile	Engine control Drive. transmission control Dashboard control	Fuel injection control Ignition timing control anti-skid	ROM, Custom micro processor

Table 2 Development in Electronics and New Semiconductor Devices (3/3)

Equipment System		New function New mechanism to be added	Necessary system circuit	New semiconductor to be needed
NEW EQUIPMENT. NEW SYSTEM	9. Videotex	Sending and receiving of letter and graphic image by telephone network	Information input terminal High speed signal processing	32 bit microprocessor 1M video RAM Bipolar linear IC
	10. Home automation	Home security control Switching of home appliances by telephone	Memory control	Custom microprocessor EPROM
	11. Business information equipment for office use	Serial colour printer G4 facsimile	High speed signal processing memory	High speed random logic IC 1M DRAM
	12. High definition TV	High definition image with more than 1125 scanning lines	Digital circuit High speed signal processing	High frequency, high band width linear IC High speed digital signal processing LSI
	13. IC card	Memory of information Calculation	Memory Calculation	64K, 256K EEPROM EEPROM with built-in microprocessor
	14. Engineering workstation	Word processing Personal computer Communications.	Network system	32 bit micro processor 1M bit RAM High speed random logic IC

Fig. 1 Demographic Change

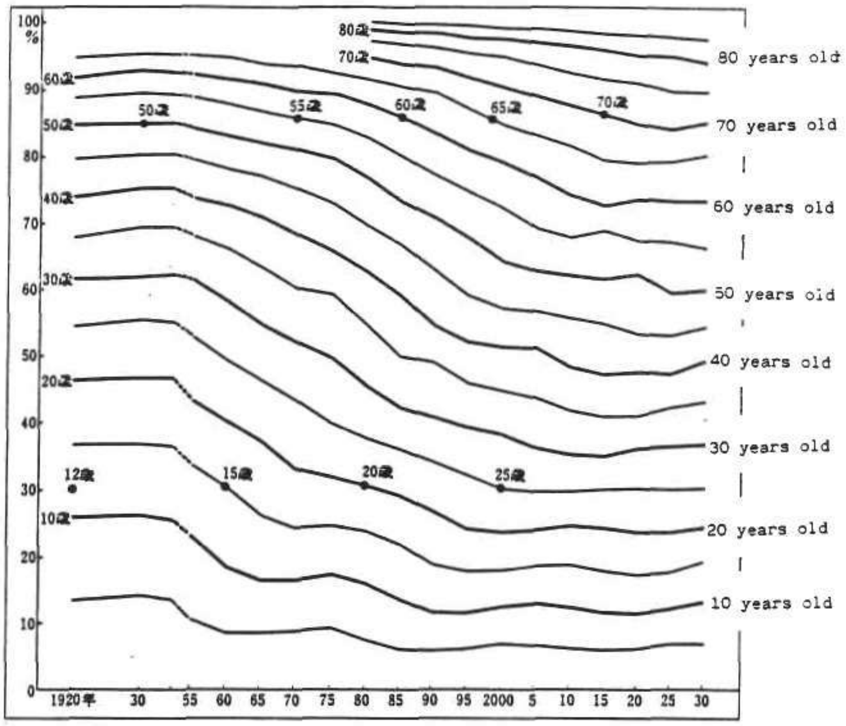
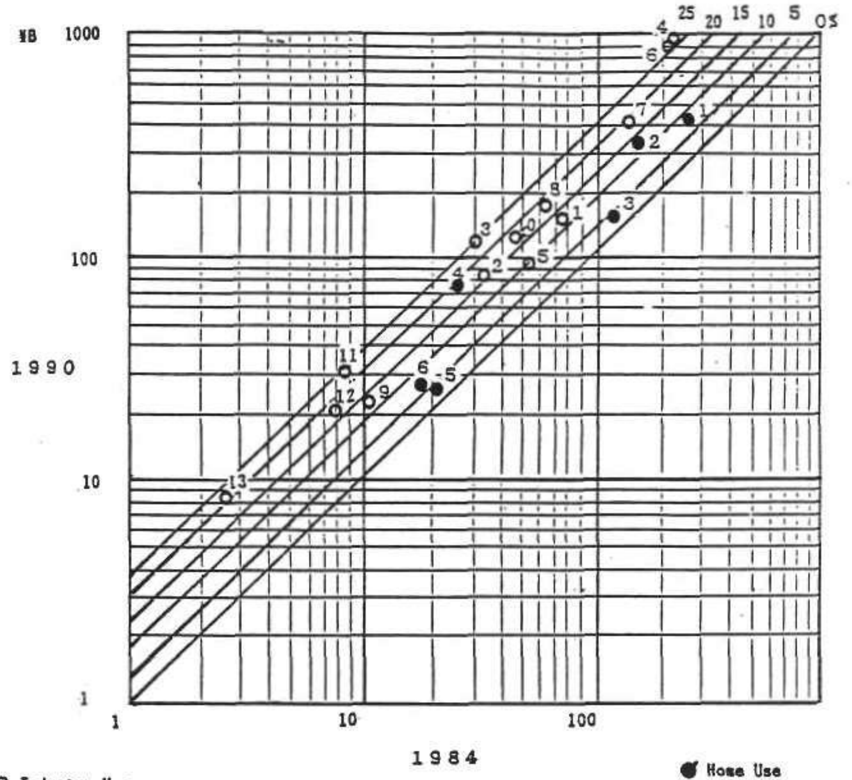


Fig. 2 Demand of semiconductors to be used in existing equipment for home and industrial use and its growth.



○ Industry Use

1. Business mamachine
2. Desk top calculater
3. Facsimile
4. Personal computer Word processor
5. Offics computer
6. Computer and peripherals
7. Communication equipment
8. Measuring and controlling
9. Medical equipment
10. Automobile
11. Robot and factory automation
12. Automatic vendor
13. Transceiver

● Home Use

1. VCR
2. Audio
3. TV
4. Home appliances
5. Camera
6. Electronic music instrument

Fig. 3 Electronic Equipment for home and Industrial Uses and Induced Demand of Semiconductors.

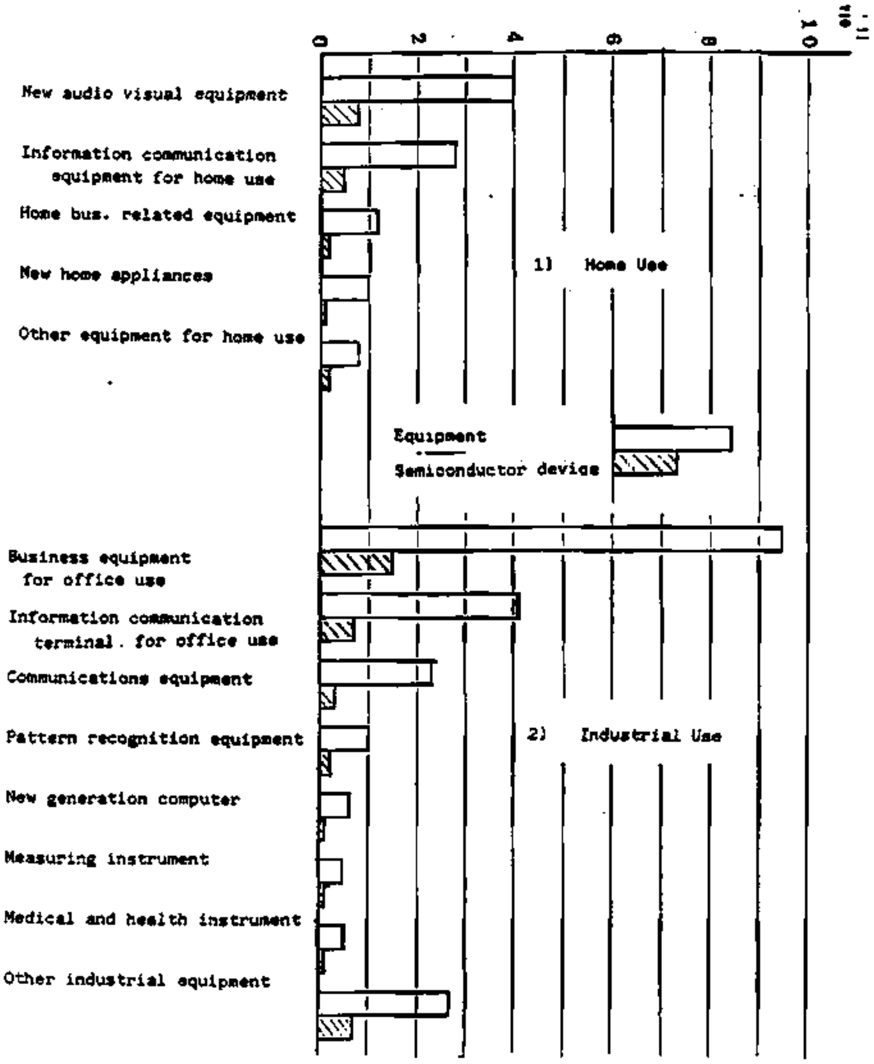


Fig. 4 Forecast of the demand for semiconductor devices in 1990

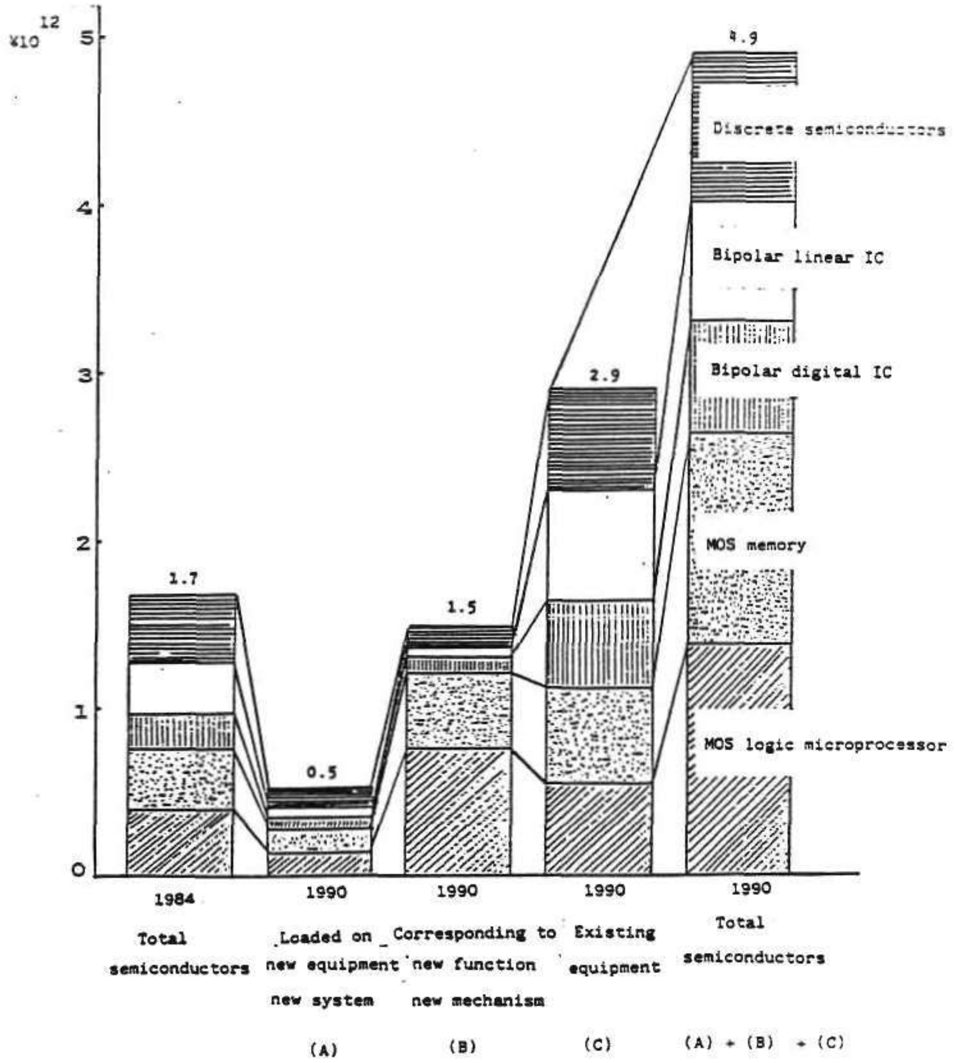
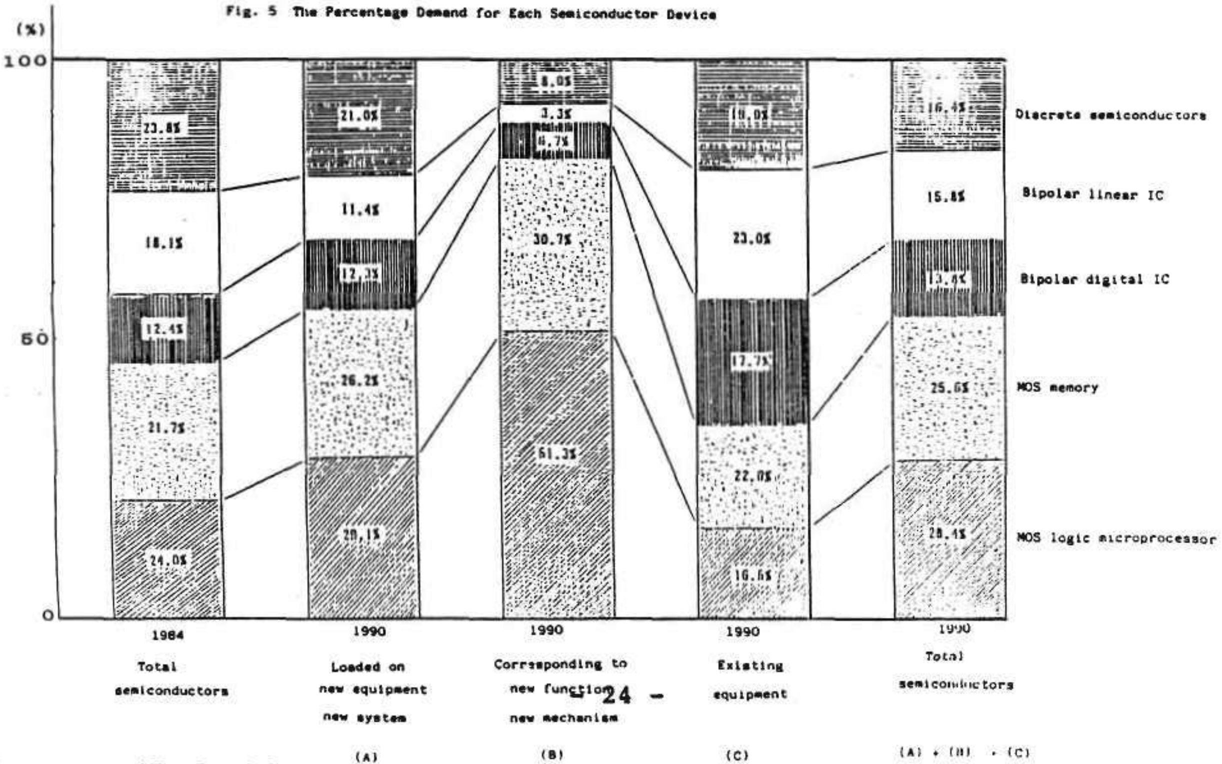


Fig. 5 The Percentage Demand for Each Semiconductor Device



１９９０年代の展望

三菱電機株式会社
電子デバイス事業本部長
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昭和６１年４月１５日

1. まえがき

１９９０年代というのは後４年弱で始まります。予測の期間としてはかなり難しい長さであります。１～２年先なら高い確率で良くなると言えるし，１０年先だと，かなり無責任なことが言えます。しかし４～５年というと夢と現実の間であり，予測は難しいものであります。

かなり大胆に主として半導体応用製品の展望をしてみたいと思います。

2. 社会の潮流

わが国のエレクトロニクスに大きな影響を及ぼす社会の潮流として，私は次の５つをあげたいと思います。

それは情報化，国際化，省力化，娯楽化，高齢化であります。それらがエレクトロニクスとどのようにかかわって行くであろうかを考えてみたいと存じます。

2.1 まず情報化であります。

街には若者を対象にした「日刊アルバイトニュース」とか「ぴあ」といった情報誌が数多く見受けられます。そして最近これらが電子化され「Ｂ－Box」 とか「チケットぴあ」のように変わりつつあります。印刷し，店頭に並んでいる間にも記載された情報が時々刻々古くなっていることを考慮すれば，このオンライン化は真に理にかなったものであるといえます。

今後，ますます多くの情報がこの例に倣って電子化されることでしょう。そして情報は使いやすくなり、社会の情報化が急速に進展するでしょう。

2.2 次に国際化について考えてみたいと思います。

今，日本では毎日米国のテレビ社会ＣＮＮの放映が行われております。またアメリカの新聞 USA TODAYも日本で印刷され販売されています。また逆に，ロンドンでは日本の朝日新聞が日本と同じように購読者の家庭に配達されています。

金融市場はロンドン，ニューヨーク，シドニー，東京、香港と２４時間休みなく動いています。

このような国際化は更に多くの国々で，更に多くの項目について進展するものと思われます。それにはエレクトロニクス，とりわけ人工衛星のような先端技術の役割がますます大きくなるでしょう。

今日は箱根に皆様方と親しくお会いしておりますが，１９９０年のこの会合はテレビ会議でそれぞれの国にいながら参加するということも不可能ではないと存じます。

2.3 第3番目に省力化であります。

わが国では戦後一家の子供の数が非常に少くなりました。戦前は人口が国の力の源泉と考えられ，「生めよ殖やせよ」といった政策がとられましたが，戦後は「少く生んで立派に育てよう」というふうに大きく変わりました。

その結果，高等教育への進学率が高くなり，若年技能労働者の数は激減しました。そこで工場にオートメーション装置を導入しました。ＮＣ工作機，トランスファマシン，マシニングセンタからついにロボットが採用されました。日本ではロボットは自分を助けてくれる有能な後輩が来たと，労働者から温く迎えられました。

ロボットに無人搬送車を組合せて，フレキシブルマニュファクチャリングシステム（ＦＭＳ）となりました。

一方加工ばかりでなく，設計の方面においてもコンピュータエイデッドデザイン（ＣＡＤ）が取り入れられ，設計のスピードアップと信頼性に大きな寄与をしました。

このようなファクトリーオートメーション（ＦＡ）は今後も更に多方面に普及して行く事でしょう。

2.4 第4番目に娯楽化について述べたいと思います。

私の年代の人間の少年時代には家庭内の娯楽でエレクトロニクスといえばラジオがあるだけでした。レコードも電蓄はなく，ゼンマイ式のものでエレクトロニクスとは無縁でした。われわれはコマをまわし，竹トンボを作って遊びました。

今は逆にエレクトロニクスでないものを探す方が難しい位です。ゲームウォッチ，ラジコン，ゲームセンター，ファミコン，トランシーバー，ステレオ，エレキギター，電子楽器，テレビ，ＶＴＲ，ＣＤ，ＶＤ，カラオケ等々枚挙に暇がありません。

チェス，将棋，碁のようなものまで電子化されて来ました。かって一世を風靡したインベーダーゲームのようにエレクトロニクスが生んだゲームも出てきました。

日本人に根強いファンが多いパチンコも最近はエレクトロニクス抜きにはなり立たなくなりました。

今後もますます多くの新しいエレクトロニクス娯楽が生まれ，われわれの生活をより豊かに，楽しいものにしてくれるでしょう。

2.5 最後に高齢化について考えたいと思います。

日本は今欧米の4倍の速度で高齢化社会に向って進んでおります。すなわち６５才以上の人が人口の8％を占めてから１８％に達するのに，欧米では１６０年かかったのを日本では４０年で到達しようとしているのです。

図1は厚生省人口問題研究所の 竹中一夫 氏 の人口階層別の年次推移でありま

す。昔は「人生５０年」といったものですが，１９２０年には５０才以上の人は人口の１５％しかいませんでした。今では２７％にもなり，２０００年には３５％にもなろうとしています。

ということは相対的に社会の中での若年層が少くなるということで，社会の活力が失われるおそれがあります。

エレクトロニクスの力で高齢者が，より活発に働けるようにすることが，社会の活力も衰えず誠に好都合であります。

高齢者は自分の健康に人一倍の注意を払います。医用電子技術はそれを可能にしつつあります。

高齢者は余暇時間も多く，趣味や娯楽に十分な時間がとれます。しかし移動には付添い人が必要になれば，自宅で電話で碁を打ったり，放送大学を見たりという方が便利になるでしょう。孫からファクシミリで手紙や絵をもらうのも大きな楽しみになることでしょう。

3. 産業の動向

3.1 １９９０年の半導体需要予測

第１表は経済同友会がまとめた「２１世紀への産業構造ビジョンを求めて」――先端技術の革新による産業社会の変貌――にある電通の後藤幹雄氏の「ニューメディア」についての論文からの引用であります。

マクロに見て，電気通信系の産業と非電気通信系産業の産出額を，１９８０年と２０００年で比較すれば前者が5.8倍に高成長するのに対し，後者は1.7倍とにしかなりません。

電気通信系産業の中では電気通信関連業が6.9倍，電気通信事業が3.5倍，放送事業が2.1倍と予測されています。

電気通信関連業の中ではソフトウェア業が31.2倍と最も大きな伸びを示しています。

3.2 半導体の需要とその伸び率

第２図は１９８４年に比して１９９０年に既存の民生用および産業用機器に使われる半導体の需要とその伸び率を示したものであります。これは㈳日本電子機械工業会の「高度エレクトロニクス社会と電子デバイスの新動向」（昭和６０年９月）を基に作成しました。

これを見ますと１９８４年より１９９０年の方が減るものはないことが分ります。しかしカメラやＴＶは５％以下の伸び率しかありません。ＶＴＲや電子楽器は５～10％の伸びであります。最も成長率が高いのは民生では家電の２０％となります。産業

用では相対的に民生よりは伸び率が高く，パソコン，ワープロ，電算機および周辺端末，ファクシミリ，ロボットのように２５%前後の伸びを示すものもあります。最も伸び率の低いオフコンでも１０%の伸びが期待されます。

3.3　１９９０年における新民生用および産業用機器の創出とそれによる半導体デバイスの需要

第３図も日本電子機械工業会（前出）のデータを基にして作られたものである。

最も大きな新製品はオフィス用事務機器で9,０００億円以上であって，そこには半導体デバイスも最も多く1,５００億円も使われます。

次いで新音響映像機器とオフィス用情報通信端末機器でいずれも約4,０００億円の市場であり，いずれも約８００億円の半導体デバイスを使います。

家庭用情報通信機器と，その他の産業用機器も市場は3,０００億円に満たないが半導体デバイスの使用量は多いのであります。

3.4　電子機器の進展と新しい半導体デバイス

次に電子機器の進展と新しい半導体製品についてみてみたいと思います。(第２表)

既存機器のうちテレビ，ＶＴＲ，音響，家電といった民生用機器は，より自動化，より高級化，より利便化するために新機能や新機構が付加され，そのために新たなシステムや回路が必要となり，新らしい半導体が用いられます。

パソコン，ワープロ，電算機と周辺端末，通信機器および自動車といった産業用機器についても同様であります。

また，ビデオデスク，ホームオートメーション，オフィス用情報事務機器，高品位テレビ，ＩＣカードおよびエンジニアリングワークステーションなどの新機器・新システムには高速ランダムロジックＩＣ，マイコン内蔵ＥＥＰＲＯＭなどの新らしい半導体が必要となります。

3.5　各電子デバイス需要金額推定

第４図に各電子デバイスの需要金額の推定を示します。各電子デバイスの需要の合計は１９８４年に1.７兆円だったものが，１９９０年4.９兆円へと2.９倍もの成長すると推定されます。

需要の4.９兆円の中でも既存機器は2.９兆円と約６割を占めます。新機能新機構に対応したものは1.５兆円と約３割，新機器，新システムに搭載されるものは約１割となっています。

3.6 各半導体デバイスの構成比

次に各電子デバイス別の需要構成比を見ますと，（第５図）最大の変化は１９８４年には全体の23.8%を占めていた個別半導体が，16.4%にまで減少することです。逆にモスロジックマイコンとモスメモリが１９８４年に24.0%と21.7%であったものが１９９０年にはそれぞれ28.4%と25.6%に増加します。

その主たる原因は１９９０年の新機能新機構対応の中でモスロジックマイコンとモスメモリがそれぞれ51.3%と30.7%という大きな比率を占めるからであります。

既存機器ではこれらの比率はモスロジックマイコンで1/3，モスメモリで2/3にすぎません。

4. 新しい電子装置とその応用

以上１９９０年代の巨視的レビューをしましたが，以下でいくつかの製品について詳しく述べたいと思います。

4.1 電子ファイル

私共の本社は丸の内にございますが，国鉄とか地下鉄が丸の内線，千代田線それに都営三田線が近いので交通は便利だし，近くに大手企業が多く取引上にも有利なのでこの地区に進出したいという企業さんが大変多いようです。当然需要と供給で家賃が決まりますので，家賃も上ってきます。

そこで一番困るのは書類の置き場が少ないことです。

いずれペーパーレス・オフィスになるにしても今すぐに全ての紙をなくすることは難しいから，せめて書棚に入れる紙だけでも電子ファイルに入れてはどうでしょうか。

部屋も広く使えて気持ちがいいし，探すのも早いから便利です。転勤とか転任の場合も，光ディスク一枚持って行けばよいようになるでしょう。

日本のように平地面積の少ない国では，真剣に考えるべき問題です。

ワードプロセッサが初め６３０万円だったものが，８年間で４万円に値下がりするという経験曲線をあてはめると，電子ファイルも将来家庭用電子商品になることも十分期待できると思います。

メモリーの媒体としても磁気ディスクよりは光メモリ，それもアドオン方式からイレーザブルになり，１枚のディスクが何回も使えるようになるでしょう。

１９９０年代には光メモリ以上の高密度記録媒体は出現せず，電子メモリなどは２０００年以降になるものと思われます。

4.2 電子セクレタリー

私が役員になりまして以来，私の一日の行動は全て私の秘書がアレンジしてくれます。今日は何時から何新聞の記者に会い，どうゆう話をしろとか，何時からどこで何々会社のお客様と昼食を食べろとか，何時には箱根へ行ってデータクエストで講演しろとか，全部のスケジュールを立ててくれます。

私の一日でありながら，自分の自由にスケジュールを組むことは出来ず，いちいち秘書にお伺いを立てなければ人と約束することも出来ません。

時には秘書と私はどっちが上司かと錯覚することもあります。

そこで腕時計の中にメモリーを入れておきそれを私でも秘書でも遠隔操作でき，スケジュールがつまっているかどうかが常に分かるようになっていれば便利だと考えることがあります。欲を言えば部下用の表示板とか，家内の献立表にも連動していると尚　便利だと思います。

4.3 パソコン会議

企業の多国籍化が進みますと，国際的な会議も多くなってきます。それも１０ケ国や２０ケ国にもなりますと，日程の調整や旅費・滞在費の捻出も容易ではありません。たとえメンバーが一堂に会しても時差のために眠い人や疲れた人がいては会議は機能しません。

パソコンが普及し，世界をつなぐ通信網も整備され，十分安く使えるようになり，多国籍企業間でメンバーが自分の国にいながらにして会議を開くことが出来ます。

議題をディスプレイで見て，自分の意見をタイプし，他人の意見に賛成意見，あるいは反対意見をタイプすればよい訳で，おそらくメンバー全員が一堂に会するスケジュールを調整している間に，パソコン会議の方は決議が終っていることでしょう。

事務局もいらず，議事録を作る手間も要らないでしょう。

4.4 テレビ会議

パソコン会議では相手の顔が見えないので物足りない人にはテレビ会議がいいでしょう。地球上どの地点からでも三つの人工衛星があれば，テレビ会議が出来ます。ある国は昼でも他の国は夜ということもあるでしょうが顔を見て親しく話しかけたり，図表や写真を見せあって説明するのも，より理解が得られることでしょう。

パソコン通信に比して，コストはかかり，誰かは眠いでしょうが，フェイスツーフェイスのコミュニケーションにはそれなりのメリットが十分期待出来るでしょう。

費用も帯域圧縮技術や電子化技術により，かなり低減出来るようになっています。

ただし，出張旅行の解放感や，メンバー同志がパーティで旧交を温めるといった楽

しみはなくなるでしょう。

4.5 在宅勤務

かつて産業革命以前には家内工業が主であったため，工業労働者も自宅または自宅の近くで働いていました。その後産業革命が起こり工場労働者が多くなり，それが益々大規模化するに伴って，工場と自宅の距離は次第に遠く離れてゆきました。

今，東京では片道１時間以内で通勤できる人は同僚から羨望の目で見られます。１時間半，中には２時間以上もかけて通う人も稀ではありません。彼は会社に来る前に疲れており，家に帰っても寝るだけの非人間的生活をしているに違いありません。

かつてアルビン・トフラーはその著「第三の波」の中で“エレクトロニック・コッテージ”なる概念を提唱しました。

これは何も都会に住まなくても，十分電子機器を備えていれば，山小屋でも仕事が出来るということを紹介したものです。

イギリスのエフ・インターナショナルというソフトウェアハウスでは，８５０人の社員のうち７５０人のプログラマーが自宅で主に働いています。

日本でも約４０社で在宅勤務が採用されています。今年から女性の雇用平等法が施行され女性の就業者も増え，結婚後も仕事を続ける人が多くなると考えられます。

わが国では保育園のような社会的インフラストラクチャーが完備されていないため，有能な女性でも出産後は育児のために退職せざるを得ないことが多いのが現状です。

在宅勤務制度が広く普及しますと，夫婦のいずれか，あるいは双方が自宅で働くことが出来，高等教育を受けた女性が，より長期間働くことが出来，人的資源の浪費が防げるようになるでしょう。

また，双方共在宅勤務出来るようになれば何も大都会の近くに住まなくても，地方で自然環境のよいところで広い家に住むことが出来，余暇時間も増え，充実した人生を送れるのではないでしょうか。

これは雇用制度さえ変えられたならば，エレクトロニクス的には十分可能であります。

4.6 人工知能

原子炉や航空機のような非常に安全性を要求されるものについては運転員に数多くの安全対策を教え，訓練を実施しています。

ところが１０年に１回経験するかどうかといった異常事態が発生すると気が動転してしまい，正常な判断を誤まり，かえって異常を大きくするような操作をしてしまうことがあります。

このような場合には感情を持たない，エレクトロニクスの方が正しい判断が出来ます。ただし，判断要素が多いため，そのロジックをコンピュータに教えるのが厄介です。

人工知能，特にエキスパートは熟練者と同じ判断を感情抜きで冷静にやってくれます。症状から薬を選んだり，車の音から故障個所を指摘するといったことが出来るようになりました。

今後，この分野は更に高度な判断機能を持ち隕石を敵機と間違えて第三次世界大戦を起こしたりすることがないシステムが出来ることでしょう。

4.7 自動翻訳機

わが国は年間３５億冊の本が売れる，世界でも有数の読書愛好国です。国民の知的好奇心は旺盛で，世界中のほとんど全ての言語で書かれた本が翻訳して出版されます。翻訳も熟練した人が手分けして行うため，時には原書よりも翻訳書が先に出版されるといった椿事が発生します。

近年ビジネスの国際化に伴い，国際入札の仕様書とか取扱説明書といった書類の翻訳が莫大になり，時間的にもコスト的にも改善をせまられるようになってきました。

そこで自動翻訳の可能性が早くから検討されてきました。最近ようやく日本語と英語に限ればかなり高度な翻訳をかなり安価に実行できるようになってきました。文学作品以外の実用文書ならば翻訳機で訳しても意が通ずるという日も近いでしょう。

ところが自動通訳機はそうは問屋が卸しません。不特定話者の発言を認識することの困難さから，その実現は２１世紀に入ってからと予測されております。

4.8 自動読書機

現在，目の不自由な人は本を読みたい場合には点字にしてもらって自分で読むか，晴眼者に読んで聞かせてもらうしかありません。いずれの場合もボランティアに依頼するので，あまり無理は言えません。

現在の光学的文字読取（ＯＣＲ）はアルファベットや数字に関してはかなり信頼性が高くなっています。これを漢字にまで引上げられれば，日本語の本が読めるようになります。これは盲人ばかりでなく，高齢者で老眼の人や，車を運転中の人などに有難い装置であるに違いありません。

欲を言えば読み手の声の質を選べると面白いだろう。宮本武蔵 を 故 徳川夢声 氏の声で読んだり，赤毛のアン を 中村メイ子さんの声で読んだり出来れば聞きごたえがあるでしょう。

4.9　ＩＣカード

現金に代わる安全で便利なものとしてクレジットカードの普及は目覚ましいものがあります。ところが最近事故も多くなり，磁気ストライプ方式のクレジットカードのセキュリティに大きな疑問が呈されてきました。

磁気カードに代わるものとしてＩＣカードが有力視されています。これはメモリー容量がクレジットカードに比して２桁以上も大きくできるのでより複雑な暗号を採用することができ，偽造するのも実際上不可能といってよいと思われます。

このＩＣカードは現在のクレジットカードのような商取引に使われるばかりでなく，身分証明や，病歴カルテ，ゲームのソフト，ワードプロセッサのメモリー，ロボットの作業指示票など無限の応用分野を持っております。今一番のネックはコストであります。おそらく１９９０年にはコストも下がり，多くの分野で採用が実現していることでしょう。

4.10 ロボット

熟練工が高齢化して、現場作業が困難になり、若年労働者が減少して熟練工の後継者がいなくなった現在、工場へのロボットの進出は当然の勢いであります。

従来のロボットは、あらかじめプログラムされた工程を忠実に正確に実行するものでした。

1990年代のロボットは知能ロボットになるでしょう。このロボットは目または触覚などのセンサーを持ち、それで認識した情報からどういう動作をすべきかをロボット自身が判断する人工頭脳を備えています。

人間が入れない原子力発電所の放射能の高い所へいって点検をしたり、補修をすることも出来るでしょう。深海底のような潜水夫も潜れない高圧下でも資源探索や採集のような作業が可能でしょう。

地震や火災の場合に人命救助に活躍することも期待出来ます。

このような高度な知能をもったロボットにはかなり高性能なコンピュータが装備されることは言うまでもありません。

5.　むすび

以上見てまいりましたように，半導体ビジネスはまだまだやるべきことが多くあり，産業の基本として今後も大きく伸びるものと思われます。

半導体に代わる機能素子とか、エレクトロニクスに代わる回路が出てくるとは思えません。

以　上

Dataquest
a company of
The Dun & Bradstreet Corporation

STATUS AND FUTURE--CHINA SEMICONDUCTOR INDUSTRY

Zhang Kai
Vice President
China National Electronic Devices Corporation

MR. KAI'S BIOGRAPHY AND SPEECH WERE NOT AVAILABLE IN TIME FOR PUBLICATION

1958 – Chou En Lai; 12 yr. Science & tech. plan. ICs targeted.

1956 – 1st IC produced at Science Academy of Science

1960 – tough times.

1963 – 4th Ministry formed. IC development ~~pag~~ promoted.

1965 –

1966 –

1968-1978 ~~Re~~ Cultural Revolution

- 450 semi plants – 20 provinces, mostly along coast in major cities.
- 1985 – 200K employees; 45 in IC develop.; 68% in discrete
- Since 1978 – Promoting ICs.
- 1985 – 1.0 Billion pieces (2.5 x 1976).
- 17,000 types of ICs; 1000 new types
- 2.798 Billion units

Dataquest Incorporated
JAPANESE SEMICONDUCTOR INDUSTRY CONFERENCE
April 13-15, 1986
Hakone, Japan

1290 Ridder Park Drive, San Jose, CA 95131-2398, (408) 971-9000 Telex 171973

Discretes

- 386 plants; 10 research insts
- 6.4% are engineers
- Types: microwave
  s/c sensors
  power transistors

diodes
transistors
opto
} most meet int'l stds.

ICs (began 1966)

- 1970-73 Product improvement plan
- 41 IC plants
- 4 major universities doing research
- Types:
  - Bipolar
  - TTL med.
  - STTL
  - HTTL
  - LSTTL
  - DCL
  - HDTL
- MOS
  - CMOS logic
  - PMOS
  - 4-bit & 8-bit MPUs
- Linear
  - TTL, ECL, CMOS interface
  - Linear amplifiers
- Consumers – TV, watches, audio
- 4-5 µm LSI. Working on 3µm.
- Finished with 16K DRAM & SRAMs.
- 600 IC products meet nat'l stds.

STATUS AND OUTLOOK OF CHINA'S SEMICONDUCTOR INDUSTRY

Speech given by
Mr. Wang Zheng Hau, Chief Engineer
China National Electronic Devices Corporation
at Dataquest's Annual
Japanese Semiconductor Industry Conference
April 13-15, 1986

Ever since the invention of the transistor, China has been keenly aware of the revolutionary changes it would bring. In the "12-year Technology Development Guidelines" promulgated by the late premier Chou En-Lai in 1956, the development of semiconductor technology was cited as an area of national emphasis. This laid the ground work for semiconductor research work. The industry had thus begun.

The year 1956 saw the birth of the first transistor in the Applied Physics Research Lab of the China State Institute of Science and Technology. By 1958, China was producing seven different semiconductor devices with a total annual output of 60K units. In 1963, the 4th Machinery Division was formed in the State Council. It proceeded to establish an objective of eliminating vacuum tubes in its radio designs and of assimilating overseas semiconductor expertise. At the same time, semiconductor devices began to find their way into more and more application areas. China designed its first IC in 1965. Mass production ensued and the structure of the industry began to take shape.

At this point, I would like to give you an overview of the status of the industry, its current production technology and the future outlook.

1. General Status of the Semiconductor Industry

China currently has more than 450 semiconductor plants situated in 28 provinces, municipalities, and autonomous regions. Most of the facilities are concentrated in the coastal areas; in particular in the coastal open cities. The basic infrastructure of the industry is well formed.

The 1985 employment was over 200,000 of which about 160,000 was engaged in the discrete sector and 40,000 in ICs.

The industry has steadily grown and improved since 1977. The 1985 production of discrete devices exceeded 1 billion units (three times the 1976 volume). Similarly, the 1985 IC production grew to 50 million units (2.5 times the 1976 volume). In 1985, there were over 1700 different parts in production, while over 1000 other parts were in various stages of development. The gross output value of the industry reached 2.8 billion Yuans (RMB). The economic benefits to the nation that result from the semiconductor industry are substantial.

2. State of the Production Technology

In the discrete area, China has 386 plants and over ten R & D labs. Engineers and technicians comprise 6.4 percent of total employment. Product lines include microwave devices, opto-electronic devices, power transistors, general purpose transistors, etc. The product quality is constantly improving. Most products are now produced under internationally accepted quality standards. Since 1978, 5 products were awarded the State Gold Medal and 17 products received the State Silver Medal award.

In integrated circuits the production volume has grown tremendously since the first devices were made in 1966. The early years were plagued by low yields and reliability problems. Therefore, we implemented a quality improvement program in the period 1970-1973. In addition, production capacity was expanded in the late seventies. Currently we have 21 dedicated IC plants, 20 non-dedicated plants, and over 40 R & D facilities in various universities and technical colleges.

IC product lines include the following 6 categories:

- Digital bipolar
  - TTL, S-TTL, LS-TTL, ECL, and HTL
- MOS
  - PMOS logic, CMOS logic, various MOS memories, 4-bit and 8-bit microprocessors
- Interface circuits
  - TTL, ECL, and CMOS
- Linear
  - Op Amps, voltage regulators, and various linear amplifier circuits
- Consumer
  - Circuits for TV, stereos, clocks, and watches
- Custom circuits
  - Applications include microwave, appliance, instrumentation, and automotive

In process technology, there has been a series of technological advances in recent years. Our clean rooms are equipped with the necessary equipment for high-volume production of 5-7 micron geometries. In addition, 3 micron processors have been developed in the labs. We have successfully introduced and qualified the 16K DRAMs and 16K SRAMs. Of the thousand new products being developed, 600 comply with international (IEC) standards. We are currently designing the first family of VLSI circuits as well as GaAs, opto ICs and microwave ICs.

We are adopting foreign technology and equipment where appropriate in the interest of accelerating our capability for self-reliance. A good example is the Jiang Nan Radio Components Factory, where design capability already exists in its linear IC line. In 1984, it acquired from abroad an IC fab production line as well as process techniques for power transistors and other discrete devices. Such infusion of know-how and equipment from abroad, when put to proper use, provides substantal technological and economic benefits.

3. Future Outlook of the Industry

The experience and success achieved by the industry up to this point will provide a strong foundation for future expansion. The market for semiconductor devices will continue its heady growth. While the consumer segment of the industry is maturing and being saturated, the industrial equipment segment holds huge potential. Moreover, as more application areas are penetrated, semiconductors will proliferate. Accordingly, we expect China's semiconductor industry to grow at a fast pace.

The task at hand for China's electronic industry is to reform and revitalize in order to grow and prosper. Our mission is to catch the technological revolution and execute the Four Modernizations in order to improve the national economy and the standard of living.

To achieve the above goals, we put the highest priority on building a vital economic structure, establishing proper strategies and tactics, and accelerating the development of our semiconductor industry. We will strive for progress at the fastest feasible speed, with the help of foreign technology where appropriate. Consistent with the spirit of developing the eastern areas of the country, we will focus on supporting the leading medium and large sized companies which constitute the driving force of the industry. We will make quality products and cultivate brand recognition. Our product reliability and quality levels must reach those achieved by advanced countries in the late 70s and early 80s. Moreover, we will establish a goal of increasing our future export of semiconductors.

To sum up, we look forward to an exciting period of fast, healthy growth of the Chinese semiconductor industry. It will assume an increasing role in the modernization of China.

- R&D Activities
  - GaAs high-speed & microwave
  - CMOS ICs

* Introducing foreign -
- Linear plant - Jianan province. 1984 - power transistor production.
- Econ. Develop. districts - eastern division. IC plants, esp. med-size firms.

- 1985 - 15 MU in production

THE ASIA-PACIFIC ELECTRONICS INDUSTRY--AN INDUSTRY IN TRANSITION

C.D. Tam
Vice President and General Manager
Asia/Pacific Semiconductor Products Division
Motorola Incorporated

Mr. Tam is Vice President and General Manager for the Asia/Pacific Semiconductor Products Division of Motorola Incorporated. Prior to joining Motorola, he spent 17 years in the semiconductor industry in engineering, sales and marketing, and product operations. Previously he worked as a teacher and electronic circuit designer. Mr. Tam received a Bachelor of Science degree with honors from Hong Kong University.

Dataquest Incorporated
JAPANESE SEMICONDUCTOR INDUSTRY CONFERENCE
April 13-15, 1986
Hakone, Japan

11/85 Production (WSTS)

- US 34.1%
- Asia 45.7%
- Europe 20.2%

.. Four Tigers (HK, Singapore, Taiwan, So. Korea)

- ~~4%~~ 40% of Japan
- Strong link to US end use mkt
- 80% of Asia-Pacific production
- Overtake Europe by 1993
- Yen appreciation → accelerate Asian IC growth

. End Use

Home elec.	44% of consumption
PC/peri.	20%
Telecom	17%
Computers	10%

. Rapid shift of A/P mkt

	1980		1986
Home	89%	→	44%
Computers	3.5%		10%

. 1980's

- Yen appreciation
- US offshore mfg → more design & automation

. Hong Kong

* Short-Cut Strategies

- Induce Chinese & Koreans to return home (Raiding)
- License technology from US & Japan
- Establish R&D & pilot lines in Silicon Valley
- More training of Asian engineers in parent cos.

Silicon Power into hands of engineers

32-bit MPUs
DSP
Bipolar ICs
MOS ASICs
→ powerful CAD tools

- Moto – $5 designs (A/P + Australia)

2 plant types → focus factory (commodity ICs)
2 plant types → "mkt support" ~~Compact~~ factory (ASICs)

Best of East + West

East	West
· Attention to detail	Technology innovation
· Productivity	Assertiveness
· Long-range, strategic thinking	Flexibility

* Tam toured top 10 IC plants.

× 21st Century – "Century of the Pacific"

THIS PRESENTATION WAS NOT AVAILABLE
IN TIME FOR PUBLICATION

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TECHNOLOGICAL CHALLENGE: THE CASE OF AUTOMOTIVE ELECTRONICS IN JAPAN

Masao Murayama
Executive Managing Director
General Manager, Automobile Electronics Group
Nippondenso Company Limited

Mr. Murayama is Executive Managing Director and General Manager of the Automobile Electronics Group of Nippondenso Company Limited. He is responsible for all automotive electronic product operations, including semiconductor devices. He started his career as a production engineer at Nippondenso's Production Technology Development Center, and served more than ten years at various key positions in the company's IC Department. Mr. Murayama has enhanced in-house capability for the development and production of custom integrated circuits for automobile electronics.

$450M revenue
- 70% ICs to Toyota
- Rest to Japanese + foreign (except Nissan)

Dataquest Incorporated
JAPANESE SEMICONDUCTOR INDUSTRY CONFERENCE
April 13-15, 1986
Hakone, Japan

THE TECHNOLOGICAL CHALLENGE :

- THE CASE OF AUTOMOTIVE ELECTRONICS IN JAPAN

I. HISTORICAL OVERVIEW OF AUTOMOTIVE ELECTRONICS IN JAPAN

Electronics made its debut in 1962 in the automotive field as rectifiers used in alternators. The first systems were assembled with discrete components. Thereafter, extensive innovation began in electronics based upon integrated circuit technology. Bipolar analog ICs were first applied in automobile radios and cruise controls on selected models in order to gain field experience and to confirm their capability. Next, more complicated systems were developed and improved, such as electronic fuel injection and skid controls which are now typical automotive applications. In 1973 the first digital ICs were employed in a condition monitoring system and in digital clocks. It follows that the continued rapid progress in automotive electronics, paralleled with the electronics industry as a whole, has led to the development of large scale CPU applications. This kind of Progress has been driven by the challenge to develope new electronic engine controls in order to meet exhaust gas emission regulations and to improve fuel economy since the oil shocks. As you are well aware, large scale CPU applications have recently expanded to electronic displays and suspension control systems. (Fig. 2)

It may be said that the history of automotive electronics is the transition from discrete devices to CPU applications. Of course, even now the expansion of automotive electronics is supported by small-scale electronic control units, comprised of discrete devices, analog ICs and digital ICs.

Other important factors in describing the development of automotive electronics are the changes in functions and device technology. (Fig. 3)

For example, the use of a simple, single-function unit like the door lock controller at an earlier stage led to the development in complex-function controllers, such as the fully automatic air conditioning system in which the interior air temperature is automatically maintained and the air flow is controlled in conjunction with exterior and interior sensors. Another example of recent developments is a more complicated multi-function system controller, such as the advanced electronic engine control system in which not only fuel injection can be controlled but also other functions such as idling speed and ignition timing angle as well.

Another perspective in this discussion is that of the evolution in device technology. Small ECUs composed of several discrete devices were supplanted by analog ICs mounted on one circuit board. This development reduced the number of devices and increased the scale of the circuit. The next step in circuit configuration development was the introduction of hybrid ICs which made possible custom applications and miniaturization. Continued development produced customized digital ICs with greater software adaptability and improved redundancy. In the next step it follows that system controllers, refered to as ECUs using CPUs were developed in 1979.

II. PROGRESS IN AUTOMOTIVE ELECTRONICS : AN EXAMPLE OF FUEL INJECTION SYSTEM

To illustrate the development of automotive electronics, I wish to discuss the example of a fuel injection system.

First developed by Robert Bosch of West Germany, the electronic fuel injection has been replacing the carburettor which vaporizes gasoline and feeds it to the cylinder. The system utilizes a mechanism in which a precise amount of highly pressurized gasoline is supplied to the cylinder through a nozzle. Automakers throughout the world agree that advanced fuel injection systems have helped meet the simultaneous challenges of meeting emission control regulations and improving fuel economy in response to the oil shocks of the 1970's.

These innovative systems are not based on a single ECU but on various complex systems consisting of a fuel pump, injection nozzles, valves, an air flow sensor, an oxygen sensor, an engine coolant temperature sensor, a pressure sensor, an after-burner using a three-stage catalyst, a canister and other components being used together with an electronic ignition system called an ignitor.

Electronic fuel injection and ignition systems are at the forefront of automotive technology. Vehicles equipped with electronic fuel injection accounted for 40% of the total production in Japan last year, excluding vehicles under 1000cc. It is predicted that the figure will reach 70% in about five years. (Fig. 4)

Since 1981, this system has been called the "Engine Control System", not simply "Electronic Fuel Injection", because related functions have been incorporated into the system. These additional functions are air-fuel feedback, advanced angle ignition timing control, idling speed control, diagnosis, transmission control, fail-safe functions, EGR, and knock control. (Fig. 5)

Meanwhile, analog IC ECUs have been replaced by multi-chip 8-bit microcomputers. These multi-chip 8-bit microcomputers have made possible ECUs with greatly expanded functions and reduced size. In turn, the multi-chip 8-bit microcomputer lately is being supplanted by the single-chip 8-bit customized CPU which offers expanded capability and reduced size. These refinements have reduced the number of components, thus attaining higher reliability.

Figure 6 shows the relationship between ECU size and ECU function over time. As you can clearly see, greater circuit densities have made possible miniaturization while engine control functions have increased. Good design has overcome the earlier problem of size increasing with increased functions.

Figure 7 compares Engine Control ECUs from 1983 and 1985 by function, the number of LSIs and cost. Each ECU photograph is also shown for your comparison.

For a clearer comparison of the two ECUs, Figures 8 shows their configuration by block diagram. Excluding the backups and voltage regulators, the 1983 model has five circuit blocks while the 1985 model has two - a one chip 8-bit CPU and an AD converter. (The 4-bit CPU was added for another purpose.)

I think that the development process of ECUs for automotive electronics has been made clear. Next, I would like to show the technological evolution of the largest LSIs used in ECUs.

Figure 9 below shows LSI evolution until the year 2,000. The solid line indicates that DRAM density, which is often referred to as estimating memory capability, will reach 300 megabite DRAM by 2,000. Although it is difficult to compare CPUs with DRAMs, we can predict CPU development will fall behind DRAM technology assuming that the technology of ROM and RAM of the CPU is the criterion for comparison. Custom CPUs developed in 1981 and 1985 are shown on the graph by circle marks. As shown on the graph, CPU technology will fall about two years behind DRAM progress. Based on this trend, I might say, the most advanced CPUs will have functional capability corresponding to one megabite DRAM by 1988.

These findings seem to indicate two main factors in LSI development for automotive applications:

1) Progress in LSIs for automotive application is closely related to DRAM technological progress
2) About two years has been required to adapt leading-edge DRAM technology in order to meet the severe demands of the automotive operating environment and the need for high reliability.

It should be noted, however, that more than 256K of ROM memory will be necessary to meet the needs of CPUs for information-related systmes anticipated around 1988, which implies that adoption of several chips may become inevitable. Before long we must think of a way to solve the problems inherent in multi-chip CPUs.

III. THE FUTURE TRENDS OF AUTOMOTIVE ELECTRONICS

I have briefly explained about automotive electronics progress, as it refers to how the electronic fuel engine system has changed to the electronic engine control system. The same can be said with electronic display instrument clusters for automobiles, in which flourescent display tubes and liquid crystal display devices have been increasingly employed on newer cars. Today electronic display panels are not necessarily one of the appealing points of new cars equipped with them. In fact, car users regard it as only one feature for car model variations.

We admit, however, that the electronic circuit of an electronic display instrument is a relatively large-scale circuit configuration and so its development is one of the challenging tasks within severe size/volume limitations and with design change flexibility considerations.

When we consider the areas that have future promise in automotive electronics, it can be discussed in two categories, namely, Driving Control Systems and Information-related Systems. (Fig. 10)

Firstly, the Electronic Driving Control System can also be described as "Wheel-related Driving Control", which includes suspension and steering wheel control, anti-skid control, traction control, 4-wheel drive control and cruise control. These electronic controls have recently attracted wide attention and it is anticipated that they will be refined using new technology, become more in demand and be equipped on many future automobiles.

The Information-related Systems will be sophisticated new information systems with increased capability using CRT displays. These systems include a Diagnosis System which can deal with more useful information including warning signals and a Navigation System with route-guidance function, and more advanced car communication systems, an example of which is a car telephone now in existence.

The future image of automotive electronics, as often discussed, will be a fully automated driving system, but, I would say, it is still a thing of the future .

A topic of concern and often discussed is how many semiconductor devices will be used in a car with the growing popularity in automotive electronics. The fact is, there are no definite agreements of opinions due to the technical innovation and uncertainty of future automotive electronics. One of the forecast in this connection with this is given in Figure 11 which shows the number of semiconductor devices that have been used and will be used in one high-class car.

When the various topics about cars are discussed, many people enjoy talking with their own dreamful expectation. I feel the same is true with automotive electronics. In actuality, however, based on our experience of the practicality of automotive electronics, it is necessary for us to challenge and overcome the difficult tasks of developing new innovative products in order to meet the severe automotive requirements. I would like to discuss this in the next paragraph.

IV. THE PURSUIT OF UPGRADING LSIS FOR AUTOMOTIVE ELECTRONICS

Figure 12 shows the requirements for LSIs and other components of automotive ECUs.

Most important is the use of highly reliably LSIs. Now discrete devices and ICs of SSI- and MSI-class have greatly improved in reliability. In comparison with these, I might say, there is necessity for improvement in reliability of automotive LSIs and hybrid devices with monolithic ICs incorporated.

As shown in the illustration, environmental conditions of electronic components mounted in a car are generally severe in terms of absolute value and furthermore changeable, to a considerably extent, according to the wide mobility of cars. Additionally these components must be able to withstand increased severeness of mechanical and electrical shocks, requiring us to make them more durable and reliable. In particular, I think, one of the most important tasks we must continue to challenge is how to make complete bug-free LSIs.

Other aspects of automotive requirements are reasonable costs and flexibility of design change and responsiveness to shorter lead time production. Flexibility means that it is important for us to be able to cope with the various types of cars and model variations, while minimizing the types of LSIs utilized.

In that sense I would like to mention one of our proposed ideas which could satisfy these requirements.

First, it is desirable, in my opinion, to employ one-chip LSI configuration, if possible technically, while satisfying high environmental resistivity and reasonable cost. For higher flexibility, it would become necessary to prepare EPROM or E^2PROM versions of key LSIs of the same function so as to meet possible specification changes. (Fig. 13)

Next, the circle-shaped illustration shows the concept of the combined capability of each function of new LSIs that will be necessary on emerging electronic systems stated earlier. One of our proposals is a 1-chip LSI incorporating 8 or 16 bit CPU, 16 to 32 bytes ROM and 256 to 512 words RAM together with AD converter and timer therein. At the same time the EPROM or E^2PROM versions of the LSI should be available and hopefully the functions of diagnosis and back-up are additionally incorporated in the LSI.

To realize this LSI, it would be necessary to develop a new C-MOS LSI with a chip size being 5 - 6 mm by 5 - 6 mm square, while incorporating required function circuits therein as well as meeting the automotive operating conditions. (Fig. 14).

It must be noted, however, that an assumption of the development time of this new LSI will come around 1991 three years behind as a next-generation CPU of the 1988 version, which is inconsistent with the technological trend of estimated DRAM density progress.

Figure 15 shows the forecast of minimum pattern size and chip size in accordance with DRAM density progress. Typical automotive custom CPUs, when rated on the graph by plotting at the level of corresponding technology, imply that up to the year 1985, the CPUs have been available about two years behind the general technological trend.

However, if we draw a limit line of restricting chip size up to 5 - 6 mm square by reasons previously stated, it becomes obvious that the progress of automotive CPUs tends to fall outside the general trend zone of chip size. In addition, if we put a limit line of operating voltage equal to pattern size of 0.8 μ, under which it is supposedly difficult for LSIs to be resistant to electrical noise involved in automotive electronics, it can be predicted that future automotive LSIs will be made outside the general trend zone of estimated pattern size innovation.

My idea of this technical prospect means that the future trend of automotive LSI technology, as a whole, will be apart from the general LSI technology trend embodied in DRAM as referred to the most advanced device.

As time goes on, such difference in technological orientation will become larger, thus requiring us to pursue our own technological approach for future automotive electronics.

[REFERENCE]

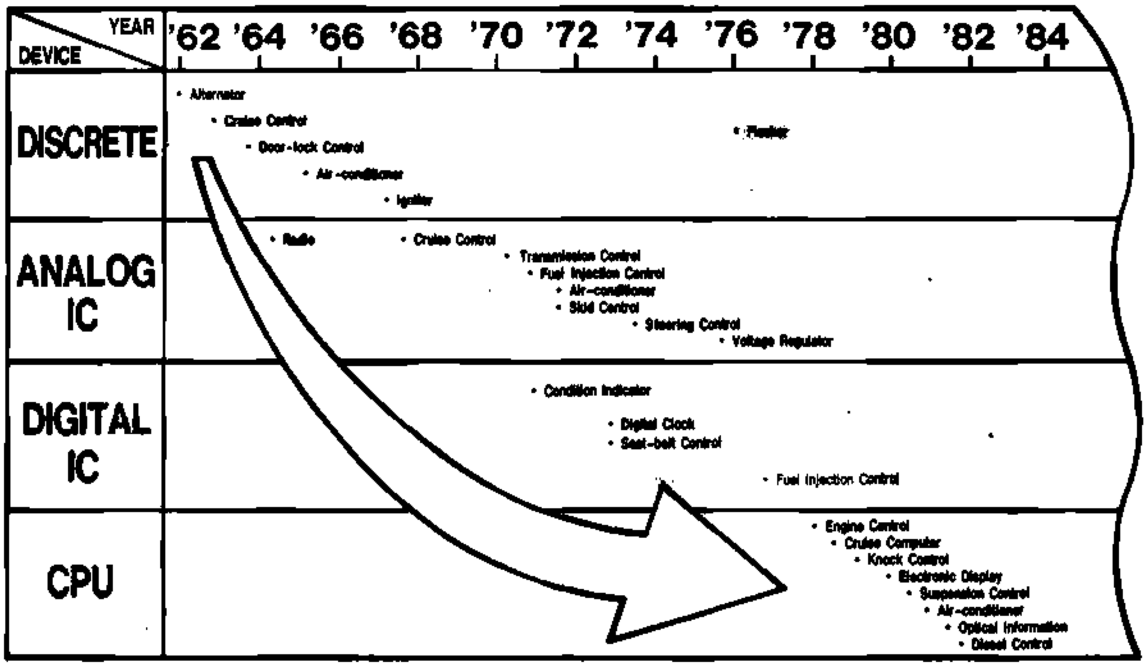
T. Kawamura, et al., "Toyota's New Single-chip Microcomputer Based Engine and Transmission Control System"
SAE 850289 FEB. 1985

TECHNOLOGICAL CHALLENGE: THE CASE OF AUTOMOTIVE ELECTRONICS IN JAPAN

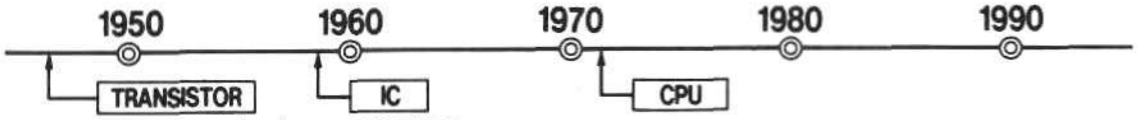
— APRIL 15, 1986 —

MASAO MURAYAMA
NIPPONDENSO CO.,LTD.

HISTORICAL OVERVIEW IN JAPAN



TECHNOLOGICAL TREND IN AUTOMOTIVE ELECTRONICS



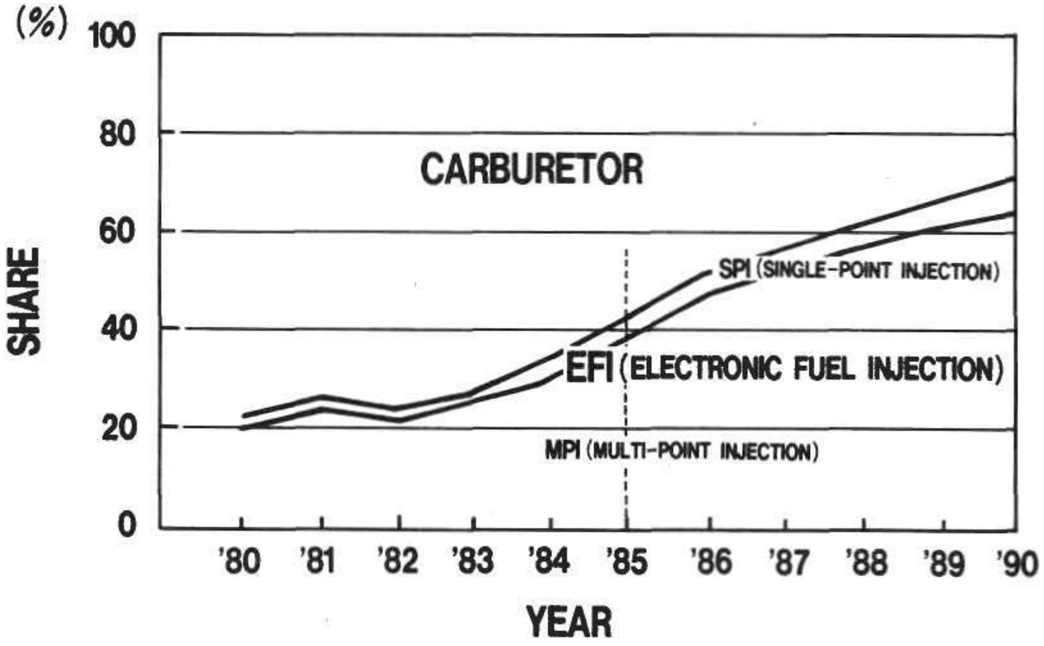
PERSPECTIVE (I) : FUNCTION

SINGLE-FUNCTION UNIT
→ COMPLEX FUNCTION CONTROLLER
→ SYSTEM CONTROLLER (CPU)

PERSPECTIVE (II) : DEVICE

DISCRETE PARTS
→ ANALOG MONOLITHIC IC
→ ANALOG HYBRID IC
→ CUSTOMIZED DIGITAL IC
→ CPU APPLICATION (MASKED ROM)

FUEL INJECTION SYSTEMS IN JAPAN



FUNCTION DIVERSIFICATION (ENGINE CONTROL)

A.flow

FUNCTION	YEAR											
	'74	'75	'76	'77	'78	'79	'80	'81	'82	'83	'84	'85
EFI (fuel injection)	○	○	○	○	○	○	○	○	○	○	○	○
A/F FEEDBACK					○	○	○	○	○	○	○	○
ESA								○	○	○	○	○
ISC								○	○	○	○	○
DIAGNOSTICS								○	○	○	○	○
ECT INTERFACE									○	○	○	○
BACK-UP										○	○	○
EGR										○	○	○
KCS											○	○
ECT											○	○

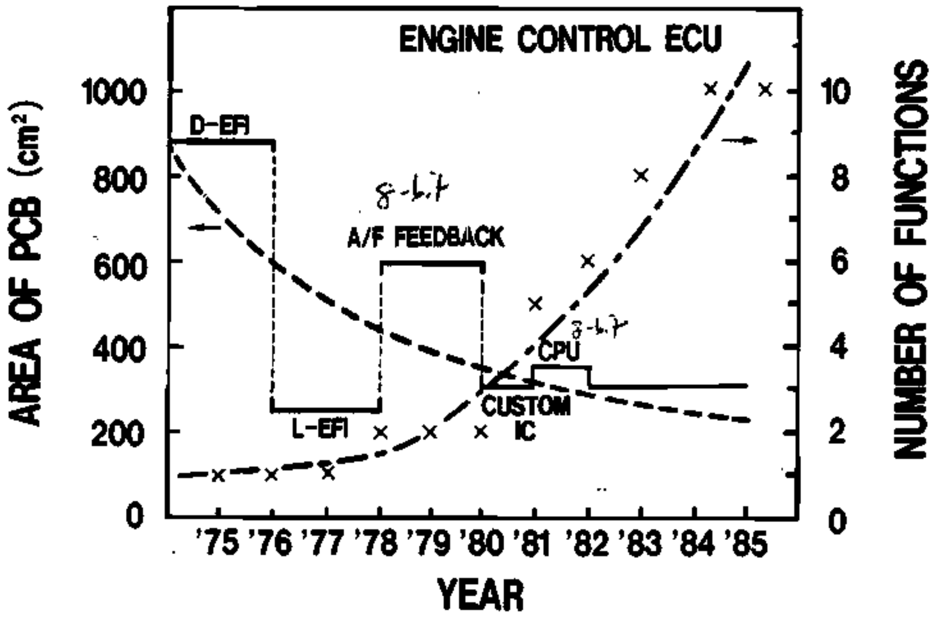
D-EFI

L-EFI (ANALOG)

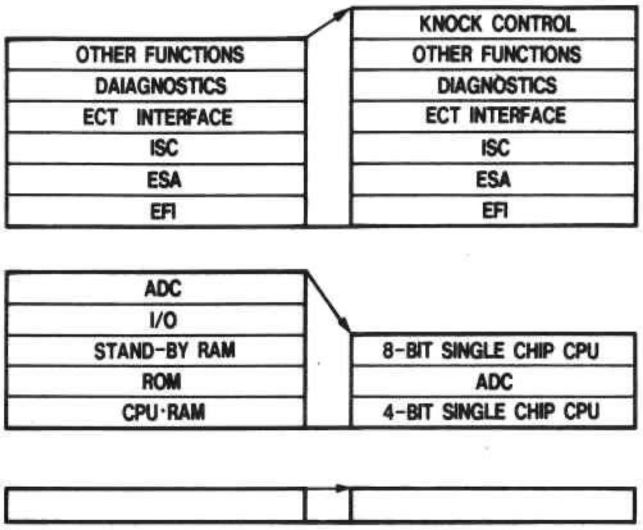
WITH A/F FEEDBACK

ENGINE CONTROL (CPU)

PROGRESS IN SIZE & FUNCTION OF ECU



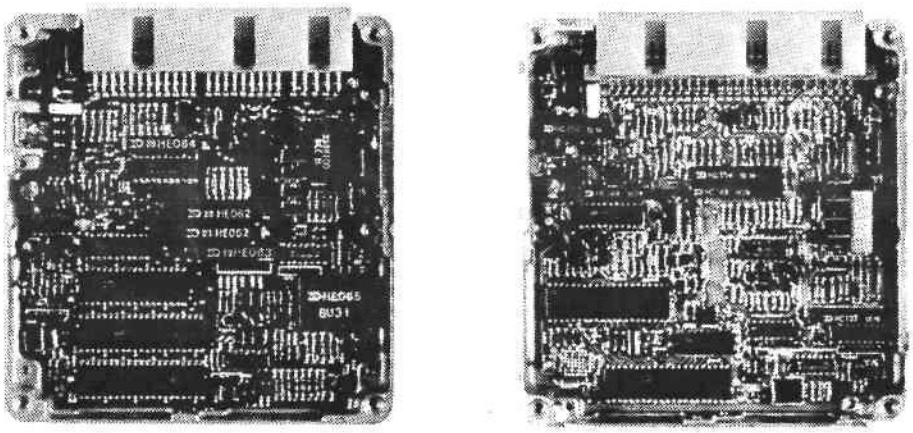
ENGINE CONTROL ECU IMPROVEMENT



	1983 MODEL	1985 MODEL
FUNCTIONS		KNOCK CONTROL
	OTHER FUNCTIONS	OTHER FUNCTIONS
	DAIAGNOSTICS	DIAGNOSTICS
	ECT INTERFACE	ECT INTERFACE
	ISC	ISC
	ESA	ESA
	EFI	EFI
No. of LSIs	ADC	
	I/O	
	STAND-BY RAM	8-BIT SINGLE CHIP CPU
	ROM	ADC
	CPU·RAM	4-BIT SINGLE CHIP CPU
COST		

ENGINE CONTROL ECU

ENGINE CONTROL ECU IMPROVEMENT

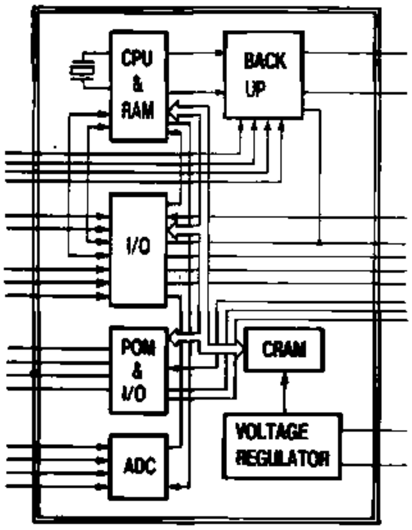


1983 MODEL

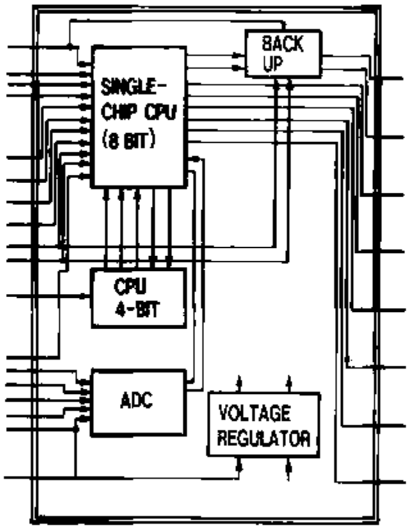
1985 MODEL

ENGINE CONTROL ECU

LSI CONFIGURATION OF ENGINE CONTROL ECU

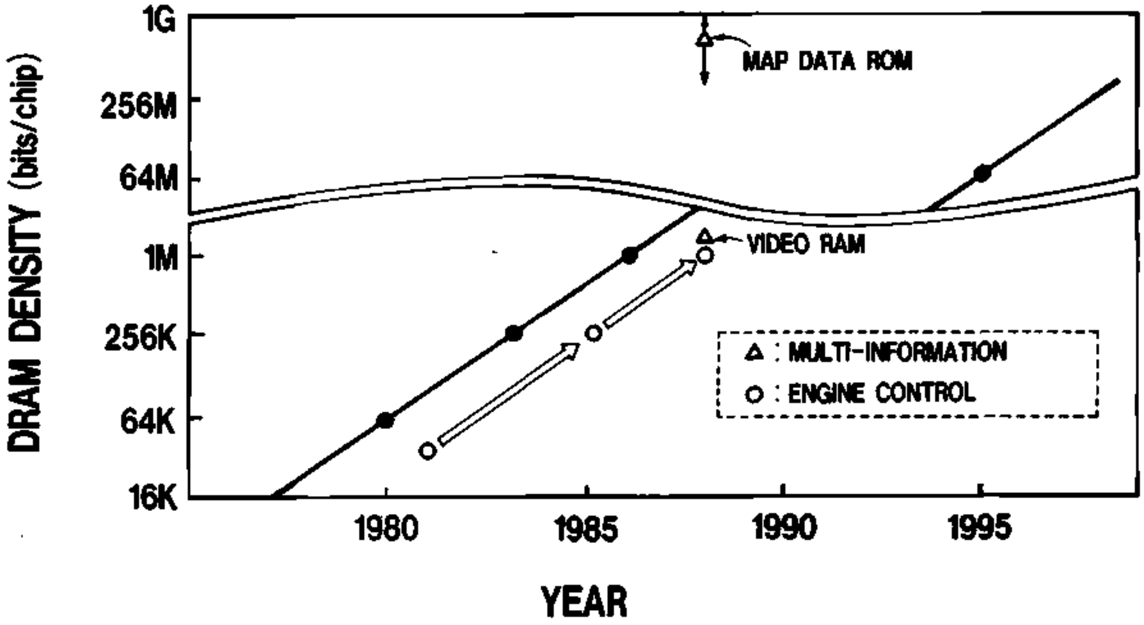


1983 MODEL
(BLOCK DIAGRAM)

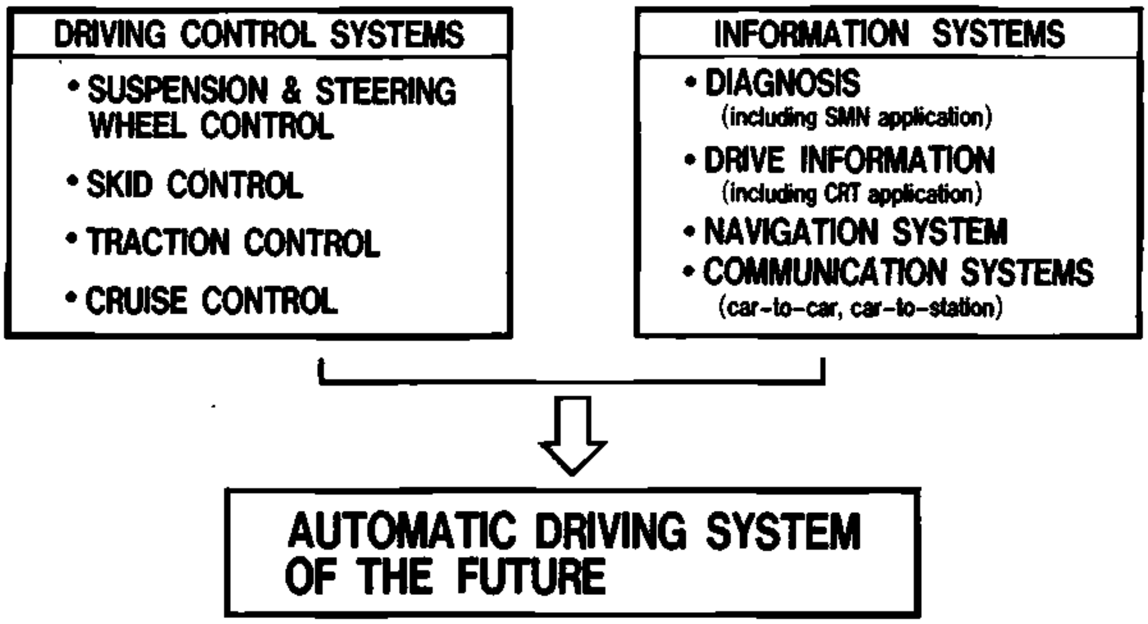


1985 MODEL
(BLOCK DIAGRAM)

CPU PROGRESS IN AUTOMOTIVE ELECTRONICS



EMERGING AUTOMOTIVE ELECTRONICS



DRIVING CONTROL SYSTEMS

- SUSPENSION & STEERING WHEEL CONTROL
- SKID CONTROL
- TRACTION CONTROL
- CRUISE CONTROL

INFORMATION SYSTEMS

- DIAGNOSIS (including SMN application)
- DRIVE INFORMATION (including CRT application)
- NAVIGATION SYSTEM
- COMMUNICATION SYSTEMS (car-to-car, car-to-station)

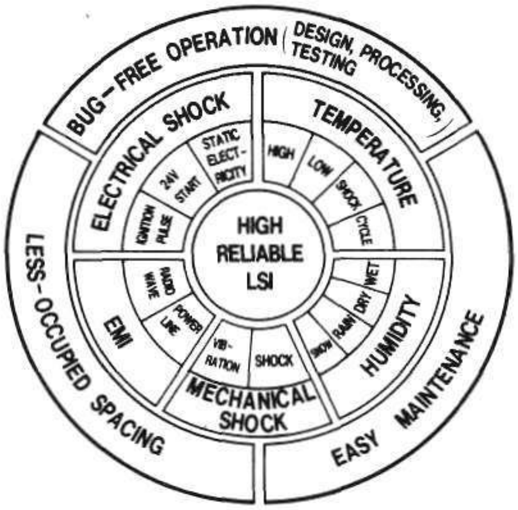
AUTOMATIC DRIVING SYSTEM OF THE FUTURE

SEMICONDUCTOR DEVICES USED PER CAR

YEAR DEVICE	1980	1985	1990
LSI	13	33	76
IC	94	153	127
DISCRETE DEVICE	373	395	441
HYBRID DEVICE	9	35	55

AUTOMOTIVE LSI REQUIREMENTS

■ HIGH RELIABILITY



■ REASONABLE COST

- CHIP SIZE
- PACKAGING

■ FLEXIBILITY

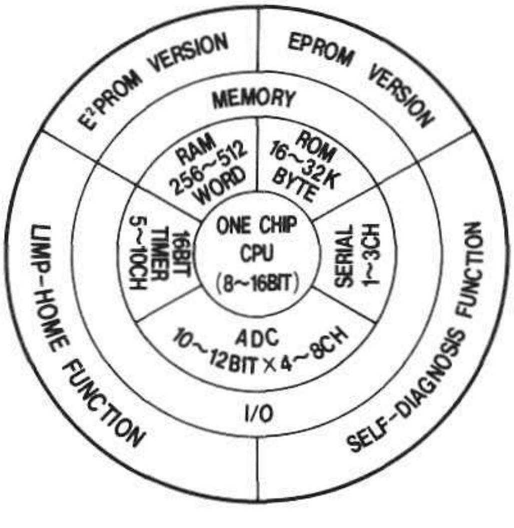
- WIDE APPLICATIONS TO VARIOUS CAR MODELS
- SHORTER LEAD TIME FOR PRODUCTION

PROPOSED LSI FOR ADVANCED AUTOMOTIVE ELECTRONICS…(1)

■ CONFIGURATION

- Single Chip Device :
  To Meet All Required Functions
- EPROM/E²PROM Version :
  To Meet Shorter Production Lead Time

■ CONCEPT OF CPU ARCHITECTURE

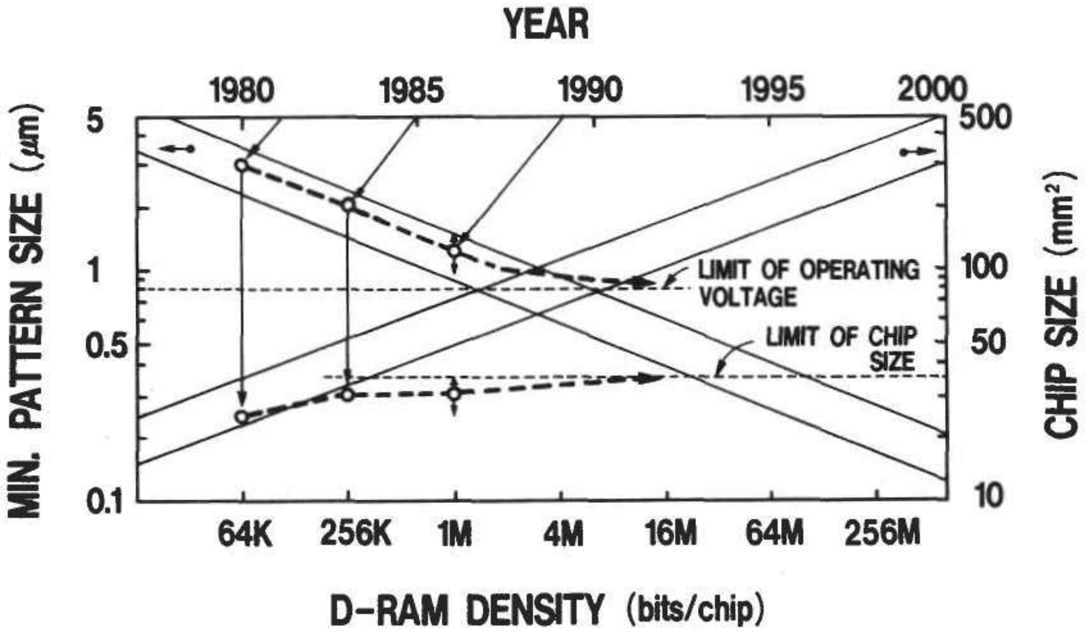


PROPOSED LSI FOR ADVANCED AUTOMOTIVE ELECTRONICS···(2)

■ DESIGN CONSIDERATIONS

- Wide Operating Temperature
  - ⇨ CMOS TYPE
- Severe Temperature Cycle
  - ⇨ MAXIMUM CHIP SIZE : 5 - 6 mm
- Severe Ambient Electrical Noise
  - ⇨ HIGH Vcc (>4V)
- Reasonable Cost
  - ⇨ ECONOMICAL PACKAGING
- Space Limitation
  - ⇨ HIGH-DENSITY MOUNTING ADAPTABILITY
- Highly Reliable Product Quality
  - ⇨ CONSERVATIVE DESIGN APPROACH

FORECAST OF AUTOMOTIVE VLSI



テクノロジーチャレンジ：自動車の場合

日本電装㈱常務取締役
エレクトロニクス事業本部長

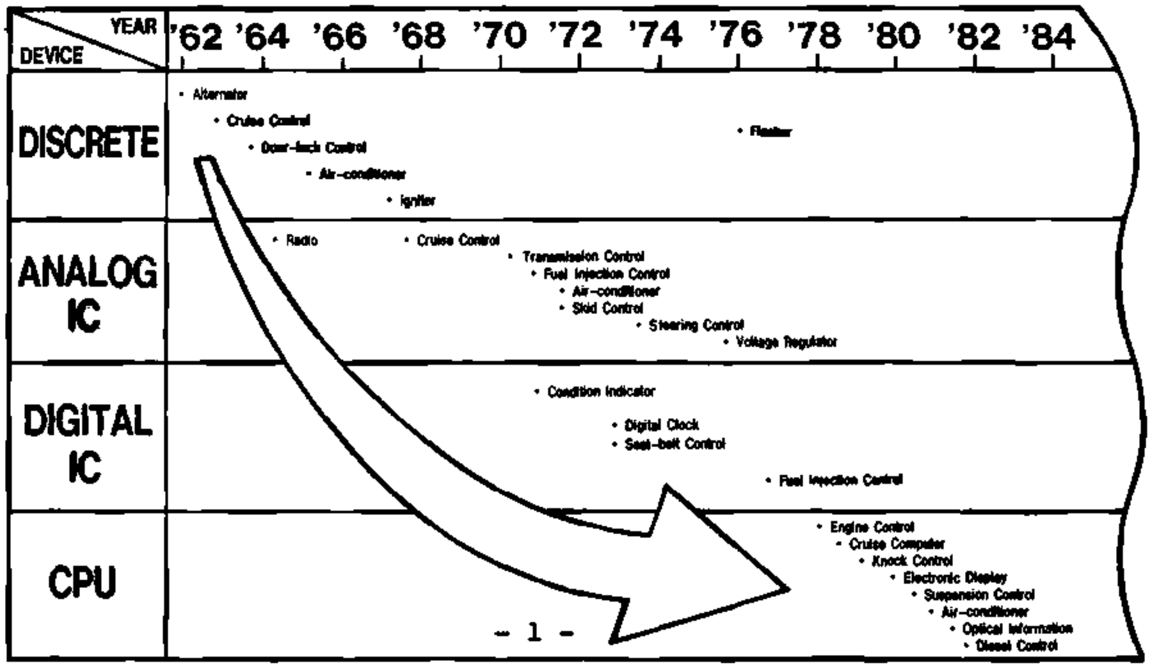
村山　正雄

1．日本におけるカーエレクトロニクスの歴史展望

エレクトロニクスが自動車用電装品に本格的に関わるようになったのは、１９６２年オルタネータに用いられたレクチファイヤが始まりでした。もちろんデスクリート部品の応用でした。その後、ＩＣが製造され始めますと、バイポーラ型アナログＩＣが、ラジオやクルーズコントローラに使用されて製品化され、年を追って大規模製品が研究されて、フュールインジェクションやスキッドコトロール等、現在でもカーエレクトロニクスの代表製品であるものの芽生えがみられました。１９７３年にはデジタルＩＣの応用が始まり、モニタ装置、デジタルクロックが車につくようになり、その間の技術の高まりは、排気規制とオイルショックをのりこえて、１９７９年から、ＣＰＵの応用製品としてＥ／Ｇコントロールを先頭にデジタルメータやサスペンションコントロールと大規横なシステム製品へ発展をしたのが、日本のカーエレクトロニクスの歴史だったと思います。

2/15

HISTORICAL OVERVIEW IN JAPAN



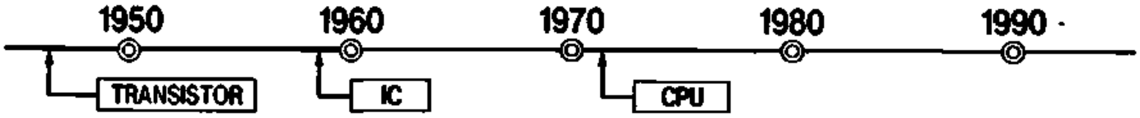
つまり、カーエレクトロニクスは、デスクリート素子からＣＰＵの応用へと進んできたと云えます。もちろん、現在でも、デスクリートやアナログＩＣやカスタムのデジタルＩＣで構成された小機能のカーエレクトロニクス製品は、引きつづいて数多く使用され、カーエレクトロニクスの広がりを大きなものにしていることは云うまでもありません。

以上のことを、技術のトレンドとして別の見方をするならば、次のように云えると思います。

ひとつの見方としてファンクションの変化としてみますと、ドアロック・コントローラのように単一機能の製品から、エアコン・コントローラのように車室内外の情況や熱源の情況によって冷房、暖房の切替と共に、温度・風量をコントロールすると云った複合的な機能をもった製品に進み、さらに、Ｅ／Ｇコントロールのように燃料噴射のコントロールの他にアイドリング・スピードや点火進角のコントロールも含めて、エンジンの運転をシステム的に制御する複雑な多機能製品に展開したと云えましょう。

又、別の見方として、デバイスの変化としてみますと、デスクリート素子で組み立てられた小さなユニットが、アナログＩＣ化されて部品数を減らしながら大規模化し始め、ハイブリッドＩＣの採用によってカスタム化と小型化をすすめたと云えましょう。さらにソフト対応と冗長性を省く目的で、カスタムのデジタルＩＣが登場し、その次の段階で、システムのコントローラとして、ＣＰＵ応用のＥＣＵが、比較的早く採用されたと思います。

TECHNOLOGICAL TREND IN AUTOMOTIVE ELECTRONICS



PERSPECTIVE (Ⅰ) : FUNCTION

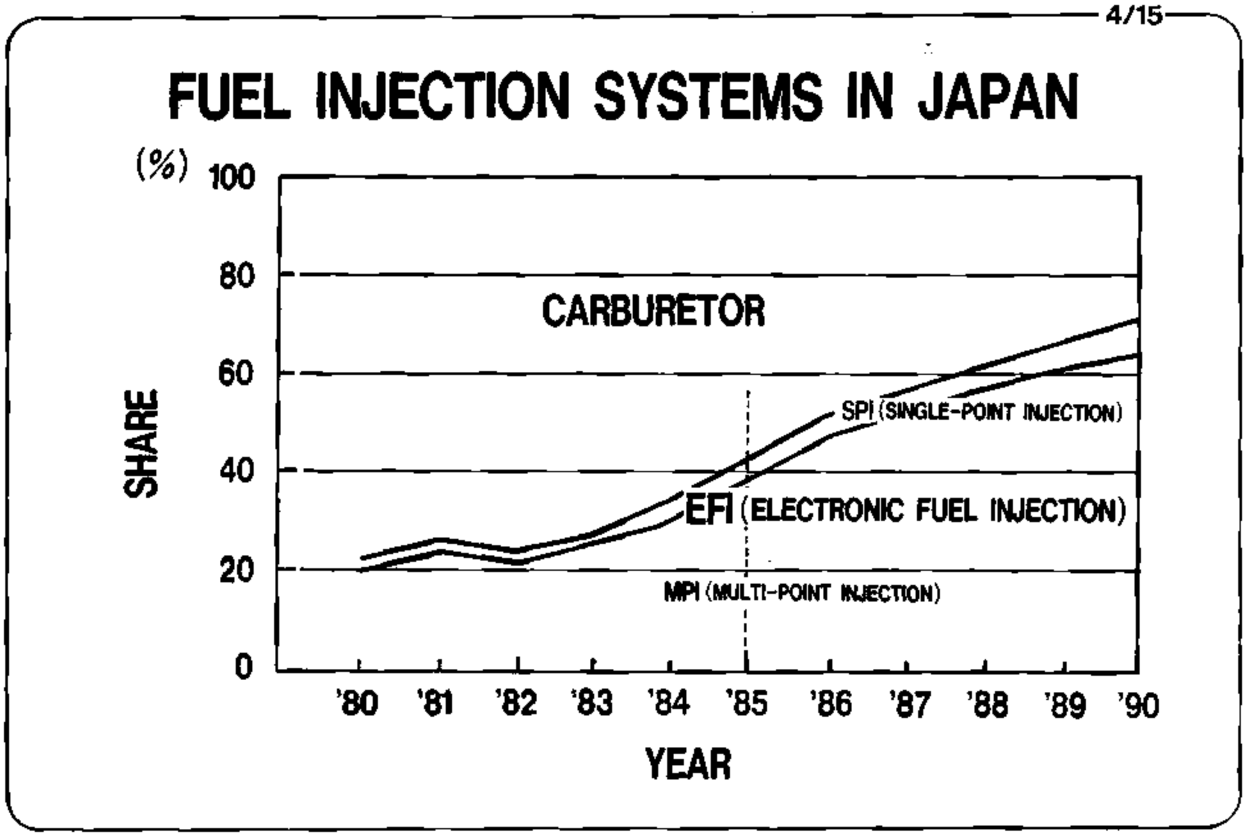
SINGLE-FUNCTION UNIT
└→ COMPLEX FUNCTION CONTROLLER
└→ SYSTEM CONTROLLER (CPU)

PERSPECTIVE (Ⅱ) : DEVICE

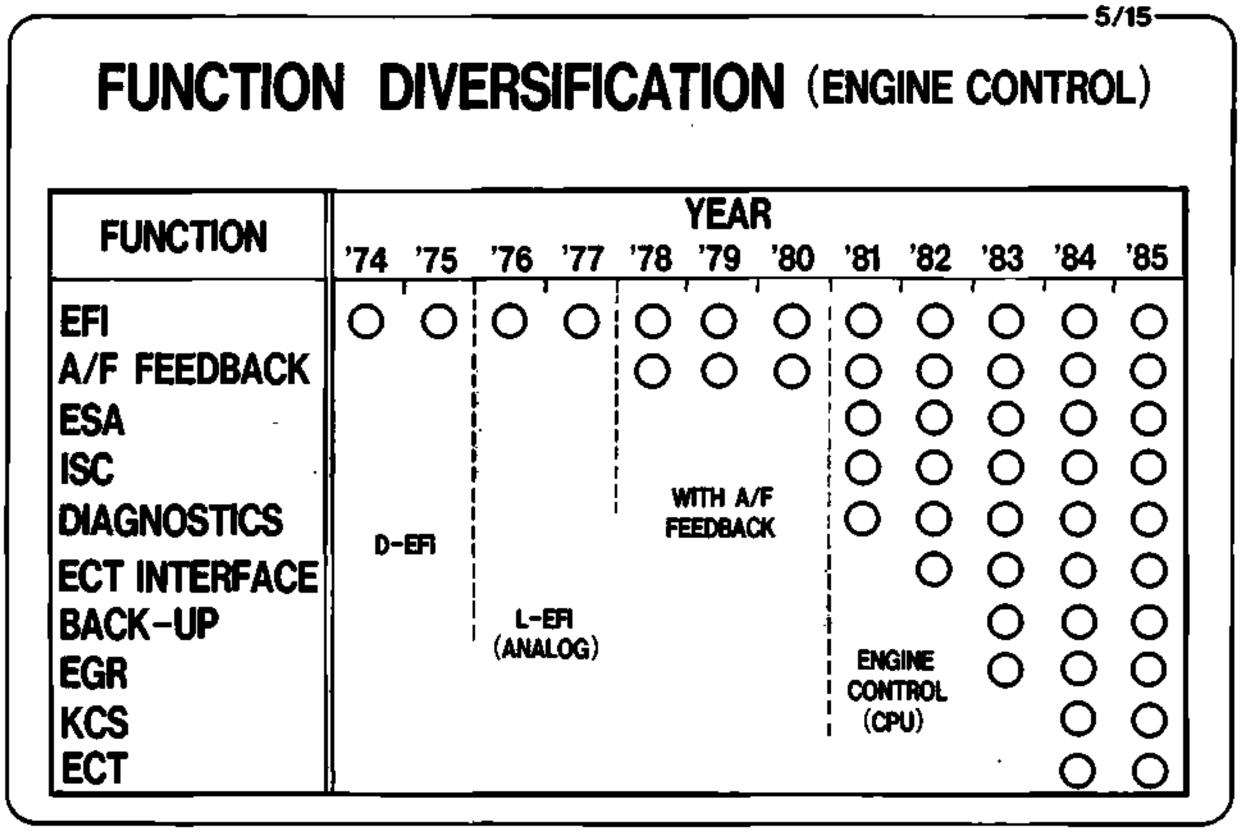
DISCRETE PARTS
└→ ANALOG MONOLITHIC IC
└→ ANALOG HYBRID IC
└→ CUSTOMIZED DIGITAL IC
└→ CPU APPLICATION
(MASKED ROM)

2．カーエレクトロニクスの展開 〈フュ　エル・インジェンクション・システムの例〉

カ　エレクトロニクスが、どのように発展してきたかを示す実際の例としてフューエル・インジェンクション・システムの例を述べたいと思います。フュ・エル・インジェンクション・システムは、西ドイツのロバート・ボッシュ社において開発されたシステムで、従来のキャブレ－タによってガソリンを気化してシリンダーに燃料を供給してきたガソリン・エンジンを、高圧にポンプアップしたガソリンをノズルから必要量だけ噴射させてシリンダ－に送り込むことによって精密なコントロールが可能なガソリン・エンジンに変えたシステムです。１９７５年前後の排気規制と石油危機で強く求められた燃費向上は、このフューエル・インジェンクション・システム………もちろん単なるＥＣＵだけではなくて、燃料ポンプ・噴射ノズル・各種弁類・エヤフローセンサ・O_2 センサ・水温センサ・圧力センサ・三元触媒によるアフタ　バ　ナ・キャニスタ等々から構成される複雑なシステムです……と、イグナイタと呼ばれる電子点火システムに、大きく依存して実現できたものでありますし、現在も車の進歩の先端を担っていると云えます。従って、年々フューエル・インジェンクション・システムを装着した車は増加しつづけ、昨年は４０％を越しました（除軽四）し、５年後には７０％に達すると予測されています。



ところで、このシステムは、年々機能が追加され、Ａ／Ｆのフィードバック・点火進角コントロール・アイドルスピードコトロール・ダイアグノシス・トランスミッションコントロール・フェールセーフ機能・ＥＧＲ・ノックコントロール機能まで加えられて、フューエル・インジェンクションの機能は一部に過ぎなくなり、１９８１年以降はＥ／Ｇコントロールシステムと呼ばれるようになりました。



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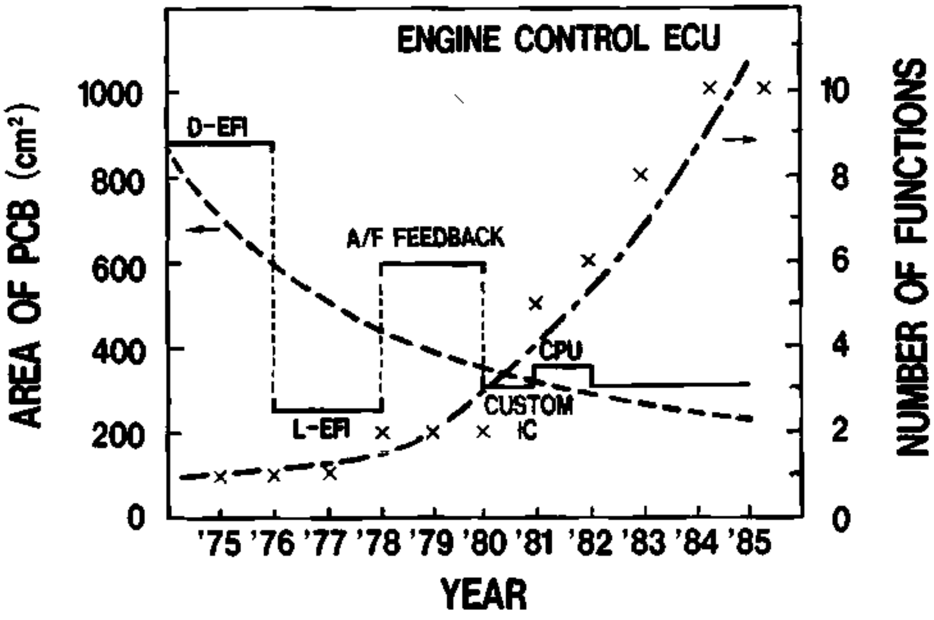
FUNCTION DIVERSIFICATION (ENGINE CONTROL)

FUNCTION	YEAR '74	'75	'76	'77	'78	'79	'80	'81	'82	'83	'84	'85
EFI	○	○	○	○	○	○	○	○	○	○	○	○
A/F FEEDBACK					○	○	○	○	○	○	○	○
ESA								○	○	○	○	○
ISC								○	○	○	○	○
DIAGNOSTICS								○	○	○	○	○
ECT INTERFACE									○	○	○	○
BACK-UP										○	○	○
EGR										○	○	○
KCS											○	○
ECT											○	○

その間、初期にはアナログ専用ＩＣによって構成されていたＥＣＵは、マルチチップ構成の8ビットマイコン型を経て、１チップ型の8ビットカスタムＣＰＵになって、機能の増加にもかかわらず小型化が進むと共に、リファインの促進と構成素子数の減少から信頼性のレベルアップが実現しました。

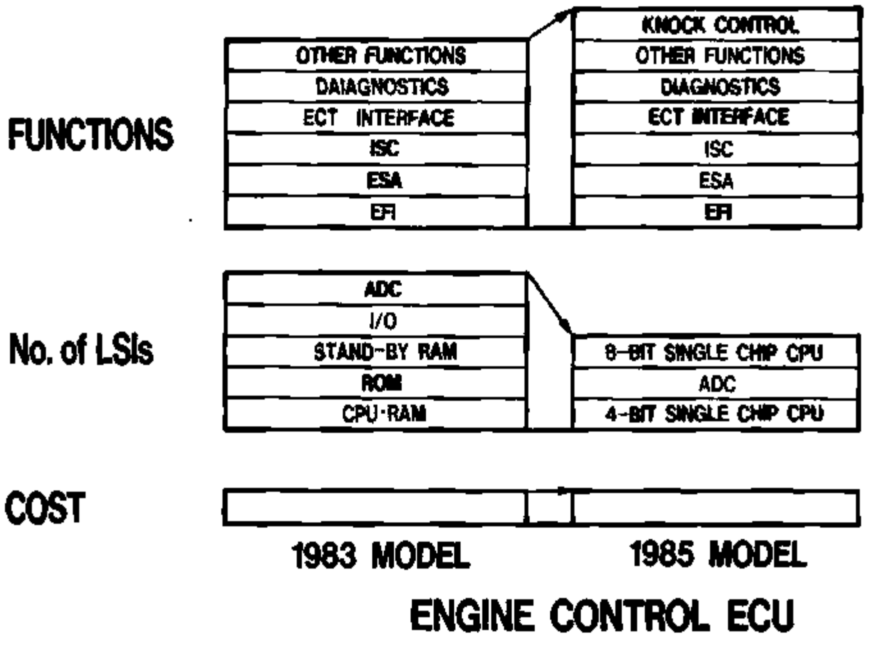
その経過をグラフ化したのが次図で、ＥＣＵの機能増による大型化が素子構成の工夫によって小型化に転じた様子がよく分かります。

PROGRESS IN SIZE & FUNCTION OF ECU



また、下図には８３年型と８５年型を機能・構成ＬＳＩの数等について比較した表と、それぞれの年式のＥＣＵの写真を比較して示しました。

ENGINE CONTROL ECU IMPROVEMENT



FUNCTIONS

1983 MODEL	1985 MODEL
	KNOCK CONTROL
OTHER FUNCTIONS	OTHER FUNCTIONS
DAIAGNOSTICS	DIAGNOSTICS
ECT INTERFACE	ECT INTERFACE
ISC	ISC
ESA	ESA
EFI	EFI

No. of LSIs

1983 MODEL	1985 MODEL
ADC	
I/O	
STAND-BY RAM	8-BIT SINGLE CHIP CPU
ROM	ADC
CPU·RAM	4-BIT SINGLE CHIP CPU

COST

1983 MODEL 1985 MODEL

ENGINE CONTROL ECU

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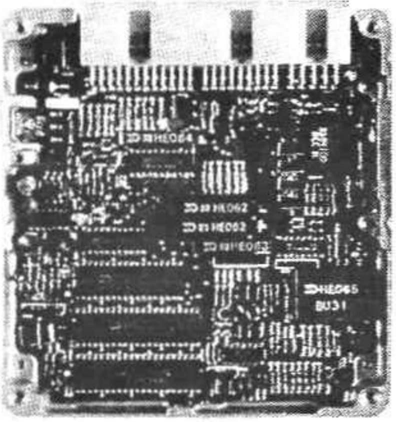
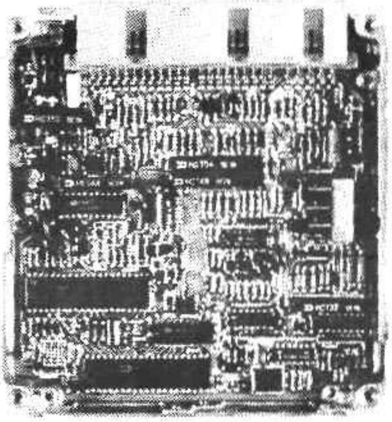
ENGINE CONTROL ECU IMPROVEMENT



1983 MODEL



1985 MODEL

ENGINE CONTROL ECU

さらに、両者の素子構成をより明確にするため、ブロックダイヤグラムを示しました。８３年型のバックアップとレギュレータを除いた５素子による構成は、８５年型では１チップ８ビットＣＰＵとＡＤコンバータの２素子構成となりました。（４ビットＣＰＵは別の目的で追加されたものです。）

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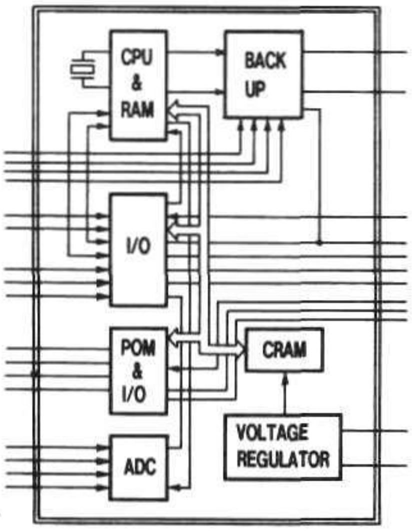
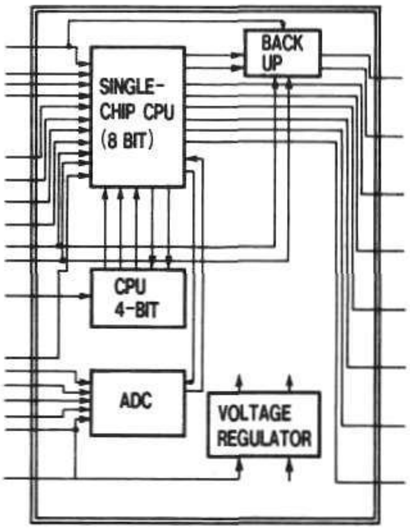
LSI CONFIGURATION OF ENGINE CONTROL ECU



1983 MODEL

(BLOCK DIAGRAM)



1985 MODEL

(BLOCK DIAGRAM)

以上で、カーエレクトロニクス用のＥＣＵの発展経過は明らかになったと思いますが、そのＥＣＵに使用されている一番大きいＬＳＩの技術的な位置づけについて検討をしたのが次頁のグラフであります。

このグラフ中の実線は、ＤＲＡＭの進歩を表し、将来を予測するのによく引合に出される直線で、２０００年に３００ＭのＤＲＡＭに到達することを示しています。ＣＰＵとＤＲＡＭは直接の比較はできませんが、ＣＰＵの中のＲＯＭ・ＲＡＭ等の技術内容をベースにして比較しますと、１９８１年および１９８５年に実現したカスタムＣＰＵの位置は、図中○印で示される位置相当と判断され、ＤＲＡＭ技術の進展に約２年遅れで追随しているものと判断しています。さらに、次の開発ＣＰＵも、１９８８年に約２年遅れの位置に達するものとみています。

このことは、カーエレクトロニクス用ＬＳＩも、技術先端を行くＤＲＡＭ技術に源流をおく技術の導入消化が基本にあって展開していることを示すと共に、車と云うきびしい環境の中で、高い信頼性を求められることに対応する検討に２年近くかかっていることを示しているものと見ております。ただし現在の見込では、１９８８年に実現したい情報システムで必要なＲＯＭ容量は、２５６Ｍを越えますので、このグラフの位置からみて、多素子対応は避けられず、対応検討を急ぐ必要があると思っております。

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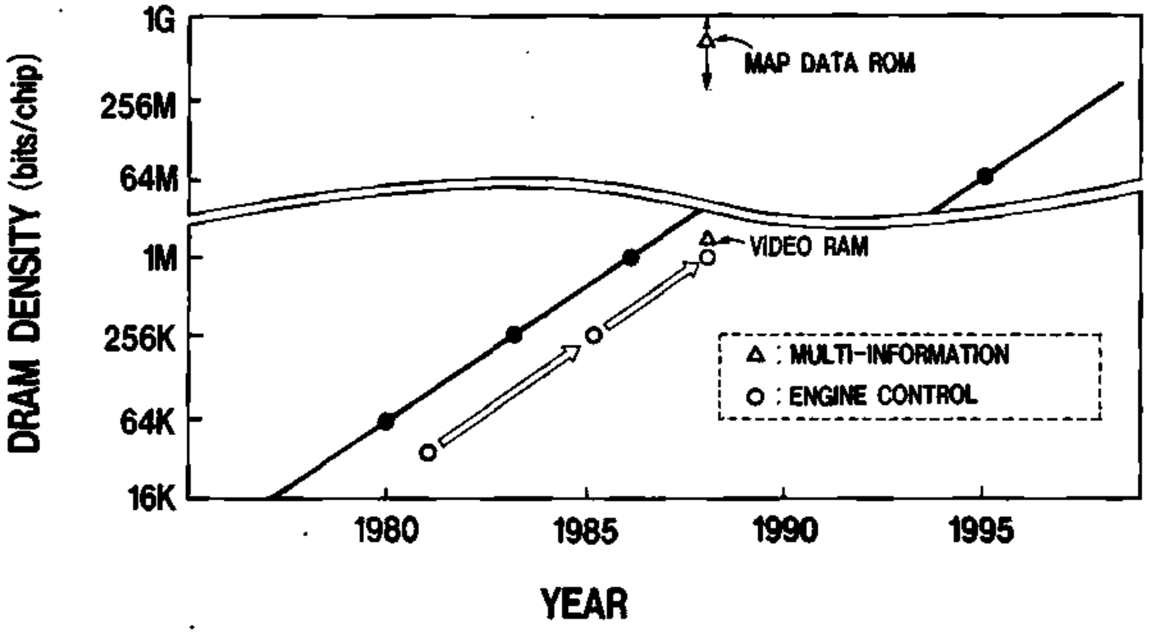
CPU PROGRESS IN AUTOMOTIVE ELECTRONICS



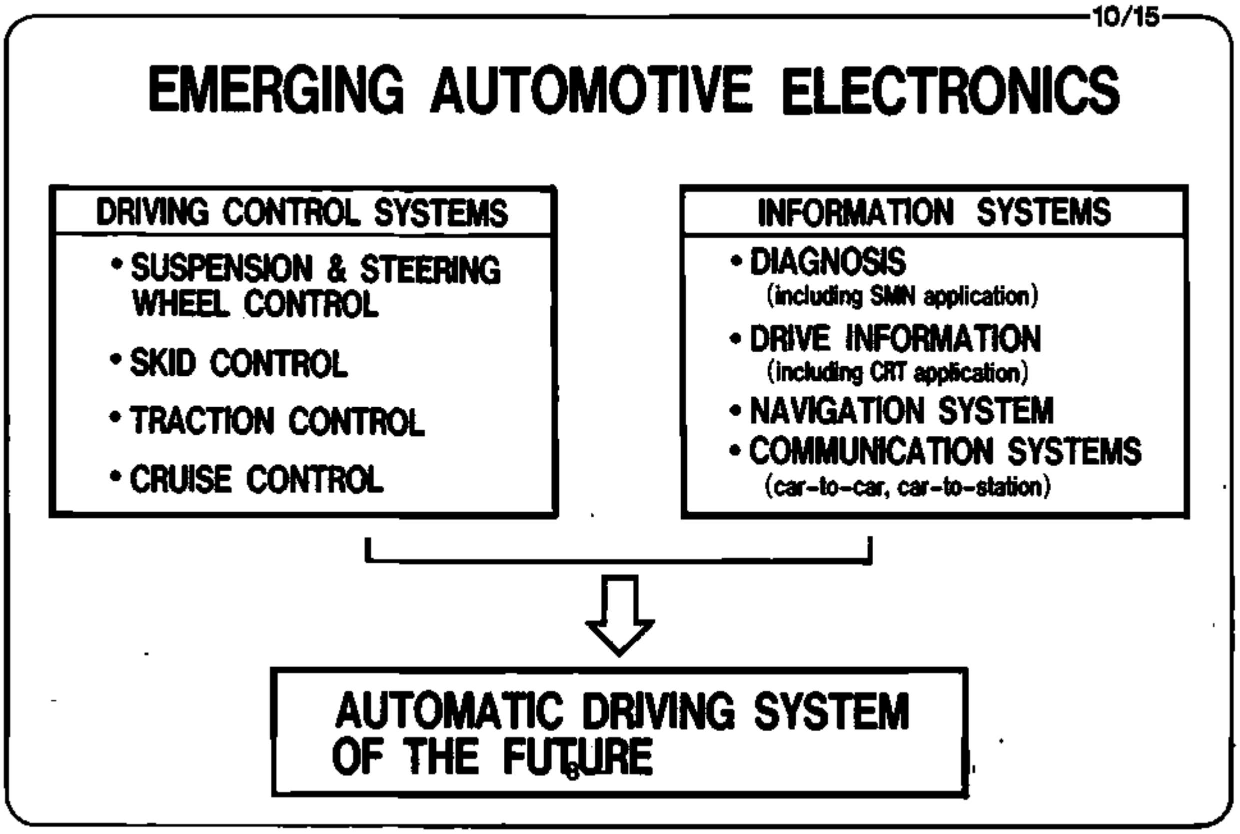
3. カーエレクトロニクスシステムの将来の傾向

例としてあげたフューエルインジェンクションシステムは、エンジンコントロールシステムにまで展開してきたことを詳しく述べました。同じようにして、　例えばデジタルメーターも、螢光表示管やＬＣディスプレイを用いて、その使用例がふえ、少なくともセールスポイントとして騒がれない程度に当たり前のことと受取られるようになりました。ただし、デジタルメーターの電子回路は、回路としてはかなり大規模なものであると共に、寸法・容積上の制約が極めてきびしくかつ、変更に対する大巾なフレキシビリティを要求される難しい仕事の一つであります。

さらに、将来展開が予想されるカーエレクトロニクスシステムとしては、下の表に示すようにドライブ制御システムと情報通信システム関係に大別して考えることができるでしょう。

ドライブ制御システムでは、一般に足まわり制御と云われる、スキッド防止システム・サスペンション制御システム・４輪駆動および操舵制御システム・発進制御システム等に加えて、定速走行システム等の発展が注目されています。

又、情報・通信システム関係では、ディスプレイにＣＲＴを用いることによって、情報の表示をより巾広いものにすることを中心に、警報機能を含めてのダイアグノシステムや案内機能を含めてのナビゲーションシステムの展開が考えられ、さらに自動車電話なども含めて、車の外との通信システムの展開も推進されると考えています。そして、その究極は、よく話にでてくるように、完全な自動操縦システムなのでありましょうが、現在ではまだまだ夢の話でしょう。



EMERGING AUTOMOTIVE ELECTRONICS

DRIVING CONTROL SYSTEMS

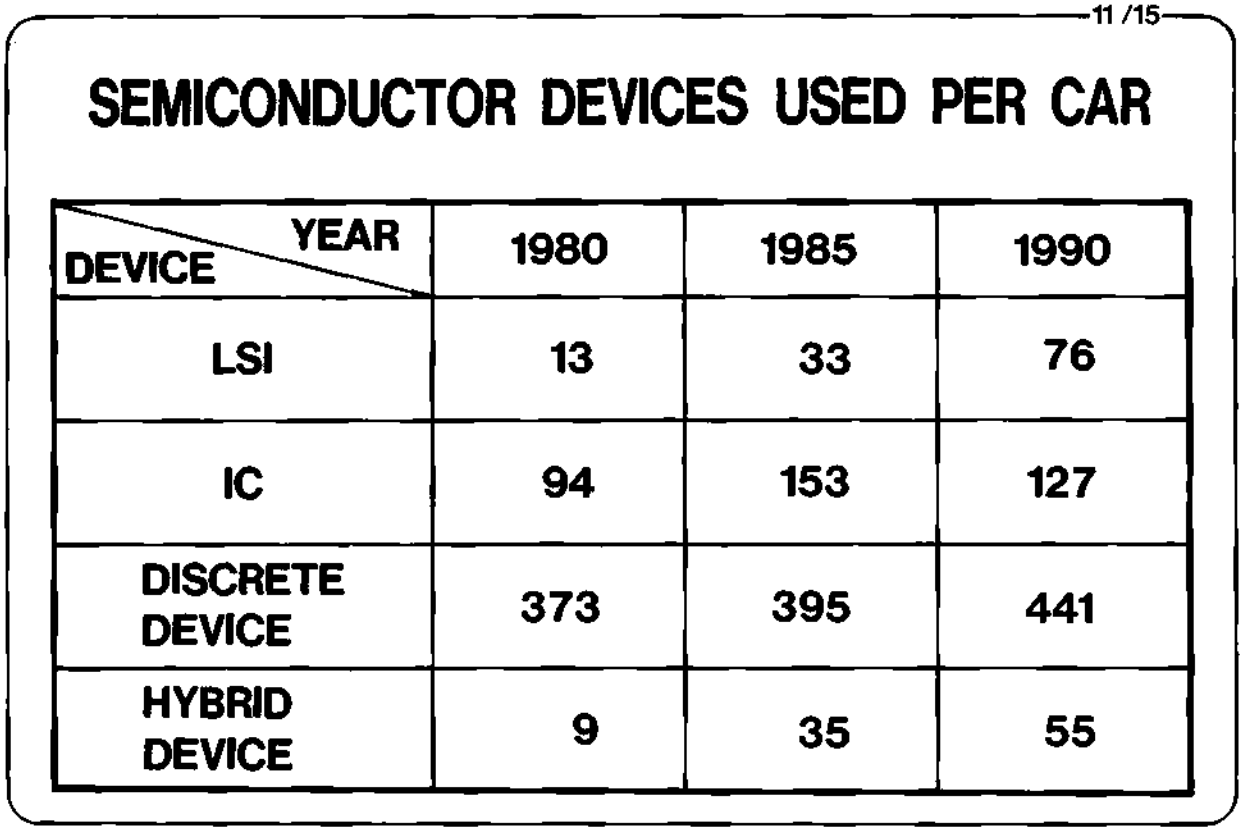
- SUSPENSION & STEERING WHEEL CONTROL
- SKID CONTROL
- TRACTION CONTROL
- CRUISE CONTROL

INFORMATION SYSTEMS

- DIAGNOSIS (including SMN application)
- DRIVE INFORMATION (including CRT application)
- NAVIGATION SYSTEM
- COMMUNICATION SYSTEMS (car-to-car, car-to-station)

AUTOMATIC DRIVING SYSTEM OF THE FUTURE

そのように、カ　エレクトロニクスが展開したら、どれだけの半導体デバイスが車に使われるかということもよく議論され、必ずしも意見は一致しませんが、下の表は、私達がみている一つの見方を示すものであるという注釈つきで、車一台当りに使用されるＬＳＩ等の個数を示したものです。



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SEMICONDUCTOR DEVICES USED PER CAR

DEVICE \ YEAR	1980	1985	1990
LSI	13	33	76
IC	94	153	127
DISCRETE DEVICE	373	395	441
HYBRID DEVICE	9	35	55

もともと車の話というものは、多くの方が夢をもって語ることが多いのですが、このように話を進めてきますと、カ　エレクトロニクスにも、何かバラ色がかかって来るような気が致します。しかし、これを実現するための現実の活動は、大変厳しいということを、次に話したいと思います。

4. カーエレクトロニクス用ＬＳＩの追求

カーエレクトロニクスが、ＥＣＵ等に使用するＬＳＩ等のデバイスにどんなことを要求しているかを一つにまとめてみたのが下表です。

第一に必要なのは、高い信頼性をもったＬＳＩであります。現在では、ディスクリートやＳＳＩ級のデバイスの信頼性は大変に高くはなりましたがそれに比較すると、ＬＳＩや大型ＩＣを含むハイブリッドＩＣの信頼性はさらに高めていく必要があると判断しております。図に示しましたように、車に装着されたＬＳＩ等の周囲環境は、絶対値がきびしいことと合わせて、車の移動に伴う変化が大きいという特徴をもっており、加えて、機械的、電気的ショックに常にさらされていることが、きびしさを倍加していると云えます。特にＬＳＩについては、バグ・フリーをどのように実現するかがこれからの大きな課題と思っております。

その他の要求としましては、ひとつは低コスト化であり、もうひつはフレキシビリティをどう出すかの要求であります。種々な車種・車型への展開は、決して画一的なシステムモデルだけでは対応できないことに対応する手段・方法が必要であると云うことです。

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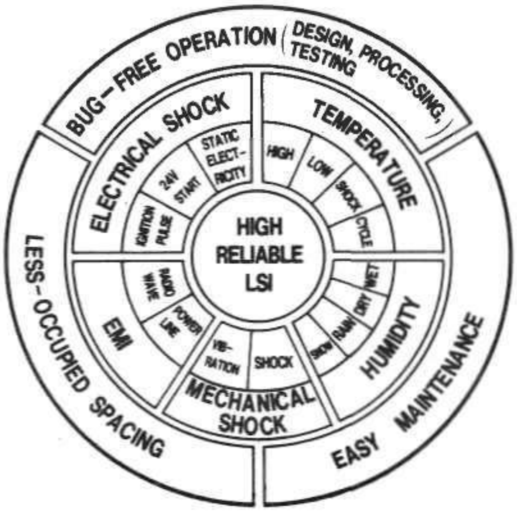
AUTOMOTIVE LSI REQUIREMENTS

■ **HIGH RELIABILITY**



■ **REASONABLE COST**

- CHIP SIZE
- PACKAGING

■ **FLEXIBILITY**

- WIDE APPLICATIONS TO VARIOUS CAR MODELS
- SHORTER LEAD TIME FOR PRODUCTION

そのような要求を満足させる方法の方向付けをしてみたのが下表です。

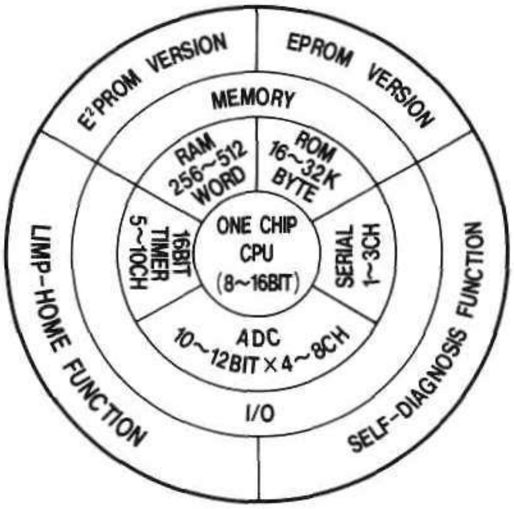
まず、耐環境性に強く低コストで作れるＬＳＩとなると、可能ならば１チップ構成であることが望ましいと云えます。その上にフレキシビリティをもつためには、種々なケースを考え合わせると、同一機能のＬＳＩについてＥＰＲＯＭまたはＥ^2 ＰＲＯＭ付のシリーズを準備しておくことが必要になってくると考えます。

PROPOSED LSI FOR ADVANCED AUTOMOTIVE ELECTRONICS···(1)

■ CONFIGURATION

- Single Chip Device : To Meet All Required Functions
- EPROM/E^{2}PROM Version : To Meet Shorter Production Lead Time

■ CONCEPT OF CPU ARCHITECTURE



PROPOSED LSI FOR ADVANCED AUTOMOTIVE ELECTRONICS···(2)

■ DESIGN CONSIDERATIONS

- Wide Operating Temperature
  ⇨ CMOS TYPE
- Severe Temperature Cycle
  ⇨ MAXIMUM CHIP SIZE : 5 - 6 mm
- Severe Ambient Electrical Noise
  ⇨ HIGH Vcc (>4V)
- Reasonable Cost
  ⇨ ECONOMICAL PACKAGING
- Space Limitation
  ⇨ HIGH-DENSITY MOUNTING ADAPTABILITY
- Highly Reliable Product Quality
  ⇨ CONSERVATIVE DESIGN APPROACH

次に、先程のべました将来システムの規模からみて、どの位の機能の容量が必要かを推定してみたのが、コンセプトを示した円型の図であります。

２５６～５１２ワードのＲＡＭと１６～３２バイトのＲＯＭをもった８又は１６ｂｉｔのＣＰＵでＡＤＣやタイマーも内蔵した１チップＬＳＩが考えられます。当然ＥＰＲＯＭ又はＥ^2 ＰＲＯＭ版も揃っています。さらに、ダイアグ機能とバックアップ機能もとり込みたいと望まれると思います。

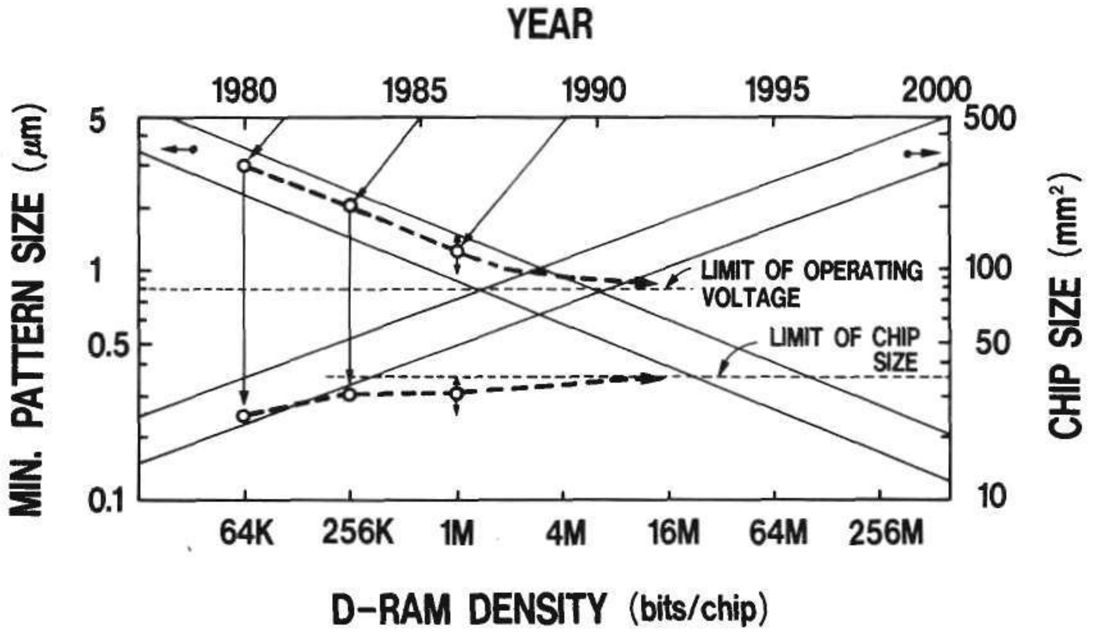
このことを実現しようとすると、究極のところＣＭＯＳ型で５～６㎜$^{\square}$のチップに必要特性を充たした上で、機能相当の回路をつめこんだＬＳＩを開発する必要性が浮かび上がってくるわけです。

しかし、このＬＳＩの実現時期を、前にのべた１９８８年の次期型として、その３年後である１９９１年としますと、現在のＤＲＡＭ技術の進歩動向といわれている動きと矛盾を生じてくるのです。

次の図は、ＤＲＡＭの１チップ規模の動向に対して、その時の最小加工寸法の可能性と、チップの大きさを加えた動向図であります。既にのべましたように、カーエレクトロニクス用のカスタムＣＰＵを相当技術で格づけしてグラフ内に示しますと、約２年遅れで１９８５年までは追随してきたことが示されています。ところが、これに先程のチップサイズを５～６㎜$^{\square}$に押さえる必要性の限界線をひくと、既に飽和した状況に達していて、この動向から外れ始めていることが明白です。また、カーエレクトロニクスの電気雑音レベルをカバーするために、少なくとも現在では、最小ゲート長を０.^{8}μ以下にすることは殆ど可能性がないと推定される限界線を入れると、これも、この動向から外れた位置でＬＳＩを成り立たせる必要が明白であります。

このことは、カーエレクトロニクス用ＬＳＩの技術の将来動向が、現在の先端技術の代表とされているＤＲＡＭの技術動向の延長線上から乖離し始めていること、今後もますます乖離が大きくなって、独自の技術動向を開拓することが、カーエレクトロニクスの将来に対して必要になっていることを示すものと判断しております。

FORECAST OF AUTOMOTIVE VLSI



以　上

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T.Kawamura,etal., "Toyota's New Single-Chip Microcomputer Based Engine and Transmission Control System"　SAE 850289 FEB.1985

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Senior Vice President
Dataquest Incorporated

Mr. Riley is a Senior Vice President of Dataquest. Previously, he was President of Intersil Incorporated and of Signetics, a subsidiary of North American Philips. He has 20 years of experience in the semiconductor industry, the last nine of which have been with Dataquest. His experience has been in the areas of corporate planning, marketing, and general management. Mr. Riley received a B.S. degree in Business Administration from Lehigh University, where he was elected to Phi Beta Kappa.

Dataquest Incorporated
JAPANESE SEMICONDUCTOR INDUSTRY CONFERENCE
April 13-15, 1986
Hakone, Japan

FORMING INTERNATIONAL PARTNERSHIPS

JAMES F. RILEY

Dataquest Incorporated

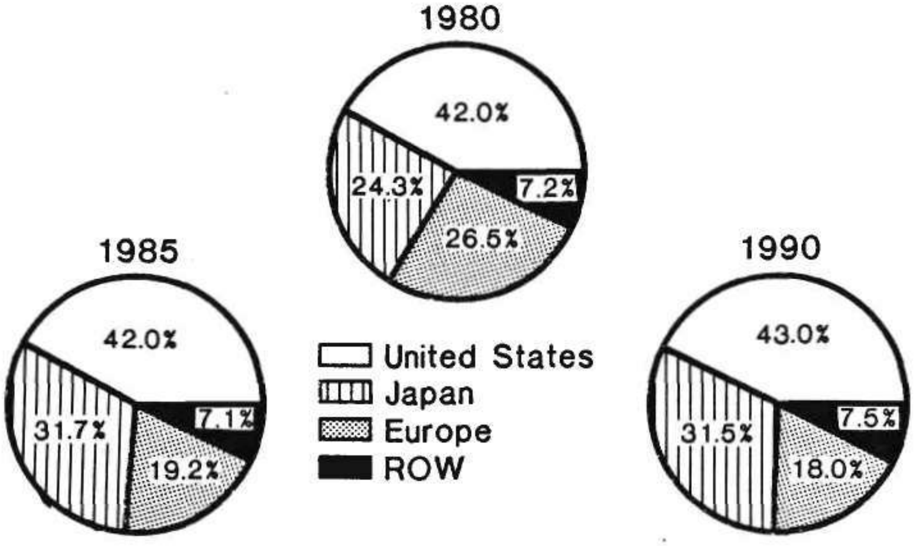
FORMING INTERNATIONAL PARTNERSHIPS

- Semiconductor industry status
- Definition of a strategic alliance
- Strategic alliances in the global marketplace
- Types of strategic alliances
- Evaluating a strategy of alliances
- The arithmetic of alliances

SEMICONDUCTOR INDUSTRY STATUS

- Internationality
- Capital intensity
- Worldwide world–class production capacity
- National consciousness
- Transitional technology
- Proliferation of alliances

ESTIMATED SEMICONDUCTOR CONSUMPTION BY REGION



Source: DATAQUEST

WAFER FAB TURNKEY COST

1975	$ 6 million
1985	$47 million
1995	$93 million

10K clean room
60K Ø bldg

Source: DATAQUEST

EXAMPLES OF WORLDWIDE WORLD-CLASS FABS

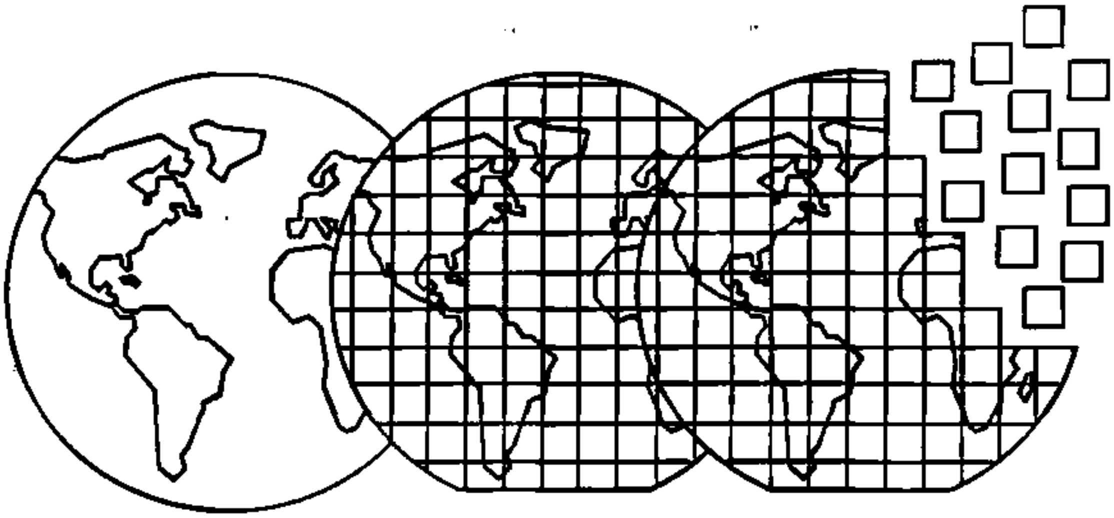
(Class 10)

COMPANY	LOCATION	COMPANY	LOCATION
BIT	U.S.	NSC	U.S.
FUJITSU	JAPAN	NSC	ISRAEL
GOLDSTAR	KOREA	SAMSUNG	KOREA
HITACHI	JAPAN	SANDIA	U.S.
HUGHES	U.S.	SGS	ITALY
HYUNDAI	KOREA	SGS	U.S.
IBM	U.S.	SILICONIX	U.S.
IDT	U.S.	TOSHIBA	JAPAN
MITSUBISHI	JAPAN	NMB	JAPAN

3-4% of WW capacity

Source: DATAQUEST

NATIONAL CONSCIOUSNESS



Source: DATAQUEST

TRANSITIONAL TECHNOLOGY

- CMOS — 1985 18% → 1995 60%
- Packaging — PGA 50% (1995)
  SMT 50% (1995)
- New architectures — smart peripherals, DSP,
- New materials — GaAs,
- Advances in manufacturing automation and processing technology

1985 JAPANESE STRATEGIC ALLIANCES BY COMPANY

Company	Number	Company	Number
Toshiba	12	Ricoh	3
Hitachi	7	NTT	3
Oki Electric	6	Seiko Group	3
NEC	5	Matsushita	2
Sony	4	Fujitsu	2
Mitsubishi	3	Rohm	2

Source: DATAQUEST

STRATEGIC ALLIANCES IN THE GLOBAL MARKETPLACE

Large – financial stability
– mfg capacity
small – innovation

STRATEGIC ALLIANCES IN THE GLOBAL MARKETPLACE

- Informed market presence
- Cultural synergy
- Complementary assets

TYPES OF STRATEGIC ALLIANCES

TYPES OF STRATEGIC ALLIANCES - 1

- Joint ventures — LSI logic/Kawasaki
- Licensing agreements — Intel/Fujitsu
- Technological cooperation — SRC, MCC
- Technical codevelopment — AMD/Sony
- Capacity/foundry agreements — WSI/Sharp
  — ETRI

TYPES OF STRATEGIC ALLIANCES - 2

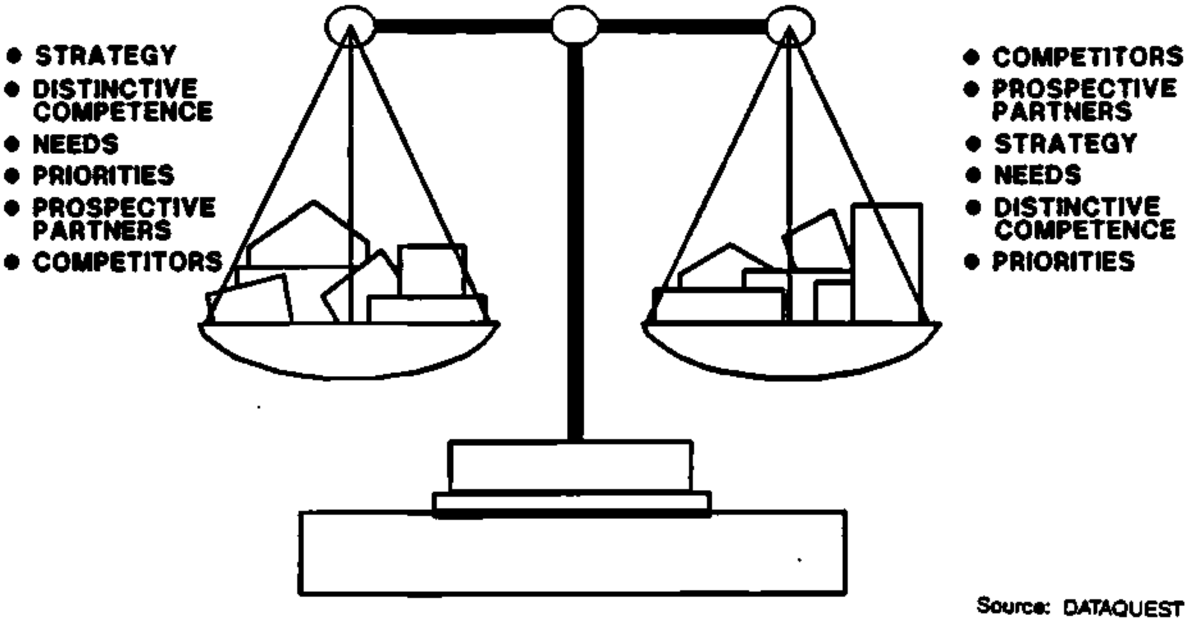
- Marketing arrangements — AMCC/Suwa
- Financial support — MITI
- Key individuals — Dr. Nishi/HP; Inamori/Vitelic – counterpoint
- Vertical alliances — Daisy/Siemens
- User/vendor relationships —

EVALUATING A STRATEGY OF ALLIANCES

- Do you need?
- How many alliances?
- Focus?
- Can you handle #?

DEVELOPING A STRATEGIC ALLIANCE

--BALANCING THE SCALES



Source: DATAQUEST

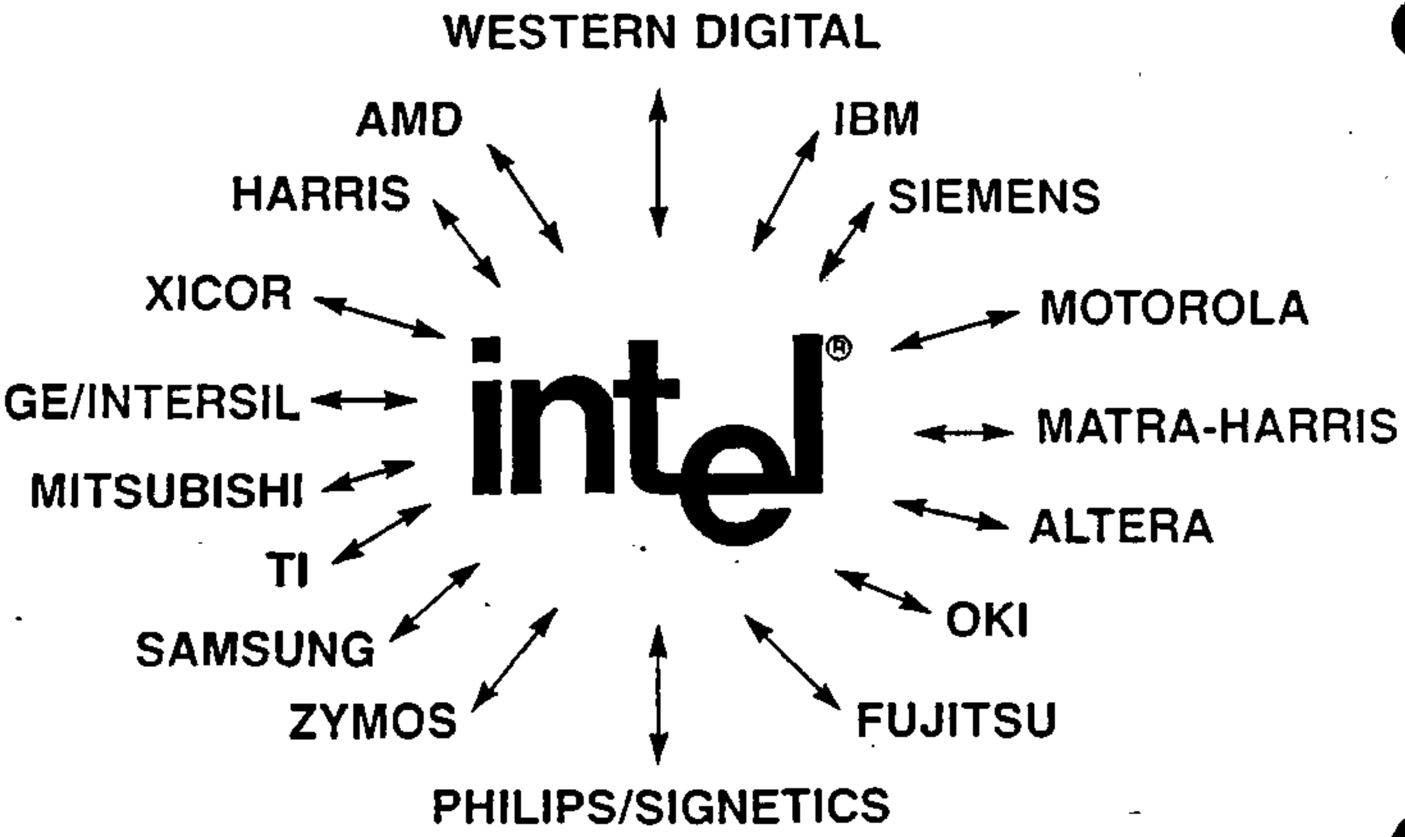
DEVELOPING A STRATEGIC ALLIANCE

- Are equal values being exchanged?
- Will the alliance work culturally? < corporate national
- Does each partner have a stake in the other's success? Conflicts of corp. philosophy?
- What is your prospective partner's experience in previous alliances?
- Does your prospective partner share your ultimate goal?

MAKING IT HAPPEN

- Know what you want and what you can get
- Treat the alliance as a major building block in your corporate strategy
- Develop the alliance top level to top level
- Establish internal consensus
- Make sure that each side knows its responsibilities
- Hold regular joint reviews of the relationship

SOME EXAMPLES . . .



intel®

WESTERN DIGITAL

IBM

SIEMENS

MOTOROLA

MATRA-HARRIS

ALTERA

OKI

FUJITSU

PHILIPS/SIGNETICS

ZYMOS

SAMSUNG

TI

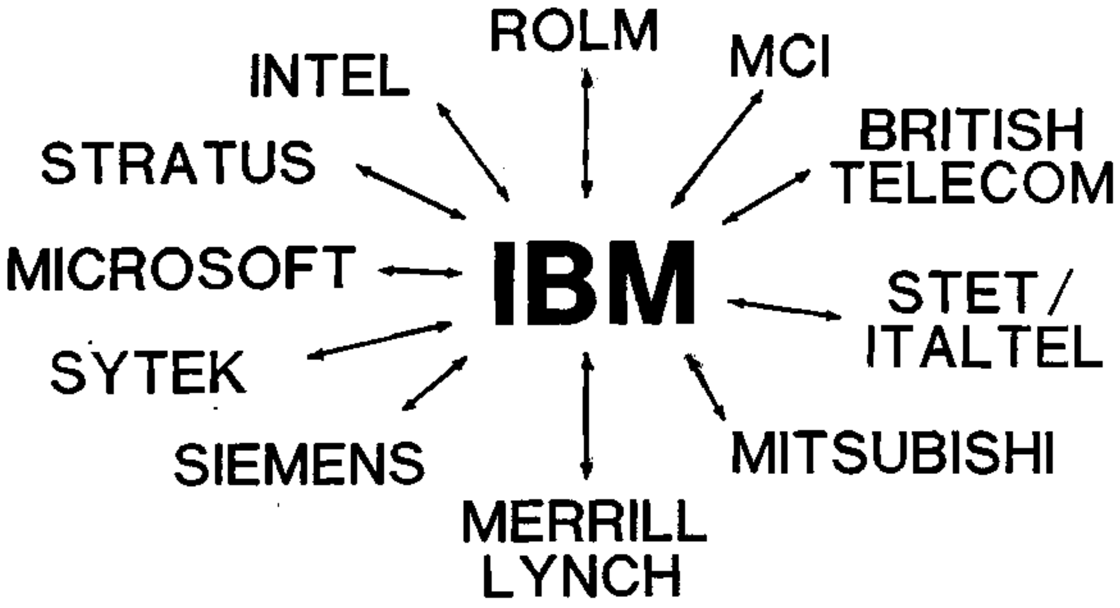
MITSUBISHI

GE/INTERSIL

XICOR

HARRIS

AMD



IBM

ROLM

MCI

BRITISH TELECOM

STET/ ITALTEL

MITSUBISHI

MERRILL LYNCH

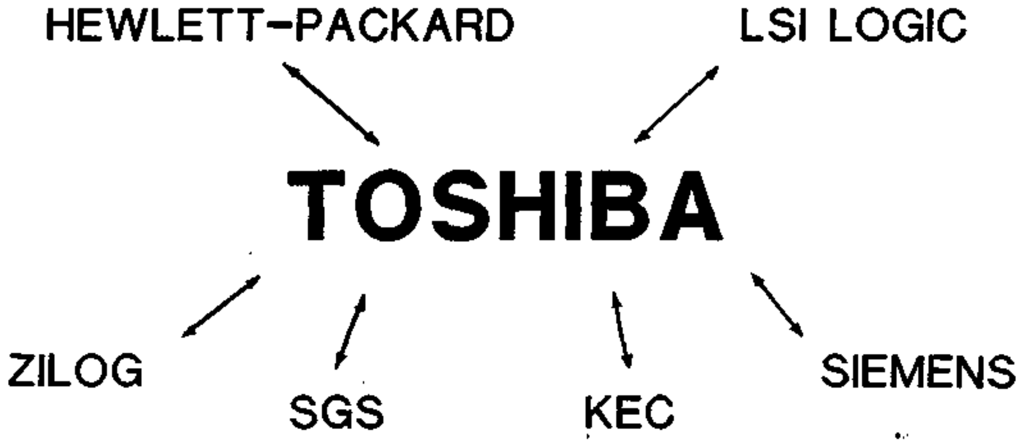
SIEMENS

SYTEK

MICROSOFT

STRATUS

INTEL



HEWLETT-PACKARD

LSI LOGIC

TOSHIBA

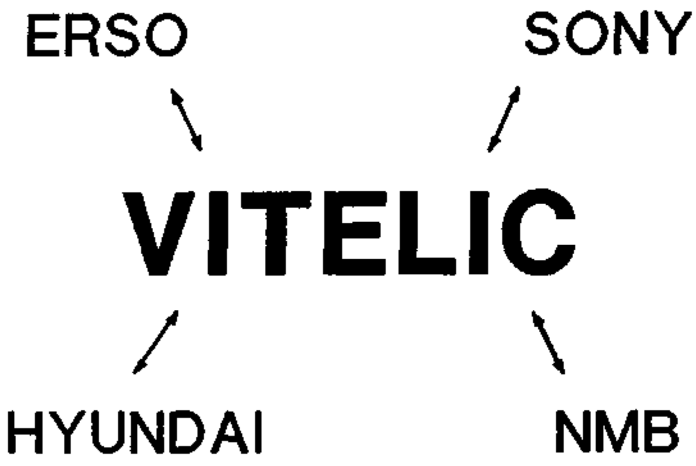
ZILOG

SGS

KEC

SIEMENS

20% equity in Olivetti



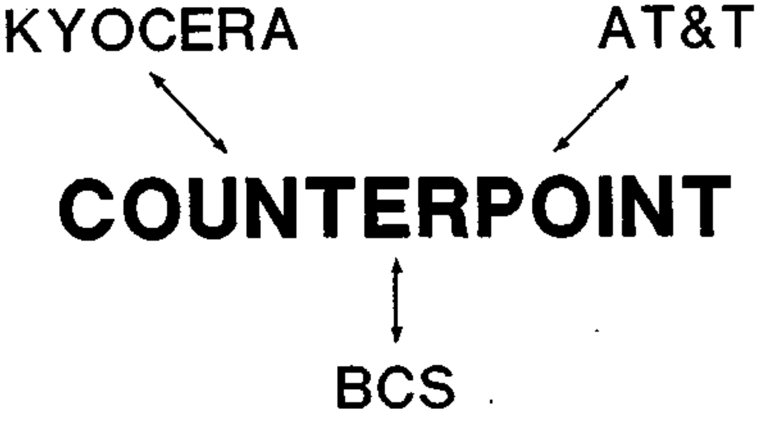
ERSO

SONY

VITELIC

HYUNDAI

NMB



KYOCERA

AT&T

COUNTERPOINT

BCS

British & Commonwealth

THE ARITHMETIC OF ALLIANCES

\+ add ~~and~~ resources

− reduce costs

÷ divide time to market

× multiply technical talent

e.g. WSI/Sharp
Cypress/Matra-Harris