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Semiconductor industry

6 SEMICONDUCTORS

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6.0 SEMICONDUCTORS

The semiconductor industry is on the forefront of a new era in manufacturing. The technology issues of the past are rapidly fading away. They are giving way to newly emerging manufacturing issues. These changes are having a profound effect on both the semiconductor industry and the equipment companies who supply them. Consequently, VLSI Research has added a new volume III covering semiconductors to better serve your needs.

This is the first issue of semiconductors for the VLSI Manufacturing Outlook. This section completes the chain which ties together all aspects of VLSI Manufacturing. The objective of Volume III will be to cover the demand side of manufacturing. It will concentrate on semiconductor markets, devices and their manufacture.

Previous users of the VLSI Manufacturing Outlook will find this new volume to be distinctly familiar. It follows the same architecture of Volumes I and II. Section 6.1 covers the semiconductor industry structure. It starts off by delineating the way in which the markets have been segmented. It then examines the more qualitative aspects of competition in the semiconductor industry. It finishes with a complete listing of all known semiconductor manufacturers in the world. This is backed up with a complete historical data base given at the end of Volume III in Section 6.10.

Section 6.2 covers market trends for the semiconductor industry. It starts with an examination of the electronics industry itself. It breaks out the key user segments and describes why they are important. It also covers the demographic distribution of the electronics industry. Section 6.2 then covers the worldwide supply of semiconductors by each of the major market segments. Sales volumes are given in both dollars and units. This section is completed with a five year forecast of the semiconductor market.

Sections 6.3, 6.4, 6.5 and 6.6 cover the major geographic market segments of the world. These sections will be released in coming months. Each of these sections will cover the major semiconductor market segments and competitors in these areas. Its focus will be on the competitors and the products which emanate from them. Attention will be given to the specific manufacturing issues emanating from each geographic area.

6.1 SEMICONDUCTOR INDUSTRY STRUCTURE

6.1.1 Products

- Device Applications
- Device Processes
- Device Complexity

6.1.2 Competitive Environment

- Supplier Segmentation
- Demographic Aspects
- Capital Expenditures

6.1.3 Supplier Concentration

- Supplier Segmentation
- Domestic
- Foreign

6.1.1 SEMICONDUCTOR PRODUCTS

The accepted market segmentation of semiconductors is one based on a history of product evolution. As such, many different product characteristics have been used as a methodology for segmentation. As a result, they often don't match well with practical applications. Today, the market is typically segmented around three key characteristics. They are shown below:

- Process
- Application
- Complexity

The first semiconductors were discrete devices. These were initially segmented by function into categories for diodes, transistors, rectifiers, etc. Integrated circuits were just developing, having been invented in 1958. MOS processes were not yet practical so the first IC's were developed with bipolar process technology. A multitude of bipolar IC market segments ensued. RTL, DTL, TTL, I^2L and ECL are examples of these. Each are different forms of logic devices with variations in bipolar process steps. With the advent of MOS and many new emerging applications, a new segmentation by application and by complexity became necessary. The most basic such segmentation was by discrete devices and integrated circuits.† Speed also became an important classification. However, speed is usually considered a subset of these other three.

Product segmentation evolved further to incorporate splits by both function and by complexity into various subsegments of the industry. The Hierarchy of market segmentation used by VLSI Research gives application the highest priority. Process type has second priority in segmentation. Finally device complexity has third priority.

The SIA's semiconductor trade statistics program utilizes a similar method as an industry standard. However, they reverse process and application in their hierarchy. We intend to maintain a similar segmentation because it provides a ready base for comparison of data. However, VLSI Research prefers to track the market by application since this is directly related to demand. As a result, it can be more accurately forecast.

† In Japan, this segmentation is entitled, semiconductors and IC's, semiconductors being the Japanese equivalent for discretes. Whereas, in the U.S. the term semiconductor is inclusive of both discretes and IC's. This can easily lead to confusion when comparing information from both countries.

Device Applications

Figure 6.1.1-1 displays the basic market segmentation which VLSI Research uses to track the semiconductor market. Their are four major segments to this market. Hybrid integrated circuits are combinations of IC and discrete die into a single package. The hybrid IC market is usually considered to be outside the mainstream of the semiconductor industry. We do not intend to cover them as a part of this volume. Hybrids dominately affect the assembly segment. Consequently, information on hybrids can be found in assembly section 5.2.2.

The photoelectric segment is also usually considered to be outside the mainstream of the semiconductor industry. These devices are manufactured by companies not normally found in the 'classic' IC or discrete markets.

The distinction between discretes and IC's are further segmented by device complexity. As IC's grew in complexity, standard product segments based on device applications emerged. IC's split into digital and linear components. Digital became further segmented into memory and logic. About five years ago, Digital and linear circuitry began merging together. A fourth category emerged as a result, which is a mixture of digital and linear. These devices are called digital signal processing (DSP). The five segments of the semiconductor market, covered in this volume, can thus be summarized as:

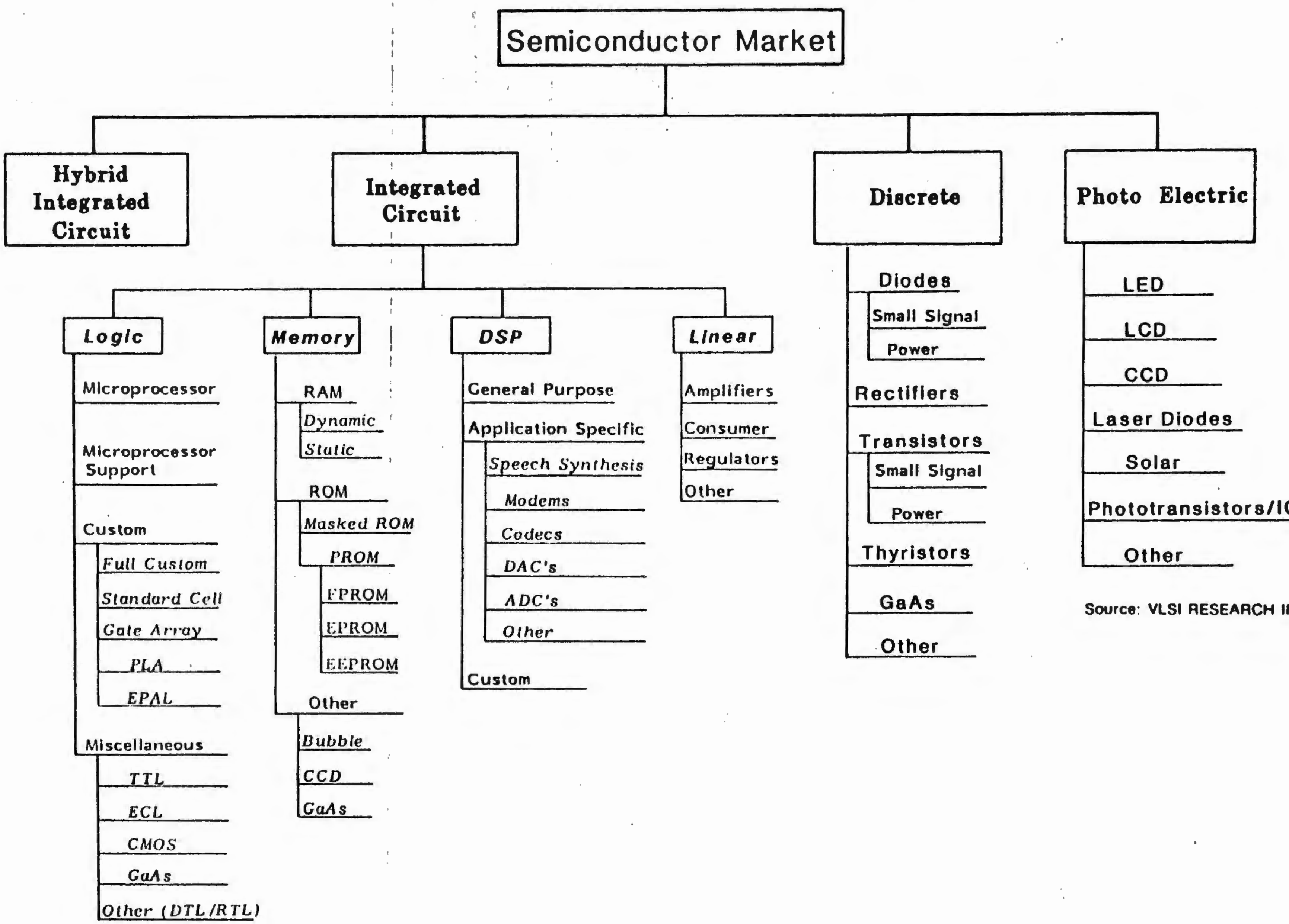
- Logic
- Memory
- Digital Signal Processing
- Linear
- Discrete & Photoelectric

The market for logic devices can be broken into at least four major submarkets. These are as follows:

- Microprocessors
  - 4 bit
  - 8 bit
  - 16 bit
  - 32 bit
- Microprocessor Support
- Custom Logic
  - Full custom
  - Standard cell
  - Gate Array
  - PLA/EPAL
- Miscellaneous Functional Blocks

Figure 6.1.1-1

MARKET SEGMENTATION



Source: VLSI RESEARCH INC.

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The microprocessor market includes microprocessors and single chip microcomputers. Microprocessor support includes all the additional devices needed to make a computer with a microprocessor. This includes transcievers, registers, drivers, receivers, controllers, gates, shift registers, etc.

Custom logic devices are those tailored to a specific customer's needs. Full custom devices are designed from scratch. Every mask level must be designed, as well as optimized, for silicon real estate. Standard cell products are devices in which predesigned functional logic blocks can be brought together in a CAD system to design a device. These are then transferred to silicon. As a result, standard cell devices are quicker to design than are full custom devices. However, all mask levels still have to be designed with standard cell devices. The gate array approach differs from standard cells in that only the upper metallized layers are designed and processed. Previously designed and processed wafers with arrays of unconnected gates are the starting point for gate arrays. This approach is even faster.

PLA's (Programmable Logic Arrays) and EPAL's (Electrically Programmable Array Logic) are programmed by the user, instead of being designed by the user. These are the quickest to be 'designed'. They also have the advantage of being a standard part.

Miscellaneous functional logic blocks include mostly SSI/MSI parts such as adders, logic register stacks, multipliers, gates, counters, inverters, flip-flops, lattices, and many other parts. These devices are more commonly identified by process rather than by function. This is because they are commodity items.

Memory can be divided into two segments: Random Access Memories (RAM) and Read Only Memories (ROM). These are further subdivided by size and by function. Sizes are measured by thousands of bits of memory (K). One K is equivalent to 1024 bits. RAM's can be further segmented into dynamic and static categories. Dynamic RAM's have higher packing density and thus are less costly than static RAM's. This is because the cell is composed of only one transistor and one capacitor. However, the cells must be refreshed periodically, which slows the device down.

Static RAM's are inherently faster since they don't have to be refreshed. Static RAM's used a flip-flop for each storage cell. This requires more devices per cell. For example, a bipolar static RAM with diode coupled cells requires two diodes, two resistors, and two diodes. ROM's are divided into two types: masked ROM's, and programmable ROM's. Programmable ROM's are further segmented into fuse Programmable (PROM or FPROM), Electrically Programmable (EPROM) and Electronically Erasable Programmable (EEPROM or E^2PROM).

Digital signal processing devices (DSP) are a new and emerging segment of the semiconductor market. These are a mixture of the microprocessor market and the linear market. As a result, data concerning this segment is often mixed into both markets. In its strictest sense, digital signal processing is a sampling method which transforms analog signals into digital ones, and vice versa. These components are sophisticated microcomputers which perform sum-of-products type applications. They typically use fast, on-chip, multipliers or ALU's with accumulators. They usually have on-chip RAM, on-chip ROM, on-chip peripherals and on-chip buses. Signals are manipulated mathematically by using software. New signals can also be generated mathematically. Consequently, conventional linear circuits such as filters, modulators and oscillators can be eliminated from the external circuit. These common linear parts are directly competitive with the more sophisticated mixed signal processors and thus are a part of the DSP market.

There are three major segments of the DSP market:

- General Purpose DSP
- Application Specific DSP
- Custom DSP

The general purpose DSP market consists of devices such as TI's TMS 310 and NEC's PD 7720. These parts are typical of the very sophisticated microprocessors previously described. Application specific DSP devices are those which have been configured for specific markets such as speed processors and modems. It also includes DSP functional blocks. DSP functional blocks are the building blocks of a DSP system. These include accumulators, DAC's and ADC's, multipliers, accumulators, pipeline registers, FFT address sequencers, etc. There are no custom DSP devices available on the merchant market. However, several are made by captive manufacturers.

Linear circuits are those whose outputs varies in proportion to their inputs. In this context, linear circuits are synonymous with analog circuits. The linear IC market consists of the following segments:

- Amplifiers
- Consumer Products
- Regulators
- Other

The discrete market is composed of four major segments. These included diodes, rectifiers, transistors, and thyristors. Additionally their is a special segment of GaAs discretes and other miscellaneous devices.

The photoelectric market is composed of light emitting diodes (LED) and liquid crystal displays (LCD). LCD's are not technically semiconductors. However, they are competitive with LED's. There are also CCD imaging devices, laser diodes, solar cells, phototransistors, photointegrated circuits, and other miscellaneous circuits.

Device Processes

Sub-segmentation of the market by process is an important adjunct to segmentation by application. There are two types of transistors: Field effect and Bipolar. Field effect devices dominate the market. By far, the largest segment of these are Silicon Gate MOS. MOS can be further segmented into complementary MOS (CMOS) and N channel MOS (NMOS). Bipolar devices are the second largest market segment. Most IC's and Discrete devices are manufactured with MOS or Bipolar processes. GaAs based MES devices are a narrow niche limited to high speed and microwave applications.

Device Complexity

As previously mentioned, there are two market segments of devices by complexity. They are discrete devices and integrated circuits. A discrete device is one in which a single electronic component is made on a chip. For example, these consist of a diode, or a transistor. However, the discrete market has evolved in a manner to obfuscate this definition somewhat. Some power discretes can have as many as a few hundred components. They resemble an SSI/MSI IC. They remain in the discrete market because they still operate like single component instead of like a circuit. Integrated circuits are composed of multitudes of discrete devices on a single chip. Additionally, IC's also contain capacitors and resistors.

Circuit complexity is defined as the total number of components needed to build a given circuit. There are seven commonly-used terms which describe this scale of complexity. Each term describes a rough range of component counts:

Complexity Scale	Component Count
• Discrete	1 - ?
• SSI (Small Scale Integration)	2 - 99
• MSI (Medium Scale Integration)	100 - 999
• LSI (Large Scale Integration)	1000 - 99999
• VLSI (Very Large Scale Integration)	100000 - 9999999
• ULSI (Ultra Large Scale Integration)	10,000000 - 999999999
• WSI (Wafer Scale Integration)	-

Wafer scale integration is not bounded by component count. In this case there are so many components that the entire wafer must be used to hold them.

These categories are not quite as numerically exact as it may appear. The upper end of these component count ranges are approximations of technology barriers which might be viewed as being somewhat akin to the sonic barrier. Chip density is an approximate measure of where one of those barriers might likely be found. Costs skyrocket as a given technology reaches it's limitations. Consequently it has been an economic necessity that each of these barriers be overcome in order for the semiconductor industry to advance.

6.1.2 COMPETITIVE ENVIRONMENT

The strong recovery of the semiconductor industry in 1983 and continuance of that momentum in 1984 turned losses into profits. It has strengthened the companies that weathered the recession and has brought new companies into the market. In turn, this market growth has increased competition, both domestically and worldwide. Specific issues as they relate to demographic areas will be discussed later in this section.

Today, the semiconductor industry consists of 407 competitors worldwide. The major competitors are concentrated in the U.S., in Japan, and in Europe. There are also several other countries which are fairly recent entrants into the market; for example, Korea, India, China, and Taiwan. In the past, most of these third world countries' involvement has been limited to assembly.

Companies that manufacture semiconductors range in size from very small laboratories to the world's industrial giants. They range in purpose from totally captive production lines to the entirely commercial or 'merchant' firms. Among the U.S. corporations, forty-seven are to be found listed in Fortune Magazine's 'Fortune 500' listing for 1983. In fact, fifteen will be found among Fortune's top 50 firms if the captive as well as the merchant firms are included.

This section describes the competitive aspects of worldwide semiconductor production. It covers the demographic distribution of competition in the market.

TYPES OF SEMICONDUCTOR MANUFACTURERS

Semiconductor manufacturers can be segmented by examining two attributes. The first attribute concerns the extent that a manufacturer is captive or merchant. The second attribute concerns the extent to which he builds his own capital equipment.

Captive semiconductor producers have substantially different equipment buying habits from the merchant producers. Buying habits are different because the motivations for production are different. A merchant semiconductor manufacturer is driven by the profit motive. The company is competing in a highly competitive and volatile market with thin profit margins. Any drop in yield or thruput can easily bring large losses. Consequently, yielded volume per unit investment is oftentimes one of the merchant user's primary considerations when evaluating and purchasing equipment. The merchant user is also very pessimistic when measuring yielded thruput per dollar invested. Typically the merchant customer will sum up the total number of die that have been processed over a one week period and divide the result by the number of hours the machines have been in use. The result is usually a very conservative measure of equipment utility. It includes just about every conceivable limiting factor that can be measured. It includes things such as break time, downtime, and preventive maintenance time. These factors cause the merchant semiconductor manufacturer to place very heavy stress upon the volume of good die processed, but not upon technology. Technology considerations are usually only a small part of his overall concern. Often these have been previously determined in the R&D phase. Consequently, the high-volume merchant producers often take conservative approaches to equipment uses.

By way of contrast, a captive semiconductor manufacturer is driven by a more complex set of motives. The essential function of a captive manufacturing line is to provide a certain source of semiconductors to its parent. Profits are rarely a principal motive for captive semiconductor production. Instead, the typical motives for captive semiconductor production usually include one or more of the following:

- To guarantee procurement of essential components
- To ensure and control product delivery
- To assure product reliability

The most common motive among captive customers is to ensure product delivery of essential components. This is particularly true when advanced semiconductor technology is involved. It has become common knowledge that VLSI integrated circuits hold many of the keys to major electronic advances that are expected in the future. Semiconductor applications are becoming prevalent throughout industry. Companies who do not maintain a leading edge capability fear that they will eventually lose out to those that do. As a result, many of the top industrial companies have taken steps to maintain such a captive source of semiconductors.

Because of this need to ensure a proprietary source of semiconductors, the captive manufacturer's buying habits will be substantially different from that of the merchant manufacturer. The captive manufacturer will stress the purchase of equipment that provides a technology edge and an ability to manufacture very advanced IC technologies. This equipment will be strongly favored over that which provides high volume. An example of this is demonstrated by the fact that world captive manufacturers hold approximately fifty percent of the world installed base of X-ray exposure and E-beam lithography equipment – yet captive manufacturers accounted for only 22.3% of world semiconductor shipments in 1983.

Likewise, high equipment throughput rates are not usually stressed by the captive manufacturer. For otherwise, E-beam lithography and X-ray exposure equipment would be less prevalent. Typical throughput of E-beam lithography equipment is one to two, four-inch wafers per hour. By contrast, a typical projection aligner used in a merchant supplier's operation will have all possible features of automation and will operate at around 60 wafers per hour.

Nevertheless, profitability may eventually enter as a constraint to captive manufacture. In recent years, many captive manufacturers began to startup gate array manufacturing operations. The purpose was to reduce design, inventory, and manufacturing costs. For the captive manufacturer, gate arrays can offer substantial advantages over conventional manufacturing. One advantage is that gate arrays can ease the burden of servicing and maintaining the manufacturer's installed equipment base. Many of the large captive manufacturers produce equipment whose lifetime installed base is less than a few thousand units. This equipment must often be supported for several years after the last unit has been built and sold. A full inventory of parts must be maintained on equipment that is not even on the market.

This can accrue large semiconductor inventory cost burdens, for, if inventory is depleted, it may be virtually impossible to rebuild semiconductors that haven't been built for many years. Manufacturing processes and equipments will have changed. It might take months to release a new recipe and make a good component.

A captive manufacturer can eliminate much of these problems by using gate arrays. With gate arrays, only the last few interconnecting metal layers need be designed. If new parts are subsequently needed, a manufacturer can simply retrieve stored masks or E-Beam tapes from his library and expose only these final layers. Additionally, one standard gate array design wafer may serve for a multitude of parts which use that common gate array configuration.

The second attribute to be examined about the nature of the customer concerns the extent that equipment is built internally. During the fifties and the sixties almost all semiconductor manufacturers maintained their own equipment design teams. They had to – it couldn't be purchased. However, equipment manufacturers began to abound in the seventies and these teams were disbanded except among two or three of the giants – notably IBM and Texas Instruments.

However, VLSI circuits are equipment dependent. Some semiconductor manufacturers have thus begun to re-establish or to strengthen internal equipment engineering groups. This generates costly internal engineering support burdens which tends to push that captive equipment supplier out into the open market, where it will become a competitor. Hitachi, Philips and Thomson CSF are examples. When internal equipment groups exist, merchant equipment suppliers tend to get only the overflow that these internal groups cannot handle.

DEMOGRAPHIC ASPECTS

Semiconductor manufacturers based in the United States accounted for 52.5% of the world market in 1983. Japanese semiconductor manufacturers accounted for 35.5% and are a growing strength in the world market. Table 6.1.2-1 gives semiconductor shipments by geographic area for 1979 through 1984 estimated. Shipments are further segmented by type of manufacturer.

TABLE 6.1.2-1

DISTRIBUTION OF WORLD SEMICONDUCTOR SHIPMENTS
($M)

	1979	1980	1981	1982	1983	1984E
United States	7785.2	10357.0	10536.5	10481.8	12792.7	18325.5
Merchant	6032.2	7974.3	7904.9	7702.3	8651.6	13797.2
Captive	1753.0	2382.7	2631.6	2779.5	4141.1	4928.3
Japan	3972.3	5868.7	6842.9	6659.8	8659.6	12344.2
Merchant	3444.0	5193.8	6042.3	5860.6	7577.7	10983.5
Captive	528.3	674.9	800.6	799.2	1081.9	1360.7
Europe	2155.7	2420.7	2188.0	2130.5	2931.7	3177.6
Merchant	2052.2	2202.3	1998.1	2022.2	2706.5	2908.4
Captive	103.5	218.4	189.9	108.3	225.2	269.2
TOTAL	13913.2	18646.4	19567.4	19272.1	24384.0	33847.3
Merchant	11528.4	15370.4	15945.3	15585.1	18935.8	27289.1
Captive	2384.8	3276.0	3622.1	3687.0	5448.2	6558.2

Source VLSI RESEARCH INC

In 1983, worldwide sales of semiconductor manufacturers grew by 24%. Last year, as the economy emerged from the 1981-1982 recession, semiconductor manufacturers began to see rapid increases in sales. Bookings and backlogs gained momentum, especially during the latter half of 1983. Total worldwide semiconductor shipments are expected to reach almost $34 billion this year. This is a 38.5% increase over 1983. Total U.S. semiconductor shipments will increase by 43% while Japanese and European shipments grow by 41% and 10%, respectively.

The captive suppliers tend to be counter-cyclical to merchant manufacturers. Captive sales increased by 1.8% in 1982, while merchant sales declined by 2.3%. In 1983, however, captive sales increased 47.8% over the previous year. In 1984, captive suppliers are expected to slow to an increase of 20.4% over 1983.

Table 6.1.2-2 shows the historical shipments of merchant semiconductor manufacturers. As can be seen, total sales increased by 24% in 1983. It is well known that Japanese suppliers have been increasing their share of the merchant market for several years. In 1983, they accounted for 40% of the total market. However, it appears that Japanese growth may level-off. In 1984, Japanese share of the overall market is expected to actually decline by 0.8%. But this decline in market share is still a 41.1% growth over 1983. During this same period, U.S. merchants are expected to reach 51% market share. The reason can be attributed to a saturation of Japanese demand by Japanese suppliers. Japanese suppliers will have to begin to make major inroads into the U.S. market to continue their market share gains.

INTERNATIONAL MARKET SHARE

The world's top fifty semiconductor manufacturers are shown in Table 6.1.2-3 by dollar volume and market share. Together these companies manufactured 89% of worldwide production in 1983.

Among these, the top ten companies account for 50% of the total world supply of semiconductors. Their market share by percent of demography is:

	World Market Share
American Companies Among the Top 10	26.4%
European Companies Among the Top 10	4.5%
Japanese Companies Among the Top 10	20.1%
All Other Domestic and Foreign Companies	50%

TABLE 6.1.2-2

WORLDWIDE MERCHANT SEMICONDUCTOR SHIPMENTS*

Year	Shipments in Millions of Dollars			
	Total	U.S.	Japan	Europe
1952	19	19		
1953	26	26		
1954	26	26		
1955	40	40		
1956	90	90		
1957	151	151		
1958	210	210		-
1959	399	395	-	4
1960	611	594	8	9
1961	631	580	21	30
1962	745	638	46	61
1963	1003	784	82	137
1964	1255	923	121	211
1965	1620	1122	183	315
1966	2224	1467	260	497
1967	2040	1383	205	452
1968	2154	1415	270	469
1969	2578	1687	376	515
1970	2839	1720	587	532
1971	2596	1511	520	565
1972	3597	2136	826	635
1973	4879	2927	1009	943
1974	6025	3431	1265	1329
1975	4903	2777	1021	1105
1976	6337	3334	1711	1292
1977	7162	3864	1835	1463
1978	9203	4705	2733	1765
1979	11528	6032	3444	2052
1980	15370	7974	5194	2202
1981	15945	7905	6042	1998
1982	15585	7702	5861	2022
1983	18935	8651	7578	2706
1984E	27289	13797	10984	2908

Source: VLSI RESEARCH INC.

* By nationality of the supplier, not by region of production.

TABLE 6.1.2-3

TOP 50 SEMICONDUCTOR MANUFACTURERS FOR 1983

1983 Rank	1982 Rank	Company	Total Revenue ($M)	Semi Revenue ($M)	Market Share (%)
1	1	TI	4542.8	1665.0	6.83
2	4	NEC	6994.5	1604.2	6.58
2	2	Motorola	4328.0	1601.0	6.57
4	5	Hitachi	19088.8	1457.3	5.98
5	3	IBM	40180.0	1304.8	5.35
6	8	Toshiba	10712.3	1125.0	4.61
7	6	National Semi	1655.1	1102.5	4.52
8	7	N.V. Philips	16204.6	874.3	3.59
9	9	Intel	1121.9	772.5	3.17
10	10	Fujitsu	4842.8	702.4	2.88
11	11	Matsushita	16618.8	595.6	2.44
12	17	Mitsubishi	7271.9	581.3	2.38
13	16	AMD	583.3	571.3	2.34
14	14	AT&T	11155.0	509.3	2.09
15	12	Schlumberger	5797.5	481.8	1.98
16	13	Sharp	4075.7	475.0	1.95
17	15	Siemens	15478.8	405.1	1.66
18	18	HP	4710.0	362.8	1.49
19	25	Tokyo Sanyo	1146.3	316.7	1.30
20	21	Mostek	14669.3	306.7	1.26
21	20	RCA	8977.3	304.8	1.25
22	27	Oki	1250.0	291.7	1.20
23	26	Delco (GM)	74581.6	278.4	1.14
24	30	Rohm Fukuoka	231.3	272.9	1.12
25	23	Nippondenso	2819.5	261.1	1.07
26	22	General Electric	26797.0	255.8	1.05
27	24	ITT	14155.4	251.7	1.03
28	19	General Instru.	896.4	232.6	0.95
29	33	Fuji Electric	1878.4	203.9	0.84
30	28	Thomson CSF	4040.7	198.7	0.81
31	29	Gould (AMI/Dexel)	1324.8	188.9	0.77
32	32	SGS-ATES	225.0	179.3	0.74
33	35	TDK	1444.1	155.6	0.64
34	31	Harris	1433.3	151.5	0.62
35	34	Telefunken	141.2	141.2	0.58
36	37	Analog	214.0	140.1	0.57
37	36	Sony	4629.3	139.7	0.57
38	38	Sanken	205.1	128.9	0.53
39	44	Kokusai	276.7	117.3	0.48
40	41	TRW	5493.0	111.1	0.46
41	50	Monolith. Mem.	105.4	105.4	0.43
42	45	Ferranti	600.0	99.1	0.41
43	51	Shindengen	174.3	88.9	0.36
44	42	Int'l Rectifier	126.8	88.6	0.36
45	48	Teikoku Elec.	120.9	88.3	0.36
46	38	Honeywell	5753.1	87.3	0.36
47	47	Stanley Elec.	389.8	85.8	0.35
48	46	Commodore	681.2	85.7	0.35
49	53	Taiyo Yuden	212.8	83.0	0.34
50	43	Rockwell	8097.9	80.1	0.33
		Total Top 50		21712.0	89.04
		Other		2672.0	10.96
		WORLDWIDE TOTAL		24384.0	100.00

Source: VLSI RESEARCH INC

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American companies continued to dominate the worldwide semiconductor market in 1983. Five of the top ten companies are American. The top position is held by an American company. The second position is essentially tied between an American and a Japanese company. The Japanese have continued their advancement into the top 10. Among the top ten there are four Japanese and one European company. Between 1982 and 1983, the top ten places were held by the same companies; only their positions changed. In 1983, U.S. companies among the top ten lost a cumulative total of three places. Overall, most Japanese companies moved up in rank. As a whole, Japanese companies gained 1.0% market share.

SEMICONDUCTOR CAPITAL EXPENDITURES

Worldwide semiconductor capital expenditures will amount to an astounding $9.3 billion in 1984. This represents an 89.8% increase in expenditures over 1983's value of $4.9B. Table 6.1.2-4 shows a 5-year history of these expenditures along with an estimate of this year's value.

Of the three main demographic areas, the U.S. has consistently spent the largest amount on capital investment - both in terms of dollars and as a percentage of sales. In total dollars, the U.S. will spend over two billion more than Japanese semiconductor companies, and four billion dollars more than European companies in 1984.

In terms of capital investment as a percentage of sales, U.S. companies spend an average of 2.1% more than Japanese companies. However, this does not mean that a conservative approach to capital investment is typical of Japanese companies. It only means that in aggregate they spend less. In fact, it can be shown that Japanese manufacturers get more capacity per dollar investment than do American suppliers.

There are four factors which contribute to this difference between capital expenditures and capacity. They are as follows:

- Interest rates are lower in Japan
- Equipment prices are lower in Japan
- Plants operate more hours per week in Japan
- Industry is more concentrated in Japan

The U.S. and European geographic areas have more small companies compared to Japan. In a small company, it is much more difficult to realize the advantages of economies of scale. That is, they are unable to optimize equipment, plant, and employees due to a smaller revenue base. Hence, it is typical that the larger a company's semiconductor sales, the lower its ratio of sales to capital investment. Moreover, there are many new start-ups each year who build new plants but have no revenue base. Thus, capital expenditures, as a percent of

TABLE 6.1.2-4

SEMICONDUCTOR CAPITAL EXPENDITURES

	1979	1980	1981	1982	1893	1984E
United States						
Total Semiconductor Sales ($M)	7785.2	10357.0	10536.5	10481.8	12994.2	18858.5
Semiconductor Capital Expenditures ($M)	1549.3	2071.4	2324.4	2180.2	2741.8	5395.7
Semiconductor Capital Expenditures (%)	19.9	20.0	20.6	20.8	21.1	28.6
Japan						
Total Semiconductor Sales ($M)	3972.3	5868.7	6842.9	6659.8	9006.3	12644.2
Semiconductor Capital Expenditures ($M)	603.8	1073.9	1163.3	1212.1	1711.2	3191.5
Semiconductor Capital Expenditures (%)	15.2	18.3	17.0	18.2	19.0	25.2
Europe						
Total Semiconductor Sales ($M)	2155.7	2420.7	2188.0	2130.5	2383.5	3177.6
Semiconductor Capital Expenditures ($M)	377.2	443.0	378.5	409.1	502.9	765.0
Semiconductor Capital Expenditures (%)	17.5	18.3	17.3	19.2	21.1	24.1

Source VLSI RESEARCH INC

revenues, are virtually infinity! The semiconductor industry in Japan, on the other hand, consists predominantly of large corporations. There are few start-ups. The facilities of the large companies are large enough to be able to take advantage of optimal plant, equipment, and employee utilization. One way to confirm this is to compare companies of equivalent size.
Table 6.1.2-5 compares the ratio of capital expenditures to semiconductor sales for U.S. and Japanese semiconductor companies' of similar size. The typical Japanese company actually spent at a higher rate than its U.S. counterpart. Japanese companies spent an average of 4.2% more than similarly sized U.S. companies.

Another important advantage that Japanese firms have is longer work weeks. Typically a Japanese plant will operate for 30 days. It will stop for one day to do preventative maintenance. An additional 4 hours of maintenance is scheduled per week and two weeks of shut down per year are taken. Such plants average 130 hours of effective operation per week. A typical American plant will achieve only 100 hours of effective operation. This advantage cuts capital cost by 23%.

Equipment prices are on average 33% lower in Japan. The Japanese market for semiconductor production equipment is the most heavily fought over area of the world. Japanese suppliers have several cost advantages over U.S. suppliers. This allows them to offer competitive gear at lower prices. In order for American companies to compete they often offer substantial discounts to Japanese semiconductor suppliers.

The final area where Japanese semiconductor suppliers have an advantage is in lower interest rates. They are typically several points lower in Japan than in the U.S.

In summary, these factors compound into a 52% real capital cost advantage over American based plants. However, American companies can take advantage of these factors by placing their plants in Japan. Several American manufacturers have done this. These are IBM, Texas Instruments, Motorola, Fairchild and Analog Devices.

Table 6.1.2-6 gives the top 50 semiconductor capital spenders for 1984. These values are projected 1984 capital expenditures based on an analysis of each company's historical performance. Texas Instruments ranked number one in total expenditures. Standard Microsystems spent the largest percentage of sales on capital – 49%! They were followed by Fujitsu, Gould, Siemens, and Matsushita, respectively.

From Table 6.1.2-6, we can see some trends emerge among some of the world's leading semiconductor producers. For example, the average capital expenditure for captive manufacturers tends to be higher. This can be attributed to the fact that captives do not place as much importance as merchants, on efficiency. One reason is they do not have

TABLE 6.1.2-5

RATIO OF SEMICONDUCTOR SALES TO SEMICONDUCTOR CAPITAL EXPENDITURES (1983)

Range of Semiconductor Sales ($M)	U.S. Companies	Capital Expenditure Ratio	Japanese Companies	Capital Expenditure Ratio
$1600-1700	Motorola Texas Instruments	11.0% 13.9%	NEC	17.4%
$1000-1500	National Semiconductor	22.8%	Hitachi Toshiba	14.3% 22.2%
$600-900	Intel	18.1%	Fujitsu	32.6%
$500-600	Advanced Micro Devices	22.4%	Mitsubishi	25.4%
$500-1700	Average Capital Investment	16.2%	Average Capital Investment	20.4%

Source: VLSI RESEARCH INC

TABLE 6.1.2-6

TOP 50 CAPITAL EXPENDITURE ESTIMATES FOR 1984

Rank	Company	Semiconductor Capital Expenditures ($M)	Semiconductor Sales ($M)	Capital Expenditures As A Percentage Of Semiconductor Sales
1	Texas Instruments	525.6	2428.9	21.6
2	IBM	500.0	1601.6	31.2
3	NEC	478.3	2391.3	20.0
4	Hitachi	478.0	1894.2	25.2
5	Fujitsu	470.8	958.3	49.1
6	Toshiba	448.0	2021.2	22.2
7	Motorola	354.7	2385.4	14.9
8	Matsushita	347.8	936.4	37.1
9	Intel	340.0	1215.4	28.0
10	National Semiconductor	299.6	1315.2	22.8
11	AT&T	280.1	719.4	38.9
12	AMD	247.5	980.0	25.3
13	Mitsubishi	230.3	760.9	30.3
14	Siemens	204.1	540.3	37.8
15	Schlumberger	191.0	746.8	25.6
16	Mostek	158.8	459.5	34.6
17	Sharp	146.1	599.2	24.4
18	N.V. Philips	145.0	1019.3	14.2
19	Hewlett Packard	126.6	484.8	20.6
20	Gould (AMI/Dexel)	114.6	263.2	43.5
21	General Electric	101.6	317.9	32.0
22	Nippondenso	100.2	386.4	25.9
23	Oki Electric	87.0	434.8	20.0
24	Tokyo Sanyo	86.9	417.6	20.8
25	Rohm Fukuoka	83.0	398.7	20.8
26	Sony	65.5	173.9	37.7
27	ITT	60.7	331.3	18.3
28	RCA	58.4	379.3	15.4
29	Delco (GM)	55.9	409.6	13.6
30	SGS-ATES	51.7	272.6	19.0
31	Monolithic Memories	50.0	200.7	24.9
32	Standard Microsystems	43.3	79.4	54.5
33	General Instruments	39.8	280.9	14.2
34	Thomson CSF	39.5	299.6	13.2
35	Harris Semiconductor	36.0	209.1	17.2
36	Fuji Electric	30.6	239.1	12.8
37	Kokusai	27.8	158.8	17.5
38	Commodore	27.0	154.8	17.4
39	Thorn-EMI	26.7	129.5	20.6
40	Unitrode	24.0	105.1	22.8
41	NCR	23.2	104.4	22.2
42	TRW	21.6	145.4	14.9
43	Rockwell	21.3	96.6	22.0
44	Sanken	20.9	147.9	14.1
45	Shindengen	19.7	105.2	18.7
46	Ricoh	19.6	65.2	30.1
47	Teikoku Electronics	19.5	102.7	19.0
48	Analog Devices	19.2	200.0	9.6
49	Taiyo Yuden	19.1	100.5	19.0
50	Stanley Electric	17.9	94.3	19.0
Subtotal		7384.5	30262.6	-
Others		747.4	4417.7	-
TOTAL WORLDWIDE		8131.9	34680.3	-

Source: VLSI RESEARCH INC.

to compete for sales on the open market – they consume the devices they manufacture. Therefore, they can afford to manufacture at a point where production can be consumed. Merchants on the other hand, are forced to run their factories at an efficient level due to the competitive nature of the industry. This is because merchant manufacturers compete in a market where price and supply are indirectly correlated. As market supply begins to exceed demand, prices fall. Thus, manufacturers are forced into lower profit margins. The only way to increase profit margins on the product, is to increase output efficiently. Due to tight profit margins, manufacturers must operate their facilities at levels that are as close to optimum as possible. This includes careful evaluation of capital expenditures.

CAPTIVE SUPPLIERS

Each year, captive suppliers have increased their share of the overall semiconductor market. In 1979, they comprised 17.1% of the total semiconductor market, and 19.0% in 1983. This may not seem like significant growth, but some industry experts have predicted that all U.S. merchant suppliers will eventually be engulfed by larger corporations.

The overall captive market realized 1.8% growth in 1982 despite the recession. While merchant manufacturers sales declined by 2.3%. This can be attributed to the fact that captives are much less sensitive to the volatilities of the merchant market. A captive supplier's device "sales" are dependent upon the market of the overall product the device becomes incorporated.

The world's top 20 captive semiconductor suppliers for 1983 are shown in the chart below. IBM remained the unquestioned world's leading supplier. AT&T passed Sharp this year to capture the second spot. American companies dominate captive manufacturing. Seventy percent of the top 20 are American based.

1983 TOP 20 CAPTIVE SEMICONDUCTOR MANUFACTURERS

Rank	Company	Semiconductor Revenue ($M)	Total Revenue ($M)
1	IBM	1304.8	40180.0
2	AT&T	509.3	11155.0
3	Sharp	475.0	4075.7
4	Hewlett-Packard	362.8	4710.0
5	Delco (GM)	278.4	74581.6
6	Nippondenso	261.1	2819.5
7	General Electric	255.8	26797.0
8	Sony	139.7	4629.3
9	Kokusai	117.3	276.7
10	Teikoku Electronics	88.3	120.9
11	Honeywell	87.3	5753.1
12	Commodore	77.4	681.2
13	Watkins-Johnson	73.5	186.0
14	NCR	69.6	3731.0
15	Westinghouse Electric	68.8	11155.0
16	Digital Equipment Corp.	63.7	4271.0
17	Sprague	54.1	
18	Sperry Univac	43.6	4914.0
19	Tektronix	43.5	1331.3
20	Ricoh	41.7	1625.0
	Top 20 Captive	4415.7	-
	Other	213.0	-
	Total	4628.7	-

DOMESTIC MANUFACTURERS

U.S. semiconductor firms have held the world's leadership in microelectronic technology since the invention of the transistor in 1948. The United States represents the world's largest manufacturing and consumption area for all types of semiconductors. The top ten U.S.

semiconductor manufacturers are listed below. These ten suppliers accounted for 35.6% of all semiconductor manufacturing:

	Company	1983 Semiconductor Sales ($M)	1983 Integrated Circuit Sales ($M)
1	Texas Instruments	1665.0	1572.0
2	Motorola	1601.0	1109.1
3	IBM	1304.8	1291.4
4	National Semiconductor	1102.5	1072.6
5	Intel	772.5	772.5
6	AMD	571.3	571.3
7	AT&T	509.3	393.6
8	Schlumberger	481.8	378.7
9	Hewlett-Packard	362.8	306.9
10	Mostek (UTC)	306.7	306.7
	TOTAL	8677.7	7713.8

The demography of domestic semiconductor production is shown in Figure 6.1.2-7.

Santa Clara County, in California, is often referred to as "Silicon Valley". It is the world's most concentrated area of semiconductor production within a 30 mile radius, by number of companies. In terms of sales distribution, we can see that the three major regions of the U.S. are almost equivalent.

DOMESTIC MERCHANT MANUFACTURERS

Domestic merchant semiconductor manufacturers accounted for 67.3% of U.S. sales and 35.5% of worldwide sales in 1983. U.S. merchant suppliers also hold the largest share of the merchant market. They accounted for 45.7% of the worldwide merchant market in 1983. The major merchant semiconductor companies are: Texas Instruments, Motorola, National Semiconductor, Intel, AMD, Schlumberger (Fairchild), and Mostek. All of these companies rank among the top 20 semiconductor manufacturers for 1983.

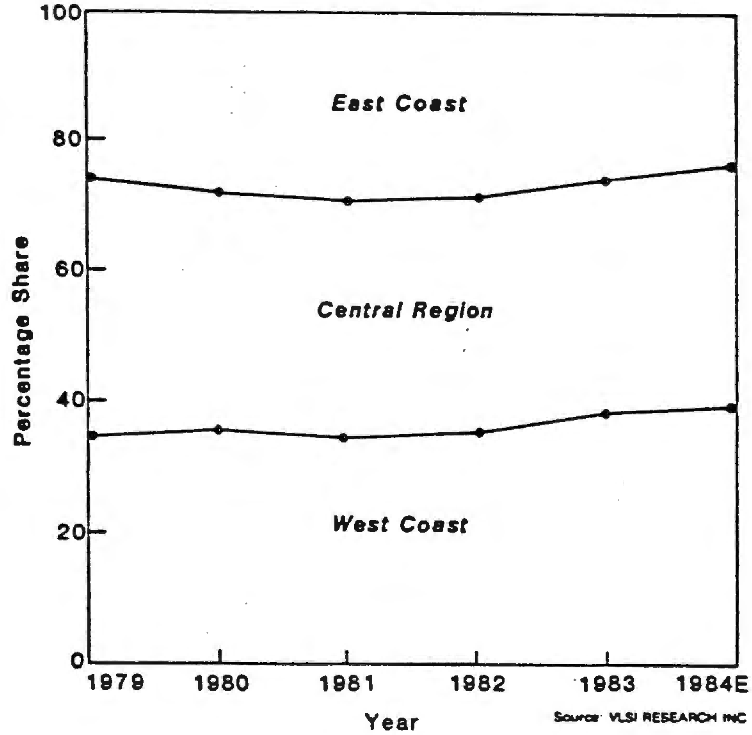

Figure 6.1.2-7

Manufacturing Distribution Of Semiconductors
By Region Of The United States

DOMESTIC CAPTIVE SEMICONDUCTOR MANUFACTURERS

The leading captive manufacturers of semiconductors are IBM, AT&T, and Hewlett-Packard. These three companies account for over 64% of all captive production of semiconductors in the United States. IBM is the world's largest manufacturer of integrated circuits. It has been building 64K DRAM's since 1975. Both IBM and AT&T have well established reputations for being leaders in the use of advanced technology equipment.

Jerry Sanders, President of AMD, has claimed that semiconductors are the crude oil of electronics. This analogy is of major importance in understanding the motives of the captives. Electronic equipment has become one of the fundamental building blocks for the "factory of the future". This futuristic factory has already begun to emerge in the form of factory automation. Many of the top U.S. industrial firms consider the ability to control this source of "crude" to be of prime importance in their strategies.

Exxon, Ford, IBM, General Electric, General Motors, Gould, and AT&T, are just a few among the larger industrial companies who have acquired or developed captive capabilities in semiconductor manufacturing.

FOREIGN SEMICONDUCTOR MANUFACTURERS

There are 177 foreign semiconductor producers. They too, range from the large multinational firms to small research and development labs. Five among the top ten integrated circuit manufacturers are foreign. They are NEC, Hitachi, N.V. Philips, Toshiba and Fujitsu. Of these, one is European, four are Japanese.

Foreign semiconductor suppliers are concentrated in four distinct categories: The Japanese supplier, the European supplier, the Communist block nations, and third world countries. Third world countries have little effect upon semiconductor capital equipment industry. There are two reasons. One is that manufacturing plants located there are almost invariably owned or controlled by corporations with purchasing locations elsewhere. The other is that these countries have little if any infrastructure which can support wafer processing. Consequently, their usage is usually limited to test and assembly of wafers that have been manufactured in the more industrialized regions of the world. Nevertheless this may be changing, as will be discussed later in this section.

JAPANESE SEMICONDUCTOR MANUFACTURERS

Japan's first transistor was made by the Sony Corporation in 1954. Merchant supply of transistors was started in 1960 at Hitachi. Hitachi was mass producing MOS IC's by 1967. From these early beginnings, Japanese semiconductor manufacturers have grown to become a major force in today's marketplace. The top ten Japanese semiconductor firms are shown in Table 6.1.2-8. These ten companies accounted for 85.7% of domestic semiconductor shipments, and 30.4% of worldwide sales in 1983.

Japanese suppliers continued to show strength in all areas of semiconductor manufacturing. Total semiconductor sales grew by 30% in 1983 to reach almost $9 billion. Integrated circuit sales accounted for $6.6 billion and discrete sales were $2.1 billion up 36% and 11%, respectively over 1982.

Total merchant Japanese semiconductor shipments increased by 29.3% in 1983 relative to 1982. Merchant Japanese semiconductor shipments accounted for 40% of the overall merchant semiconductor market in 1983. This was a 2.4% increase over 1982. Captive semiconductor sales were slightly over $1B or 12.5% of Japan's total sales in 1983. This was a 35.4% growth for Japan's captive shipments over 1982. Capital expenditures by all Japanese semiconductor manufacturers amounted to over $1.7 billion in 1983 – 34.5% of worldwide capital expenditures.

TABLE 6.1.2-8

1983 MAJOR JAPANESE SEMICONDUCTOR MANUFACTURERS
(Worldwide Sales In $M)

Company	Semiconductor Sales	IC	Discrete
NEC	1604.2	1290.4	313.8
Hitachi	1457.3	1072.3	385.0
Toshiba	1125.0	869.3	255.7
Fujitsu Ltd.	702.4	605.0	97.4
Mitsubishi	581.3	423.8	157.5
Matsushita	595.6	380.5	215.1
Sharp	475.0	459.5	15.5
Tokyo Sanyo	316.7	220.9	95.8
Oki	291.7	266.4	25.3
Rohm Fukuoka	272.9	108.7	164.2
Sub Total	7422.1	5696.8	1725.3
Others	1237.5	869.2	368.3
TOTAL	8659.6	6566.0	2093.6

Source VLSI RESEARCH INC

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There are sixty-one Japanese firms that produce semiconductors. A major portion of their production is on the Island of Kyushu in Southern Japan, (see Figure 6.1.2-9).

This is not surprising, for Kyushu is a remarkable island that has oftentimes served as Japan's front door to the world. As such, it has witnessed the winds of change in Japan. In ancient times, when the Japanese court sent envoys to the Chinese Tang Dynasty, Kyushu was the cultural exchange base. Later, Portuguese merchants increased trade there between Japan and the rest of the world. Jesuit priests next brought Christianity to the islands. Kyushu was their main stronghold of converts. During the Shogunate period the port of Nagasaki, in western Kyushu, was the only place that foreigners were allowed on Japanese soil, and these were limited to traders.

Kyushu has witnessed the winds of change once again as it has come to be known to the world as the Japanese 'Silicon Island'. The traders of the eighties are now semiconductor capital equipment vendors.

One might ask – is that name 'Silicon Island' justified? We think so. Seventeen of Japan's more than 60 semiconductor factories are on Kyushu. A listing of all companies in Kyushu is shown in Table 6.1.2-10. Twelve of those seventeen factories belong among the top ten Japanese semiconductor manufacturers – NEC, Toshiba, Fujitsu, Matsushita, Mitsubishi, Oki and Rohm Fukuoka. These seven manufacturers provided 59.7% of all Japanese domestic semiconductor manufacturing in 1983. More importantly, they provided 60.1% of Japan's domestic integrated circuit manufacturing for 1983. Kyushu's IC industry alone employs over 10,000 people.

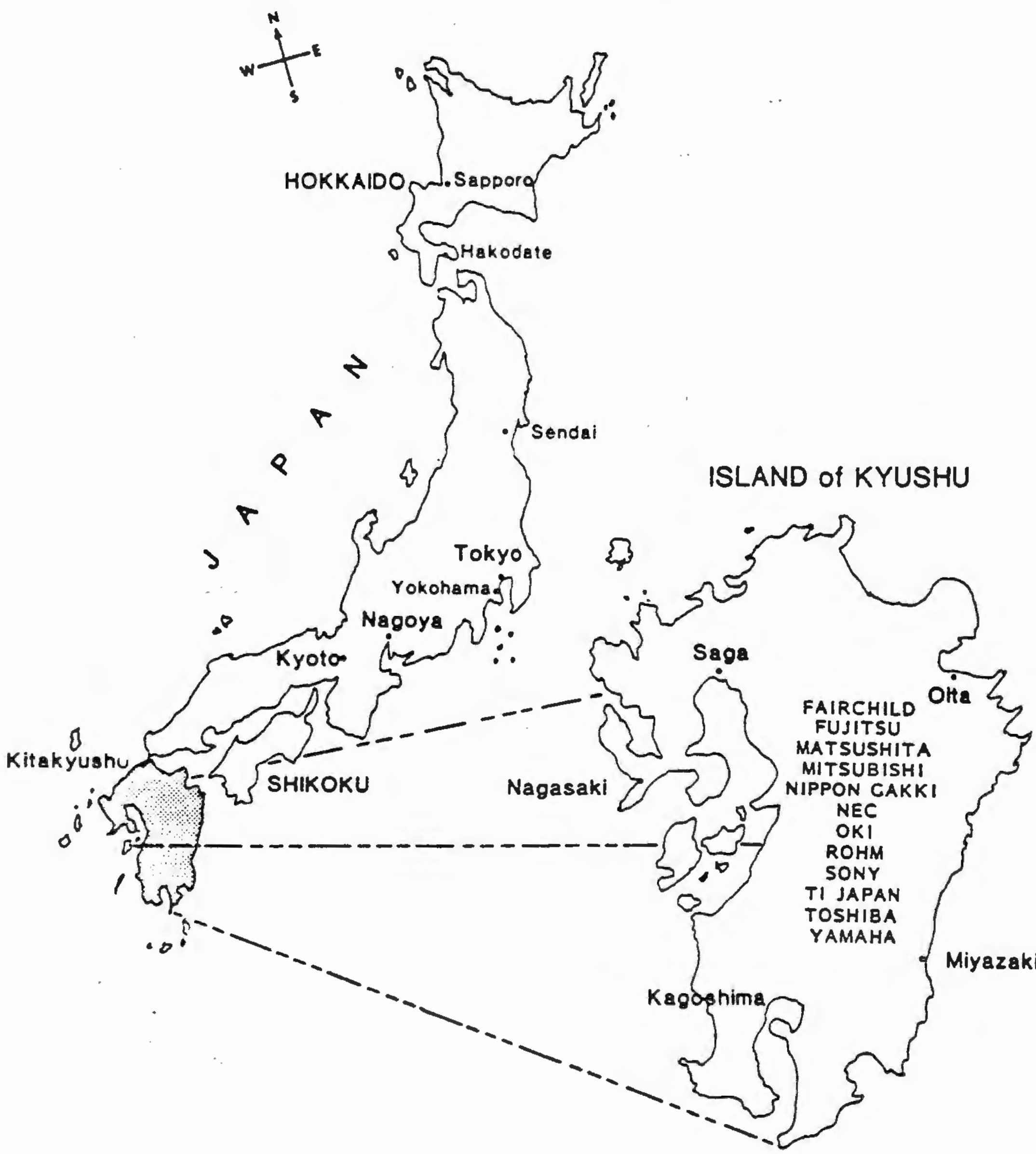
There are seven prefectures in Kyushu. They are:

- Kumamoto
- Nagasaki
- Oita
- Saga
- Miyazaki
- Kagoshima
- Fukuoka

The prefectures of Nagasaki, Saga and Fukuoka are on the north side of the island. Oita and Miyazaki are on the eastern side. Kumamoto and Kagoshima are on the western side of the island.

Principal cities are Kitakyushu, Nagasaki, and Kumamoto. Kitakyushu is at the northernmost point of the island in Fukuoka prefecture. It is the political, economic, cultural and communication hub of Kyushu. The city is new, having been established in 1963 by the merging of five former cities. Its population is well over 1,000,000. It is also the

SILICON ISLAND



VLSI RESEARCH INC.

Figure 6.1.2-9

TABLE 6.1.2-10

SEMICONDUCTOR OPERATIONS ON KYUSHU

Company	Prefecture
Fairchild Japan	Nagasaki
Fujitsu	Kagoshima
Matsushita	
Kagoshima Matshushita Electric	Kagoshima
Mitsubishi (2 Plants)	
Mitsubishi Kitaitami Mfg.	Fukuoka
Mitsubishi Kitaitami Mfg.	Kumamoto
NEC Kyushu Ltd. (3 Plants)	
Fukuoka NEC	Fukuoka
Kyushu NEC	Kagoshima
Oita NEC	Oita
Nippon Gakki Kagoshima	Kagoshima
Oki Electric	Miyazaki
Rohm Fukuoka (Rohm Co., Ltd.)	Fukuoka
Sony Kokubu	
T.I. Japan Hiji	Oita
Toshiba (3 Plants)	
Busen Toshiba Ltd.	Kumamoto
Nogata Toshiba Ltd.	Fukuoka
Oita Toshita Ltd.	Oita
Yamaha Kagoshima	Kagoshima

Source: VLSI RESEARCH INC

home of the Kyushu Institute of Technology. Nagasaki has a population exceeding 500,000. It is a major seaport. Kumamoto is in the western corner of the isle. It too has a population of more than 500,000. Fukuoka City and Kagoshima City are also large metropolitan centers.

Kyoshu is approximately 130 miles across, east to west. It is 175 miles from north to south. Total population of the island was reported in 1978 as 12,723,000. Population density on the northwestern side of the island is very dense from Nagasaki to Kitakyushu. It exceeds 700 persons per square mile. The remainder of the island ranges from 60 to 250 persons per square mile. Kitakyushu City is known as one of the 'Big Four' densely populated Japanese regions along with Tokyo, Osaka and Nagoya.

OTHER ASIAN SEMICONDUCTOR MANUFACTURERS

For many years, semiconductor production remained within the spheres of U.S., Japanese, and European companies. However, over the past few years, semiconductor processing has become a growth industry for the developing nations of Asia as well. Production is concentrated in Korea, Taiwan, China, India, and Hong Kong. The existence of government development labs, coupled with the birth of a wide variety of semiconductor manufacturing firms, suggests that sustained growth in this area is likely for the foreseeable future.

KOREA

Over the past few years, Korea has emerged as an up-and-coming competitor in the semiconductor manufacturing industry. In the past, Korea's role in this industry was primarily as an assembly house. The assembly houses still exist in Korea but primarily assemble foreign components. Most component manufacturers in Korea maintain their own internal assembly line.

Electronics Industry Structure

The electronics industry structure that is emerging in Korea is rather unique. The domestic industry is dominated by three large corporations. The companies are: Gold Star Co. Ltd., Samsung Electronics Co. Ltd., and Daewoo Electronics Co. Ltd. These three firms are gradually absorbing almost 800 smaller electronic parts and components manufacturers in Korea. Gold Star controls a group of 76 firms and is planning to purchase about 44 more companies this year. Samsung Electronics presently owns 68 companies. Daewoo Electronics has 120 companies at this time with plans to purchase about 30 more this year. As smaller companies are acquired, usually the identity of the acquired firm is not lost. Typically, each of the small firms continue to operate as a separate entity and many maintain the same name. By the end of 1984, almost 50% of the Korean electronics industry is expected to be controlled by Gold Star, Samsung, and Daewoo.

There are several reasons for the development of a ologopolistic structure in the Korean semiconductor industry. The main reasons are consolidation of R&D efforts, ability to acquire needed supplies, and availability of government funding. Each of the dominant firms allocates R&D projects among its subsidiaries. Thus, technological research is guided and can be accessed and consolidated by the parent company. The advantage to sharing research, is that within each corporation there is an optimum dispersion of R&D funds. Also, the smaller companies have access to technological research that alone they would be unable to afford. A total of $100 million has been allocated by the three large parent companies for R&D projects in the smaller firms.

A second reason Korean semiconductor companies are tending to consolidate under a large corporation is due to availability of quality inputs. Inputs in the form of manufacturing equipment and materials. Most of the semiconductor equipment and materials used in Korea must be imported. Limited availability of funding to purchase needed inputs is oftentimes a problem for smaller companies. The larger corporation can aid in terms of capital funding. In addition to aid from internal sources, the Korean government recently approved a low-interest loan program for electronic component manufacturers. The large corporations will probably be able to access most of these funds since they can offer a greater return on investment – in terms of R&D and production capacity. Details of the government loan program will be discussed later.

Competitors

There are two companies which dominate the Korean semiconductor industry, by a number of subsidiary companies. They are Gold Star and Samsung. Additionally, Hyundai Electronics and Daewoo Electronics have recently joined these two multi-million dollar companies in the Korean semiconductor market. Daewoo, one of the three largest electronics corporations in Korea, is planning to enter the merchant semiconductor market later this year.

Gold Star Semiconductor

Gold Star Semiconductor Ltd. was established in 1979 as a member of the Lucky-Goldstar Group. This was a result of a technology transfer agreement with Western Electric. Today, Western Electric has a controlling interest of 44% of the company's stock.

Gold Star's main manufacturing facilities are located at two plants in the Gumi Industrial Complex. There are about 1,000 employees between the two plants. Total capacity is approximately 5,000 wafer starts per week. Both fabrication and assembly takes place within these facilities. 70% of semiconductor production is sold in the Korean market. The remaining 30% of Gold Star's output is sold mainly in the Hong Kong and Taiwan semiconductor markets.

The Lucky-Goldstar Group began construction this year on a private R&D facility that will cover the areas of electronics and communications. The center will be located in Anyang, which is about 32 miles south of Seoul. This facility will be used by the seven affiliate companies of the Lucky-Goldstar Group. As was previously mentioned, Gold Star Semiconductor is a member of this group.

Samsung Electronics

Samsung Electronics owned the first operational fab line in Korea. Samsung Semiconductor and Telecommunications Co. Ltd. (SST) and Samsung Semiconductor are two of the main subsidiaries involved in semiconductor production. Samsung has three main manufacturing facilities. They are located in the Gumi Industrial Complex, Buchon City, and Suwon City. All phases of semiconductor production are in-house, from fab through assembly.

Samsung's first products in the semiconductor market were CMOS watch components in 1974. Since then, they have introduced linear ICs, in 1978; and video ICs for color television receivers, in 1981. In 1983, they signed a contract with Micron Technology for 64K DRAM and 256K DRAM technology. This year, Samsung introduced 64K DRAMs and is beginning to increase production capacity. By November of this year they expect to be producing one million 64K DRAMs per month.

Last year, 90% of Samsung's total semiconductor output was exported. The major markets for their products are Southeast Asia and the U.S. linear devices accounted for two-thirds of their total IC sales in 1983.

Hyundai Electronics

Hyundai Electronics America was formed in March 1983. It is a wholly-owned subsidiary of the Hyundai Group, the largest company of Korea. The parent company's 1983 sales were nearly $10 billion.

During a press conference on October 22, 1984, the Hyundai Group officially announced its entry into the world semiconductor industry. Their new $40 million, 100,000 square foot facility is located in Santa Clara, California. The building features an 11,000 square foot class

100 clean room area. It has a processing capacity of 50,000 five inch wafers per year.

Additionally, at Ichon, Korea there is a 150,000 square foot facility. The building features a 20,000 square foot clean room area. It has a processing capacity of 200,000 five inch wafers per year. The assembly operation can produce 15 million plastic or ceramic packages per year. Scheduled to open in June 1985, is an additional 720,000 square foot assembly facility. It will be capable of producing 300 million plastic or ceramic DIP's per year.

Hoon Yang, Hyundai Senior V.P. and CEO explains why the semiconductor division is establishing sites on two continents. "This, we feel, gives us significant competitive advantages by combining Silicon Valley's technical and marketing expertise with the manufacturing economies of scale at Ichon." Both facilities have identical manufacturing technologies, including the latest implantation equipment, wafer steppers and all-dry etch processes.

Hyundai Electronics America initially intends to offer products for existing markets. A 16K static RAM and a 128K ROM will be introduced in the first quarter of 1985. Both use a 2.5 micron NMOS process. Subsequent products will be in CMOS. For example, 1K EEPROMs in CMOS is in the planning stage. Further product plans include a full microprocessor family as well as high density CMOS SRAM's and non-volatile memory circuits. Hyundai expects to eventually pioneer new technologies and compete in new markets.

Syntek Design Technology

Syntek Design Technology Ltd. is another Korean company established in late 1981. They design and manufacture custom monolithic ICs. Presently, Syntek specializes in metal gate, CMOS 5-micron designs; and silicon gate CMOS and NMOS processes. Syntek's fab facility is located in the Hsinchu Science Based Industrial Park. In January 1984, they signed an agreement with Synertek. The contract provides Syntek with Synertek's technology for VLSI and standard cell manufacturing.

Issues and Driving Forces

The semiconductor market in Korea is in its early growth stages. The main force driving this market is the Korean government's promotion and support of the semiconductor industry.

Until recently, Korea was known as a low volume producer of semiconductor devices. Most of their production was for low end device types. The Korean government has taken an active supporting role in the semiconductor industry. On January 30, 1984 the Korean Minister of Commerce and Industry announced plans to offer a low interest loan program for electronic component manufacturers. The total amount of funding has been set at $463 million.

The offering of financial support is part of the Korean government's long term strategy to be independent of outside semiconductor sources. In the past, their reliance on imported components, mainly from Japan, has caused production backlogs for products which use these components. This problem was especially apparent during periods of under supply in the semiconductor market.

The Korean government is placing a strong emphasis on high-end semiconductor components. Funds have already been set aside for projects on production of 64K and 256K DRAMs. There are several strategies Korean firms are using to implement their R&D programs.

The strategy which most of the large Korean conglomerates are using, is the establishment of R&D projects in Silicon Valley. Use of this method enables the Korean companies to gain technological knowhow from experienced engineers. In most cases, when these R&D projects are complete, the technology will be transferred to Korea for implementation in manufacturing.

Another method being used to gain technical information, is by signing joint ventures with U.S. firms. This reduces the time involved in developing and implementing a technology.

Samsung is an example of a conglomerate that used the two aforementioned methods together. Samsung established Tristar Semiconductor in Silicon Valley to develop and manufacture memory devices. Tristar acquired its DRAM product designs from Micron Technology. Their 16-Kbit EEPROM device was developed in conjunction with Exel Microelectronics. Tristar announced it will begin providing samples of the EEPROM part in the fourth quarter of 1984 with production scheduled for the first quarter of 1985. This will make Tristar the first Korean company to develop and build a device in the U.S. production technology for the EEPROM device will also be transferred to a new fab facility in Sunan, Korea.

Most of the Korean conglomerates that manufacture semiconductors have recently begun selling their devices in the U.S. Typically, they are using sales rep firms as their channel of distribution. The devices they are marketing in the U.S. are mainly medium to high end memory products such as 16K static RAMs, 64K DRAMs, and EEPROMs. In the future we can expect to see Korea becoming an increasing source of semiconductor devices in both Asian and U.S. markets. The size of the Korean government's loan affirms their emphasis on developing their own semiconductor industry.

TAIWAN

The largest semiconductor manufacturer in Taiwan is United Microelectronics Corp. They currently have a monthly output of 40,000 4-inch wafers per month. 100% of their production is in MOS ICs.

Taiwan's government lab is the Electronics Research and Service Organization (ERSO). ERSO has been an RCA CMOS licensee since 1976, providing the Taiwanese with an American source of information and engineering skill in semiconductor technology. The ERSO facility, located in Hsinchu, produces 36,000 3" wafers annually. The majority of these are custom chips consumed by Taiwan's domestic electronic industry. Today, ERSO is still Taiwan's only linear device manufacturer with CMOS, NMOS, and bipolar technologies. In 1983, their total production was a 1:9 split between linear and digital devices.

INDIA

India's semiconductor industry could be headed for a period of growth after a slump in the late 1970's caused by labor troubles and low priced imported devices. The Indian government has announced new trade policies which will severely curtail the importation of semiconductors. India's consumer electronics industry in the past few years has grown at a rate of 25% per year and will have to fulfill its demands for semiconductors primarily through Indian manufacturers.

Two firms which will benefit from this new policy are Bharat Electronics and Electronics Corporation of India. Both firms produce LSI devices. Together they account for 70% of India's semiconductor production. Other firms will also benefit by the change.

HONG KONG

Hong Kong's Tai Po industrial park, located on the mainland, is proving to be a focal point for a period of rapid growth in the wafer fabrication and processing industry. These plants will produce a variety of devices, including silicon and metal gates, ROM's, RAM's, CMOS IC's, and discretes. The output from all of these plants is expected to be consumed in Hong Kong.

EUROPEAN SEMICONDUCTOR MANUFACTURERS

The top five European semiconductor manufacturers are NV Philips, Siemens, ITT, Thomson CSF and SGS-ATES. They accounted for 65%

of all European semiconductor shipments and 7.8% of world semiconductor shipments in 1983. Total sales for these five companies were:

TOP 5 EUROPEAN SEMICONDUCTOR MANUFACTURERS

	Company	1983 Semiconductor Sales ($M)
1	NV Philips	874.3
2	Siemens	405.1
3	ITT	251.7
4	Thomson CSF	198.7
5	SGS-ATES	179.3
	TOTAL	1909.1

ITT is included as a major European semiconductor manufacturer, having most of its manufacturing in Freiburg, Germany.

Production of semiconductors in Europe is concentrated in six countries – Denmark, France, West Germany, Italy, Spain and the United Kingdom. Table 6.1.2-11 shows the production volume for each country. West Germany produces the largest volume of semiconductors and accounted for almost 33.9% of total European production in 1983. West Germany grew by 17.1% last year and is expected to increase by 42.6% in 1984. The United Kingdom increased 15.1% since 1982 and is forecast to continue increasing slightly in 1984. France has been rapidly growing as a producer of semiconductors. France grew by 36.7% in 1983 and is forecast to increase another 18.5% in 1984.

European semiconductor production grew 11.9% in 1983 and is forecast to increase by 33.3% in 1984. Although this is a strong growth rate, Europe's worldwide market share is predicted to decrease slightly to 9.2% in 1984.

COMMUNIST BLOCK COUNTRIES

There are two segments in the Communist Block countries. The Soviet Satellites and China. Trade with the Chinese segment is small but growing. Trade restrictions have eased in past years. China is very interested in acquiring American semiconductor equipment. Currently, the fab facilities operating in China are using almost 100% domestically manufactured equipment.

TABLE 6.1.2-11

MAJOR EUROPEAN SEMICONDUCTOR PRODUCTION AREAS†

	1977	1978	1979	1980	1981	1982	1983	1984E
DENMARK	4.0	4.4	3.9	4.0	3.9	4.0	4.7	5.4
FRANCE	327.5	441.5	437.0	453.7	497.7	583.0	796.7	944.2
WEST GERMANY	594.8	677.0	715.4	760.2	696.8	690.6	808.9	1153.5
ITALY	97.4	109.9	113.1	116.0	102.9	103.1	148.7	200.7
SPAIN	22.9	30.4	32.9	38.4	27.9	28.2	33.8	35.0
UNITED KINGDOM	263.2	295.9	352.3	457.1	548.6	540.2	622.0	631.8
OTHER	58.1	66.1	69.2	77.8	59.8	60.4	73.5	88.2
TOTAL	1367.9	1625.2	1723.8	1907.2	1937.6	2004.5	2488.3	3058.8

Source: VLSI RESEARCH INC

† By area of production, not by nationality of corporation.

The semiconductor industry structure in China is rather unique. Organizations exist within specific geographical areas. The four city-states of Beijing, Carten, Shanghai, and Canton each have their own semiconductor organizations. Manufacturers within a given area, report directly to the organization. The semiconductor plants that are not located within one of the aforementioned city-states, are grouped by province. Each province supports a semiconductor organization. There are also several semiconductor facilities which directly serve the government.

Today, China has just over 10 fab lines in operation. Most of these facilities are running 1.5 and 2 inch wafers. Typical devices being manufactured are TTL, 8080A MPU, 4000-series CMOS, and 4K DRAMs. Test and assembly are still done manually. Total employment within each of these operations is often three to four times that of a similar fab line in the U.S. This can be attributed to China's nationwide strive for 100% employment. Typically, operational efficiency is a relatively unimportant factor in all types of Chinese industries.

The Chinese economy is highly agrarian. In 1978, China's GNP was $407 billion versus a staggering $2,127.6B for the United States. More than 85% of the Chinese labor force is occupied in the feeding of China. 3.4% is occupied for the same cause in the U.S. The Chinese per capita GNP is $406 versus more than $10,000 in the U.S.

There are several indications that the Chinese semiconductor market will remain small for several years to come. One indicator is the monetary situation. The Chinese lack a large supply of exchange dollars that would permit trade with other countries. For example, recently, an exchange was made where Bing cherries were traded for hard goods in lieu of currency. This is currently being eased by loans to China through the export-import bank, and by admission of China to the International Monetary Fund.

6.1.3 SUPPLIER CONCENTRATION

This section lists all known semiconductor manufacturers. Companies are listed alphabetically in Tables 6.1.3-2 through 6.1.3-5. Three main attributes of each company are listed. They are the type of company, annual corporate sales by semiconductor technology, and equipment expenditures. Additionally, the tables show the information segregated by demography. North American, Japanese and European firms are listed separately.

The first group of columns in the tables characterizes the company according to whether it is merchant or captive. If the firm is a captive, it is further characterized according to whether it sells on the open market in addition to being a captive firm.

As was mentioned earlier, some semiconductor manufacturers also manufacture their own equipment. And some of these even resell equipment to become competitors in semiconductor manufacturing equipment. The tables indicate the degree to which semiconductor manufacturers are believed to be competitors in the equipment market as well.

Table 6.1.3-1 outlines the scheme used for identifying the degree of involvement in semiconductor equipment market. Four classes are used according to this scheme. A Class 1 manufacturer is one who buys as much equipment as is feasible, and builds none. In contrast, a Class 4 customer is one who generally builds most equipment to be used, but seldom buys. Of the other two intermediate types of customers identified, a class two company builds only when the need arises. A class three customer is one who not only builds its own equipment, but also sells equipment in the merchant market.

TABLE 6.1.3-1

NATURE OF THE CUSTOMER
(Typical Equipment Purchasing and Manufacturing Practices)

Primary Objective As An Equipment User	Merchant Semiconductor Supplier		Captive Semiconductor Supplier	
	TYPICAL COMPANY	Company Type	TYPICAL COMPANY	Company Type
Purchases most equipment. Avoids building where possible and sells none of the equipment built.	AMD Intel National Semiconductor	M1	Delco Digital Equipment Corp Honeywell	C1
Purchases most equipment. Builds when necessary, but sells none of the equipment built.	Zilog Texas Instruments	M2	Western Electric Lockheed Hewlett-Packard IBM	C2
Purchases equipment. Also builds equipment and sells it as a merchant equipment supplier.	Fairchild Hitachi Phillips Toshiba NEC	M3	Canon Electronics	C3
Builds most equipment for internal use. Sells little to none of the equipment built.		M4		C4

Source: VLSI RESEARCH INC

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TABLE 6.1.3-2

NORTH AMERICAN SEMICONDUCTOR MANUFACTURERS

SEMICONDUCTOR MANUFACTURER					CORPORATE SALES							PLANT & EQ. EXPENDITURES			
		MFG. Type				Semiconductor Sales[1] ($M)							Semiconductor Division ($M)		
			Captive[3]				Integrated Circuits								
Company	Customer Type[2]	Merchant	With Sales	Without Sales	1983 Total Sales ($M)	Total Component Sales	Total IC Sales	MOS	Bipolar	Linear	Discrete Devices	Total Corporate ($M)	Total Division	Total Equipment	Total Plant
Acrian, Inc.	M1	o			16.5	16.5					16.5	1.9			
Advanced LSI	M1	o						o							
Advanced Semiconductor															
Aerojet Electro Systems	C1			o			o								
The Aerospace Corporation	C1			o											
Aertech	C1	o													
Allied Corp.	M1			o	10022.0	5.9	5.9				-	607.0			
Alpha Industries	M1	o			42.6	15.5	-				15.5	4.9			
Alphatron					2.9	2.9	2.9	o	o		-				
Altera Semiconductor Corp.	M1	o					o	o							
AMD	M1	o			583.3	571.3	571.3	262.4	248.0	61.0	-	129.2	127.7		
Amdahl	C1			o	777.7	1.7			1.7			157.4			
Amperex (Philips)	M1	o													
Ampex	C1		o			2.6E									
Analog Devices	M3	o			214.0	140.1	140.1	55.6	-	84.5	-	19.0	14.3		
Analog Systems	M1	o													
Analogic	M1	o			128.8							12.7			
Applied Microcircuits Corp.	M1	o			8.5	8.5	8.5	o	8.5	-	-				
AT&T Technologies	C2			o	11155.0	509.3	393.6				115.7	675.2	128.4		
Avantek	M1	o			119.4	12.2	4.9				7.3				
Aydin	M1	o			152.9										
Barvon Research	M1	o					o	o							
Bell Canada	C1			o	8874.6										
Bell Labs (Pilot Line)	C2			o											
Bipolar Integrated Tech.	M1	o					o		o						
Boeing	C1			o	11308.0	1.0						223.0			
Bowmar	C1			o											
Burr-Brown	M1	o		o											
Burroughs	C1	o		o	4389.7	11.8	11.8					589.0	0.0		
California Devices Inc.	M1	o			8.7	8.7	8.7	8.7	-	-	-				
Cambridge Memories	M1	o													
Cermetek Microelectronics	M1	o			6.1		1.2					1.5			
Cherry Electronics	M1	o			103.6	12.4	11.8		2.9	8.9	0.6	10.2	1.3		
Circuit Design Group	M1	o													
Collins Radio (Rockwell)	M1	o													

[1] Equivalent internal transfers at merchant market rates. [2] See text. [3] With sales' indicates a captive firm who also sells to the open market.

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TABLE 6.1.3-2

NORTH AMERICAN SEMICONDUCTOR MANUFACTURERS

SEMICONDUCTOR MANUFACTURER		MFG. Type	Captive[1]		CORPORATE SALES	Semiconductor Sales[1] ($M)	Integrated Circuits					PLANT & EQ. EXPENDITURES	Semiconductor Division ($M)		
Company	Customer Type[2]	Merchant	With Sales	Without Sales	1983 Total Sales ($M)	Total Component Sales	Total IC Sales	MOS	Bipolar	Linear	Discrete Devices	Total Corporate ($M)	Total Division	Total Equipment	Total Plant
Collmer Semiconductor	M1	o													
Comdlal	M1	o			147.3	3.0	3.0	3.0	-	-	-				
Commodore	C1	o		o	681.2	85.7	85.7	85.7				46.4	16.4		
Condesin	M1	o													
Control Data Corp.	C1			o	4582.8	17.5	17.5					176.7	6.2		
CTS Microelectronics	M1	o				o									
Custom MOS Arrays Inc.	M1	o													
Custom Silicon Inc.	M1	o													
Cypress Semiconductor Corp	M1	o					o	o							
Data General	C1			o	828.9	34.4						72.8	2.9		
Data Tech (Penril)	M1	o													
Datel Systems	M1	o													
Delco (GM)	C1		o		74581.6	278.4	219.8				58.6	1923.0	38.0		
Digital Equipment Corp.	M1	o		o	4271.9	63.7	63.7				-	419.2	10.1		
Dionics	M1	o			2.5	2.5			o	o	o	.1	.1		
Dynatek Electronics (Canada)															
E-Systems	M1		o		770.0E							23.6			
Eastman Kodak	M1			o	10170.0	5.1						899.0	1.1		
Elantek Inc.															
Electronic Arrays (NEC)	M1	o							-	-	-				
Electronic Technology Corp.	M1	o					o	o							
Energy Conversion Devices	M1	o													
Erie Tech Products	M1	o													
Essex		o	o												
Exel Microelectronic Inc.	M1	o					o	o							
Fluke	C1			o	172.7	1.8	1.8					9.5			
Ford	C1			o	44454.6	2.9	0.7				2.2				
Frontier	C1			o											
Galileo I/O	M1	o													
General Dynamics	C1			o	7146.3	2.6E	2.6E					215.2			
General Electric (Intersil)	C1	o	o	o	26797.0	255.8	156.8	98.2	14.9	43.7	99.0	1721.0	81.7		
General Instrument	M1	o			896.4	232.6	194.7	176.0		18.7	37.9	65.9	33.0		
General Semiconductor	M1	o			21.0	19.9				o	19.9				
Gigabit Logic	M1	o				o	o								
Gould (AMI/Dexcel)	M1	o			1324.8	188.9	188.9	188.9	-	-	-	118.8	54.2		

1 ... ivalent internal transfers at merchant market rates. [2] See text. ... ith sales' indicates a captive firm who also sells to the open mark...

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TABLE 6.1.3-2

NORTH AMERICAN SEMICONDUCTOR MANUFACTURERS

SEMICONDUCTOR MANUFACTURER					CORPORATE SALES							PLANT & EQ. EXPENDITURES			
		MFG. Type				Semiconductor Sales[1] ($M)							Semiconductor Division($M)		
			Captive[3]				Integrated Circuits								
Company	Customer Type[2]	Merchant	With Sales	Without Sales	1983 Total Sales ($M)	Total Component Sales	Total IC Sales	MOS	Bipolar	Linear	Discrete Devices	Total Corporate ($M)	Total Division	Total Equipment	Total Plant
Grumman	C1			o											
GTE	C1			o	12408.8	30.1	30.1	30.1	-	-	-		6.8		
Harris Semiconductor	M1	o			1433.3	151.5	151.5	43.3	62.4	45.8		81.4	26.1		
Hewlett-Packard	C2	o		o	4710.0	362.8	306.9				55.9	466.0	101.1		
Holt	M1	o			2.6E	2.6E	2.6E	o	-	o	-				
Honeywell	C1			o	5753.1	87.3					-	350.4	10.7		
Hughes	C3	o			1157.3	31.2	31.2	31.2							
Hutson		o													
Hycom															
Hypres															
IBM	C2			o	40180.0	1304.8	1291.9	o	o	o	12.9	2578.0	272.7		
IC Sensors															
ICC		o													
ICS	M1										-				
ILC Data Device Corp	M1	o													
IMP	M1	o													
Intech IFMI	M1	o													
Integrated Circuits Inc.	M1	o													
Int'grtd Device Technology	M1	o													
Int'grtd Frequency Device	M1	o													
Intel	M1	o			1121.9	772.5	772.5	723.8	45.7		-	145.0	140.0		
Interdesign (Ferranti)	M1	o				35.6	35.6	13.7	8.7	13.2	-				
Int'nl CMOS Technology	M1	o					o	o							
Int'nl Microcircuits Inc.		o			12.7	12.7	12.7	o	-	o	-				
Int'nl Microel'trnc Prdts		o			14.0	14.0	14.0	14.0							
Int'nl Rectifier		o			126.8	88.6	-	4.4	-	-	84.2	4.1	3.3		
Iridian Microwave															
Kertron		o													
KMC/MA	M1	o													
LaserPath	M1	o					o	o							
Lattice Semiconductor	M1	o					o	o							
Lincoln Semiconductor	M1	o			0.4	0.4									
Linear Tech	M1	o			6.9	6.9				6.9		1.5	1.5		
Linear Technology	M1	o				6.9	6.9			6.9		1.5	1.5		
Litronix	M1	o													

[1] Equivalent internal transfers at merchant market rates. [2] See text. [3] With sales' indicates a captive firm who also sells to the open market.

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TABLE 6.1.3-2

NORTH AMERICAN SEMICONDUCTOR MANUFACTURERS

SEMICONDUCTOR MANUFACTURER: Company	Customer Type [2]	MFG. Type: Merchant	MFG. Type: Captive[3] With Sales	MFG. Type: Captive[3] Without Sales	CORPORATE SALES: 1983 Total Sales ($M)	Semiconductor Sales[1] ($M): Total Component Sales	Integrated Circuits: Total IC Sales	Integrated Circuits: MOS	Integrated Circuits: Bipolar	Integrated Circuits: Linear	Discrete Devices	PLANT & EQ. EXPENDITURES: Total Corporate ($M)	Semiconductor Division ($M): Total Division	Total Equipment	Total Plant
Lockheed	C2			o	6490.0	6.1									
Logic Devices							o	o							
LSI Computer Systems	M1	o			4.0	4.0	4.0	4.0							
LSI Logic	M2	o			34.9	25.0	25.0								
Magnavox (Philips)	C1		o												
Magnuson															
Martin Marietta	C1			o	3899.3	4.0E									
Master Logic	M1	o			0.7	0.7	0.7	-	-	-	-				
Maxim Integrated Circuits	M1	o					o	o							
McDonnell Douglas	C1			o	8111.0	5.1									
MCE Semiconductor Inc.	M1	o			7.0	7.0		-	o	o	-				
Microcircuit Technology Inc.	M1	o				1.3	o	o	-	-	-				
Micro Components Corp.	M1	o													
Micro-Linear Corp.	M1	o					o	o		o					
Micro Networks	M1	o													
Micron Technology	M1	o			13.1	13.1						10.6	10.6		
Micro Power Systems (Seiko)	M1	o				27.7	27.7	15.1		12.6			4.3E		
Micro-Reliability	C1			o											
Microsemiconductor Corp.	M1	o			24.4	24.4					24.4	0.6	0.6		
Microtechnology															
Microwave Semiconductor	M1	o						o	o	o	o				
Mitel	M1	o			262.0	15.0	15.0					73.5			
Modern Electrosystems							o	o							
Modular Semiconductor Inc.	M1	o					o	o							
Monolithic Memories	M1	o			105.4	105.4	105.4	-	105.4	-	-	27.5	27.5		
Monosil	M1	o				6.4		o	o	o	o				
MOS-Technology Corp.	M1	o													
Mosaic Systems	M1	o													
Mosfet Microlabs				o											
Mostek (UTC)	M1	o			14669.3	306.7	306.7	306.7	-		-	624.8	113.4		
Motorola	M3	o			4328.0	1601.0	1109.1	605.5	277.1	226.5	491.9	406.0	174.2		
National Microelectronics		o					o	o							
National Semiconductor	M1	o			1655.1	1102.5	1072.6	387.2	393.7	291.7	29.9	278.1	251.1		
Naval Ocean Systems Center	C2			o		1.5F									
NC Micro Computers (MA)															

1 ...uivalent internal transfers at merchant market rates. 2 See text. ... ith sales' indicates a captive firm who also sells to the open marke...

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TABLE 6.1.3-2

NORTH AMERICAN SEMICONDUCTOR MANUFACTURERS

SEMICONDUCTOR MANUFACTURER					CORPORATE SALES							PLANT & EQ. EXPENDITURES			
		MFG. Type				Semiconductor Sales[1] ($M)							Semiconductor Division($M)		
			Captive[3]				Integrated Circuits								
Company	Customer Type[2]	Merchant	With Sales	Without Sales	1983 Total Sales ($M)	Total Component Sales	Total IC Sales	MOS	Bipolar	Linear	Discrete Devices	Total Corporate ($M)	Total Division	Total Equipment	Total Plant
NCR	C1			o	3731.0	69.6	69.6	69.6	-	-	-	127.9	8.0		
Nitron	M1	o			5.5	2.4	2.4		-	-	-	0.4			
Northern Telecom	M2	o			3304.0	33.1	18.2				14.9E	376.9	7.0E		
Northrop	C1			o	3260.6	0.3	0.3				o	293.1			
Nucleonic Products		o													
Omtac															
Opcoa		o													
Optical Electric															
Optimax	M1	o													
PPC Products (Synergetic)					1.5	1.5					1.5				
Penn Central Corp.															
Penril					38.7							1.2			
Perkin-Elmer	C3			o	1015.4										
Polycore Electronics		o													
Precision Monolithics Inc.	M1	o			45.9	36.7	29.2	-	o	o	7.5				
Raugen Semiconductor	M1	o													
Raytheon	M1	o			5937.3	68.7	49.2	-	24.3	24.9	19.5	304.9	11.3E		
RCA	M2	o			8977.3	304.8	212.8	124.2	7.0	81.6	92.0	495.2	46.9		
Reticon (EG&G)	M1	o													
Riehl Time		o													
Rockwell	M1	o			8097.9	80.1	80.1	80.1	o	o	o	479.4	17.6		
RSM Sensitron		o			6.0	6.0	-	-	-	-	6.0				
S MOS	M1	o					o	o							
S-T Semicon		o			2.9	2.9					2.9				
Sanders Associates					578.1	1.6E	1.6E								
Sandia National Labs				o	1.5E										
Schlumberger (Fairchild)	M3	o			5797.5	481.8	359.5	50.0	243.5	85.2	103.1	517.0	125.0		
Seeq	M1	o			4.2	4.2	4.2					13.6	13.6		
Semi Processes Inc.	M1	o			12.1	12.1	12.1								
Semtech	M1	o													
Senitron (EM&M)	M1	o			79.2	33.5						2.9			
Sensor Technology	M1	o			7.5E										
SGS Semiconductor	M1	o													
Si-Fab	M1	o			2.6	2.6	2.6								
Sierra Semiconductor							o	o							

[1] Equivalent internal transfers at merchant market rates. [2] See text. [3] 'With sales' indicates a captive firm who also sells to the open market.

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TABLE 6.1.3-2

NORTH AMERICAN SEMICONDUCTOR MANUFACTURERS

SEMICONDUCTOR MANUFACTURER					CORPORATE SALES							PLANT & EQ. EXPENDITURES			
		MFG. Type				Semiconductor Sales[1] ($M)							Semiconductor Division ($M)		
			Captive[3]				Integrated Circuits								
Company	Customer Type 2	Merchant	With Sales	Without Sales	1983 Total Sales ($M)	Total Component Sales	Total IC Sales	MOS	Bipolar	Linear	Discrete Devices	Total Corporate ($M)	Total Division	Total Equipment	Total Plant
Signal Process Circuits							o			o					
Silicon General	M1	o			29.0	29.0	29.0	-	13.9	15.1	-	3.2	3.2		
Silicon Microsystems	M1	o					0.3								
Silicon Systems	M1	o			22.7	22.7	22.7	22.7				4.1	2.7		
Siliconix	M1	o			69.6	68.9	42.0	12.1	1.1	26.4	29.3	8.1	8.1		
Siltronics	M1	o			4.8	4.7	4.7				-	0.7	0.7		
SMC Microsystems	M1	o													
Solid State Scientific	M1	o			41.0	41.0	41.0	41.0	o	o			7.4		
Solidstate Devices Inc.	M1	o													
Solidstate Microwave(Varian	M1														
Solitron Devices	M1	o													
Spectronics (Honeywell)	M1	o					-	-	-	-	o				
Sperry Univac	C1			o	4914.0	43.6						310.5	9.3		
Sprague (GK Technology)	M1	o				54.1	44.5			44.5	9.6		7.5		
Standard Microsystems	M1	o			44.4	44.4	44.4	44.4				12.8	12.8		
STC Computer Research				o											
Storage Technology	C1			o	886.6	0.2		o				86.6			
Supertex	M1	o			15.5	14.7	14.7	14.7	-	o	o	2.4	2.4		
Synertek (Honeywell)	M1	o				62.3	62.3	62.3	-				5.2		
Tektronix	C1			o	1331.3	43.5					o	90.1	7.9		
Teledyne Crystalonics					2860.0										
Teledyne Inc. (Microsemi)	M1	o			2979.0	26.2	17.9	11.6	3.3	3.0	8.3	75.8	6.3		
Teletype		o		o	8.6	8.6	8.6		-	-	-				
Telmos	M1	o			2.3	2.3	2.3	2.3				3.8	3.8		
Texas Instruments	M2	o			4542.8	1665.0	1572.0	612.6	662.6	296.8	93.0	.454.1	232.0		
Texet Corp.							o	o							
Torric Corp.															
Trilogy	C1			o											
TRW	M1	o			5493.0	111.1	44.3	o		44.3	66.8	309.9	15.7		
Unitrode	C1	o			159.6	79.8	3.1	-	-	3.1	76.7		10.3		
Universal Semiconductor	M1	o			1.6	1.6	1.6	1.6							
Varian	M1	o			760.3	18.2					18.2	33.7	3.8E		
Varo Semiconductor	M1	o			100.8	28.0	-	-	-	-	28.0		5.4		
Vatic Systems	M1	o			0.0	0.0	0.0	o	o	o	-				
Veeco (Lambda Semicon.)	M3	o			122.1	11.4		-	-	-	-	5.5	3.4		

1 . . valent internal transfers at merchant market rates. . 2 See text. ... th sales' indicates a captive firm who also sells to the open market.

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TABLE 6.1.3-2

NORTH AMERICAN SEMICONDUCTOR MANUFACTURERS

SEMICONDUCTOR MANUFACTURER					CORPORATE SALES							PLANT & EQ. EXPENDITURES			
		MFG. Type				Semiconductor Sales[1] ($M)							Semiconductor Division ($M)		
			Captive[3]				Integrated Circuits								
Company	Customer Type[2]	Merchant	With Sales	Without Sales	1983 Total Sales ($M)	Total Component Sales	Total IC Sales	MOS	Bipolar	Linear	Discrete Devices	Total Corporate ($M)	Total Division	Total Equipment	Total Plant
VHSIC Technology	M1	o													
Virginia Semiconductor	M1	o													
Visic Inc.	M1	o					o	o							
Vitelic	M1	o					o								
VLSI Technology Inc.	M1	o			35.8	28.3	28.3	28.3				22.4	22.4		
Votrax	M1	o			3.3	3.3									
Wafer Scale Integration	M1	o					o	o							
Watkins Johnson				o	186.0	73.5							14.9		
Western Digital	M1	o			50.6	43.8	43.8	43.8	o	o	o	6.4	5.7		
Westinghouse Electric	C2	o		o	9532.6	68.8	-	-	-	-		716.0	14.1		
Wietek	C1			o											
Xerox	C1			o	8463.5	17.5	17.5					325.3			
Xicor	M1	o			15.7	15.7	15.7	15.7	-	-	-	11.5	11.5		
Xilinx	M1	o					o	o							
Zenith Electronics	C1			o	1361.0							31.4			
Zilog	M2	o		o	89.1	55.8	55.8	55.8	-	-	-		11.6		
Zymos	M1	o			8.9	8.9	8.9	8.9				6.0	6.0		
Zytrex	M1	o					o	o							

[1] Equivalent internal transfers at merchant market rates. [2] See text. [3] With sales' indicates a captive firm who also sells to the open market.

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TABLE 6.1.3-3

JAPANESE SEMICONDUCTOR MANUFACTURERS

SEMICONDUCTOR MANUFACTURER					CORPORATE SALES							PLANT & EQ. EXPENDITURES			
		MFG. Type				Semiconductor Sales[1] ($M)							Semiconductor Division($M)		
			Captive[1]				Integrated Circuits								
Company	Customer Type 2	Merchant	With Sales	Without Sales	1983 Total Sales ($M)	Total Component Sales	Total IC Sales	MOS	Bipolar	Linear	Discrete Devices	Total Corporate ($M)	Total Division	Total Equipment	Total Plant
Asahi Electric		o													
Canon Electronics	C3			o	2933.8	3.7									
Computer Development Labs			o												
Fine Products Microelect.															
Fuji Electric Co.					1878.4	203.9E							26.1E		
Fujitsu Ltd.	M2	o	o		4842.8	702.4	605.0	394.5	185.0	25.5	97.4	407.7	229.2		
Hamamatsu TV					42.7E	12.6E									
Hitachi	M3	o	o		19088.8	1457.3	1072.3	576.6	165.2	330.5	385.0	1636.3	208.3		
Hokuriku Electric Industry		o			106.3	73.3	27.6				45.7		13.9E		
Ind. Tech. Rsh. Inst.															
Japan Precision Circuits															
Japan Resistor					33.2	6.6	o				6.6				
KH Electronics															
Koa Denko		o			83.3	78.3	65.0				13.3	6.3	6.3		
Kokusai Electric	M3		o		276.7	117.3					-		20.5E		
Kyodo Denshi															
Matsushita	M2	o	o		16618.8	595.6	380.5	161.6	14.1	204.8	215.1	602.0	125.0		
Meidensha Electric					406.7										
Minebea	M1				761.0										
Mitsubishi	M2	o	o		7271.9	581.3	423.8	208.3	68.9	146.6	157.5	303.3	147.9		
MMK (Monsanto)															
Moririca Electronics		o			12.6	12.0					12.0				
NEC	M3	o	o		6994.5	1604.2	1290.4	856.8	128.0	305.6	313.8	968.4	279.2		
New Japan Radio	M1	o			76.3	45.8	5.8			5.8	40.0		4.8E		
Nippon Denshi Gijutsu															
Nippon Gaki	C1			o	1687.0	28.8E	o	o			o				
Nippon Prec. Circ. (Seiko)	M1	o			29.7	29.7	29.7	29.7							
Nippondenso	C1			o	2819.5	261.1	o	o		o	o		61.9E		
Nissan Motor				o	18251.1										
NTIS (NEC, Toshiba)		o													
NTT	C2														
Ohzami															
Oki Electric	M1	o	o		1250.0	291.7	266.4	245.6	14.8	6.0	25.3	108.4	55.0		
Omron Tateisi Electronics					1006.3							105.5			
Origin Electric		o			79.2	12.7E					12.7E				

1 . ..valent internal transfers at merchant market rates. 2 See text. ...th sales' indicates a captive firm who also sells to the open marke...

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TABLE 6.1.3-3

JAPANESE SEMICONDUCTOR MANUFACTURERS

SEMICONDUCTOR MANUFACTURER		MFG. Type			CORPORATE SALES							PLANT & EQ. EXPENDITURES			
			Captive[3]			Semiconductor Sales[1] ($M)							Semiconductor Division ($M)		
							Integrated Circuits								
Company	Customer Type[2]	Merchant	With Sales	Without Sales	1983 Total Sales ($M)	Total Component Sales	Total IC Sales	MOS	Bipolar	Linear	Discrete Devices	Total Corporate ($M)	Total Division	Total Equipment	Total Plant
Pioneer Electronics	C1			o	1286.4	1.1					-				
Primo Co.															
Ricoh				o	1625.0	41.7	41.7					150.5	8.3E		
Rohm Fukuoka					231.3	272.9	108.7				164.2	0.9			
Sanken Electric Co		o			205.1	128.9	o				o	62.5	50.0		
Sansha Electric															
Seiko Sound	C1			o											
Sharp	M2	o		o	4075.7	475.0	459.5	375.9		83.6	15.5	833.3	83.3		
Shindengen Electric		o			174.3	88.9					88.9		16.6E		
Shinitsu															
Sony	M2	o		o	4629.3	139.7	52.6				87.1	236.0	55.2E		
Stanley Electric		o			389.8	85.8					85.8	34.5	16.3E		
Sumitomo Electric Ind.		o			2359.4										
Suwa Seikosha															
Switch Industries															
Taiyo Yuden Co.		o			212.8	83.0	o				o		15.8		
TDK Electronics		o			1444.1	155.6	o				155.6	126.9			
Teikoku Tsushin				o	120.9	88.3					88.3				
Tokyo IC		o			16.7E	16.7E									
Tokyo Sanyo Co.	M1	o			1146.3	316.7	220.9	63.7	15.0	142.2	95.8		50.0		
Toshiba	M3	o	o		10712.3	1125.0	869.3	526.6	73.4	269.3	255.7	520.0	250.0		
Toyo Electronics Ind.		o						-	-	o	o				
ULSI															
Unizon Corp.		o			9.4	9.4					9.4				
Yamaha	C			o						o					
Yuasa Battery Co.		o			256.1	28.2					28.2	15.5			

[1] Equivalent internal transfers at merchant market rates. [2] See text. [3] With sales' indicates a captive firm who also sells to the open market.

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TABLE 6.1.3-4

EUROPEAN SEMICONDUCTOR MANUFACTURERS

SEMICONDUCTOR MANUFACTURER					CORPORATE SALES							PLANT & EQ. EXPENDITURES			
		MFG. Type				Semiconductor Sales[1] ($M)							Semiconductor Division($M)		
			Captive[1]				Integrated Circuits								
Company	Customer Type 2	Merchant	With Sales	Without Sales	1983 Total Sales ($M)	Total Component Sales	Total IC Sales	MOS	Bipolar	Linear	Discrete Devices	Total Corporate ($M)	Total Division	Total Equipment	Total Plant
AME															
Ansaldo															
ASEA-AB															
BASF															
BBC															
Bosch			o			15.4E	15.4E								
British Aerospace															
Cogie															
Compania Telefonica				o											
Diehl Group															
Ebauches															
Efcis															
Elcoma (Philips)															
EMD								o							
Eurosil		o					15.0E	15.0E							
Faselec (Philips)						26.6E									
Favag						1.3E									
Ferranti		o			600.0E	99.1	84.5	13.0	47.5	24.0	14.6	32.0	11.1		
Hafo-Rifa															
Hassler															
Honeywell Bull															
ICCE															
ICL															
Integrated Photomatrix															
Integrated Power Semicon.															
Iscom															
ITT		o			14155.4	251.7	120.9	54.7	22.8	43.4	130.8	744.1	46.1		
L.M. Ericsson Telephone															
LNT															
Lucas Aerospace															
Marconi Electronic Devices		o				1.3E									
Matra/Harris															
Microelectronic Technology															
Mistral															
Mullard (Philips)															

1 ..uivalent internal transfers at merchant market rates. 2 See text. ...ith sales' indicates a captive firm who also sells to the open mark.

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TABLE 6.1.3-4

EUROPEAN SEMICONDUCTOR MANUFACTURERS

SEMICONDUCTOR MANUFACTURER					CORPORATE SALES							PLANT & EQ. EXPENDITURES			
		MFG. Type				Semiconductor Sales[1] ($M)							Semiconductor Division ($M)		
			Captive[3]				Integrated Circuits								
Company	Customer Type[2]	Merchant	With Sales	Without Sales	1983 Total Sales ($M)	Total Component Sales	Total IC Sales	MOS	Bipolar	Linear	Discrete Devices	Total Corporate ($M)	Total Division	Total Equipment	Total Plant
N.V. Philips	M3	o		o	16204.6	874.3	655.6	162.5	290.9	202.2	218.7	874.0	123.3E		
Piher															
Plessey	M1	o			1755.2	47.3	42.7	18.9	10.3	13.5	4.6		7.6		
Post Office Research Center				o											
Racal Electronics plc															
Remo															
RSRE															
RTC (Philips)															
Semikron															
Semitron															
Sescosem		o													
SGS-ATES		o			225.0E	179.3	140.7	41.0	39.0	60.7	38.6		28.7		
Siemens		o			15478.8	405.1	210.0	91.9	86.9	31.2	195.1	663.0	97.6		
Silec															
Sintra															
Smiel															
Spath															
SSC															
STC Semiconductors															
STL TI															
TAG						15.8									
Telefunken Electronic		o			141.2	141.2	42.4	33.7		8.7	98.8		11.3		
Tesla															
Thomson CSF		o			4040.7	198.7	88.2	38.3	38.8	11.1	110.5		28.0		
Thorn-EMI					3670.0	48.2	48.2	48.2					10.2E		
Tungsram															
Unitra-Cemi															
Valvo						33.8E							6.4E		
Veb Funwerk Erfurt															
Veb Halbeiterwerk															
Westcode															
Znet															

[1] Equivalent internal transfers at merchant market rates. [2] See text. [3] With sales' indicates a captive firm who also sells to the open market.

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TABLE 6.1.3-5

ROW SEMICONDUCTOR MANUFACTURERS

SEMICONDUCTOR MANUFACTURER					CORPORATE SALES							PLANT & EQ. EXPENDITURES			
		MFG. Type	Captive[1]			Semiconductor Sales[1] ($M)							Semiconductor Division($M)		
							Integrated Circuits								
Company	Customer Type[2]	Merchant	With Sales	Without Sales	1983 Total Sales ($M)	Total Component Sales	Total IC Sales	MOS	Bipolar	Linear	Discrete Devices	Total Corporate ($M)	Total Division	Total Equipment	Total Plant
ADT (TWN)															
Anam Industrial Co. (Kor)							o				o				
AWA Microelectronics (Aust)															
Bharat Electronics (Ind)							o	o	o		o				
Central Electronics Ltd. (Ind)															
CDIL (Ind)															
Conic Semiconductor (HK)															
Continental Device (Ind)															
CSIST (Twn)															
Daewoo Electronics (Kor)					3000.0	1.0									
Eastern Engineers															
Elcap (HK)							o	o							
Electrodomesticos Durex (EQU)															
Electronics Corp. of India															
Fine Products (Twn)							o			o	o				
G I T (Twn)															
Gold Star Semi. Ltd (Kor)			o							o	o				
Goyo Electronics Co., Ltd.					10.4		o								
Hanguk Electronics (S.Kor)					0.7E	0.7E				0.7E					
Hindustan Aeronautics Ltd.															
Hindustan Conductors															
Hua Ko (HK)															
Hyundai Electronics (S.Kor)															
Indian Telephone Ind. (Ind)															
Integrtd.Microelect.Ltd (Ind)															
ITRI/ERSO (Twn)						24.8E	o	o	o	o					
Itsuwa Shoji Kaisha Inc.															
KIET (Kor)				o			o	o	o	o					
Korea Electronics Co. (Kor)			o		60.0	30.0					30.0				
Korean Microsystems (Kor)															
Kumsong (S.Kor)															
Laison (Twn)															
Meltron Semiconductor (Ind)					0.8	0.8					o				
Microelectronics (HK)															
Orient Semiconductor (Twn)															

1 ... valent internal transfers at merchant market rates. 2 See text. ...th sales' indicates a captive firm who also sells to the open mark...

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TABLE 6.1.3-5

ROW SEMICONDUCTOR MANUFACTURERS

SEMICONDUCTOR MANUFACTURER					CORPORATE SALES							PLANT & EQ. EXPENDITURES			
		MFG. Type				Semiconductor Sales[1] ($M)							Semiconductor Division ($M)		
			Captive[3]				Integrated Circuits								
Company	Customer Type 2	Merchant	With Sales	Without Sales	1983 Total Sales ($M)	Total Component Sales	Total IC Sales	MOS	Bipolar	Linear	Discrete Devices	Total Corporate ($M)	Total Division	Total Equipment	Total Plant
President (Twn)															
RCL (HK)							o				o				
Rectron (Twn)															
Ruttonsha Int Rect. (Ind)											o				
Samsung Electronics (Kor)		o					o	o	o	o					
Semiconductor Complex Ltd.															
Siltronics Ltd. (Ind)															
Symbol Semiconductor (Twn)					0.7E	0.7E	0.7E			0.7E					
Syntek Design Tech. (Twn)							o								
Taihan Telecommun. (Kor)															
Tatung (Twn)		o													
Teleart (HK)							o	o							
Telecommunications Lab (Twn)															
Tristar Semiconductor (Kor)									o						
United Microelect.Co.(Twn)					23.3E	23.3E	23.3E	23.3E							

1 Equivalent internal transfers at merchant market rates. 2 See text. 3 With sales' indicates a captive firm who also sells to the open market.

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6.2 SEMICONDUCTOR INDUSTRY MARKET TRENDS

6.2.1 Market Demand

6.2.1.1 User Descriptions

- *Automotive Electronics*
- *Communications Electronics*
- *Computer Electronics*
- *Consumer Electronics*
- *Government Electronics*
- *Test & Measurement Electronics*
- *Other Electronics*

6.2.1.2 Demographic Aspects

6.2.1.3 Buyer Issuers

6.2.2 Market Supply

6.2.2.1 Logic IC

- *Microprocessor*
- *Support*
- *Custom Logic*
- *Miscellaneous*

6.2.2.2 Memory IC

- *Dynamic RAM*
- *Static RAM*
- *ROM*
- *PROM/EPROM*

6.2.2.3 Digital Signal Processing IC

6.2.2.4 Linear IC

6.2.2.5 Discrete & Photoelectric

6.2.3 Overall Semiconductor Outlook & Forecast

6.2.0 SEMICONDUCTOR INDUSTRY MARKET TRENDS

This year, the semiconductor industry has achieved record growth rates of 38.8%. This is being driven by rapid growth in the overall electronics industry. In 1983, it grew by 22% over 1982. With the exception of the solar power industry, electronic equipment is the sole source of demand for semiconductors.

This section delineates this market, its size, and overall trends in the demand for semiconductors. It also examines the supply of semiconductors in detail. The various market segments are examined. It concludes with forecast of the total market in Section 6.2.3.

6.2.1 MARKET DEMAND

In 1983, electronics production totaled over $277 billion. This represents a 16.8% increase over 1982. Table 6.2.1-1 gives a three year electronics production summary for the world. Production is forecast to be $539.5 billion by 1988. The industry should grow at a compounded annual rate of 14.2% per year.

Electronics has become an integral part of life as we know it today. It is pervasive in the home as well as at work. Even still, there is significant room for further growth. Electronics still only accounts for just over 2% of GNP. Yet, over 50% of the population works in information related jobs.

It is commonly known that semiconductors play a vital role in this industry. From microcomputers to VCR's and from pocket pagers to electronic devices in automobiles it is ultimately semiconductors which are at work. Moreover, semiconductors are diffusing into electronics at a positive rate. This section describes the various electronic markets. It also shows why they drive demand for semiconductors.

6.2.1.1 USER DESCRIPTIONS

The electronics industry can be neatly divided into nine major categories. They are shown below:

- Automotive
- Communications
- Computers
- Consumers
- Government
- Industrial
- Medical
- Office
- Test & Measurement

TABLE 6.2.1-1

WORLDWIDE ELECTRONICS PRODUCTION
(in millions of $)

	1982				1983				1984			
	US	JAPAN	EUROPE	TOTAL	US	JAPAN	EUROPE	TOTAL	US	JAPAN	EUROPE	TOTAL
AUTOMOTIVE	2839	3182	1194	7215	3696	4143	1527	9366	5243	5876	1953	13072
COMMUNICATIONS	23923	5629	11400	40952	26939	6755	11720	45414	32900	8049	12040	52989
COMPUTERS	44678	14521	11170	70369	50103	18707	15199	84009	59822	22311	18127	100260
CONSUMER	9993	13623	6475	30091	11350	15559	6532	33441	13280	22289	6564	42133
GOVERNMENT	29574	780	10123	40477	34672	1045	11193	46910	43043	1310	13040	57393
INDUSTRIAL	11752	3967	4658	20377	12804	5036	6350	24190	15262	5950	8657	29869
MEDICAL	3370	1127	1455	5952	3977	1343	1638	6958	4583	1435	1822	7840
OFFICE	7439	4962	2977	15378	8727	6545	4364	19636	10236	11552	5118	26906
TEST & MEASUREMENT	2196	1771	1025	4992	2454	1904	1075	5433	2905	2361	1211	6477
OTHER	960	405	610	1975	1133	478	708	2319	1306	551	806	2663
TOTAL	136724	49967	51087	237778	155855	61515	60306	277676	188580	81684	69338	339602

Source VLSI RESEARCH INC

0210B4M11/1

AUTOMOTIVE

Automotive electronics is the seventh largest segment. Nevertheless, it is not small and unimportant. In 1983, automotive electronics production achieved $9.4 billion worldwide. This was a 29.8% increase over 1982.

Automobile manufacturers are discovering the magic of silicon chips. In this industry, electronics applications are growing. Isuzu recently advertised that their Impulse had "three on-board computers". Today's automobiles typically utilize semiconductors to improve performance, economize fuel and control emissions. Electronic control modules (ECM) precisely regulate the fuel-air mixture to achieve these results. ECM's work with several sensors which collect and send data to the ECM. There is usually one ECM per car.

Semiconductor intensive electronics are replacing the traditional electromechanical devices of cars. For example, distributors have been obsoleted by more advanced systems. Electronic ignition systems have replaced points and condensers which regulate spark dwell and timing. Furthermore, electronic fuel injection systems are replacing carburetors. Similarly, hydraulic systems are being added and improved.

Besides engine improvements, dashboards displays are another area of interior electronic advancements. Analog type gages are becoming obsoleted by digital ones. Digital dashboards now read-out measurements of oil pressure, temperature, speed, RPM's, etc. These systems are more precise, more convenient and more attractive to consumers. Similarly, trip computers, voice synthesis, distributorless ignitions and other "bells and whistles" are gaining popularity among consumers.

Of course, semiconductors are at the heart of these automotive innovations. Microprocessors control ECM's. Commonly, 8-bit chips are used. However, 16-bit microprocessors show favorable market potential in the latest automotive designs. Their flexibility and faster speed make them desirable. Speed is critical in automotive applications because of the real time nature of the job. CMOS chips are gaining popularity since they dissipate less heat and are now less expensive compared to previous years. Despite their advantages, low heat resistance remains a disadvantage. Power MOSFET's also appeal to this user segment because of their high current capabilities and efficiency. Semiconductors have only begun to make their mark in this industry and the future looks promising.

COMMUNICATIONS

In 1983, communication electronics production reached $45.4 billion worldwide. This was a 10.9% growth over 1982. It is the third largest electronics segment.

This year will prove to be the most challenging to this industry because of the break-up of American Telephone & Telegraph (AT&T). Moreover, this event will affect industry for many years to come. In communications, competition is expected to be fierce between the existing companies. New start-ups will emerge. For semiconductor manufacturers, many new customers will replace what used to be a concentrated customer base. The impact of this topic will be further discussed in the "Buyer Issues" portion of this section.

One area of new demand is the ordinary, familiar telephone. Since the break up, it is no longer necessary to lease them exclusively from AT&T. Thus, the market is opening up to new telephone manufacturers and competition. In the near future, telephones could well become disposable consumer products. Consequently, this is one market semiconductor manufacturers should keep an eye on.

Furthermore, the cellular (mobile) telephone industry is blossoming. At present, there are few companies supplying this market. However, this is rapidly changing as competition grows. This in turn is causing price drops. Consequently it can be expected that cellular phones will no longer be considered a "luxury" item. Meanwhile, the market continues to expand and is expected to become very large indeed! Within the next 10 years everyone will have one... or want one. This market may well be the next great boom replacing personal computers and video games.

As in automotive electronics, digital devices are replacing analog devices in telecommunications. Hence, market demand for digital switching systems is rising. When the computer's demand for telecommunication trunklines first arose, digital signals were being transmitted on analog circuits that were designed for speech. Back then, demand for digital signals was small. Today, it has become a major portion of telephone usage. It is thus more efficient today to pulse-code-modulate speech signals and then transmit them as digital codes through digital circuits rather than vice versa. The codec helps make this happen. It is a DSP circuit which combines analog and digital circuits.

As data-communications electronic applications have grown, a need for modems and multiplexers has also been generated. Modems are necessary to transmit data over telephone lines for computer to computer "talking". Similarly, favorable growth is expected in the micro-to-mainframe computer-communications and packet switching.

COMPUTER

The computer segment is the largest electronics segment. In 1983, computer production reached $84.0 billion worldwide. This represented a 19.4% growth over 1982. This segment includes computers, peripherals and software. IBM is the unquestioned leader in this industry. The computer market has a dramatic impact on semiconductor consumption not only because of its size, but also because it follows the first derivative of the economy.

The market for computers is driven primarily by growth in worldwide industry itself. One way of measuring industry's effect on computer's is through the acceleration principal of economics. That principal states that any firm's investment in new equipment will vary directly with the change of its own revenue. Thus the primary driving forces for computers will be determined by industry's magnitude of growth, not by its actual sales. Consequently, it's driven like the end of a whip – increasing or decreasing at the slightest agitation of the economy.

The personal computer is the recent champion of this segment. Presently, computer usage is quite common in business. However as personal computers have become more affordable, they have found their way into professional offices and homes. In the future, they will be used for everything from home banking to airplane ticket purchases.

The peripheral market is flourishing as well. For the most part, this is due to computer segment growth. In addition, the software market, still in its infancy, is a high growth market. Software manufacturers are addressing two issues: standardization and user friendliness.

CONSUMER

The consumer segment of electronics represents a relatively stable market for semiconductors. In 1983, production reached $33.4 billion worldwide. This marked an 11.1% increase over 1982. However, correctly gauging the whims of consumer choice makes it a tough market to compete in.

The product life cycle in consumer electronics tends to rapidly escalate into maturity. Primary demand (i.e. first-time buyers) usually cause a consumer electronics product sales to explode. However, secondary demand (i.e. second-time buyers) is always much lower than primary demand. Consequently, once a primary demand peak is reached, a market soon collapses. Prices fall first, and then volume. There is a huge graveyard of here-today-gone-tomorrow consumer electronics fads. Some of these have been calculators, CB radios, and video games.

Video cassette recorders (VCR), televisions and video games are video items included in this segment. VCR's have had a very bright future. The video boom: cameras, games and especially VCR's, have touched off sales in the TV market. Consumers are upgrading their televisions to improve picture quality.

Disk players, stereos/tape decks and radios are audio items included in this segment. Disk players are the newcomer to the industry. It is still in the introduction phase of the product lifecycle. Hence, the price must drop somewhat before it will gain mass consumer acceptance. Additionally, appliances, from microwave ovens to cameras are included in this electronic segment.

GOVERNMENT

The government is the second largest segment of electronics. It is also one of the most stable of all markets. Military electronics expenditures compose the majority of this segment. Government/military electronics production achieved $46.9 billion worldwide in 1983. This was a 15.9% increase over 1982.

The long term outlook in this electronics segment continues to be good despite pressures from the deficit. In particular, defense expenditures are increasing. Even so, this does not mean that electronic-type expenditures will increase significantly. The percentage of electronics spending to total defense dollars will remain at about 18% until the 1990's. In general, rising program costs and Congress limiting funds prevents further growth in this segment. Furthermore, military planners are playing a game of "Catch-Up". Under Reagan, they are still trying to accomplish Carter's programs. At the same time, there is a discrepancy between what military planners want and what Congress will approve. Also, funds are allocated such that 80% of the budget goes to 20% of the projects.

Despite this, there will be new opportunities for electronics companies and in turn, semiconductor companies. For instance, growth potentials exist in command, control and communications counter measures (C3CM), portable devices and Navy anti-war warfare. NASA will also be indulging in more electronics merchandise since Congress authorized $150 million for a civilian space station. All in all, the government electronics demand should remain steady through 1988.

TEST & MEASUREMENT

The test and measurement electronics market is looking forward to a bright future. In 1983, production totaled close to $5.5 billion worldwide, up only 9.0% from 1982. But, in 1984 the market should grow

19.2% to almost $6.5 billion. An improved economy is responsible for growth in this industry. In addition, the augmented growth of digital-electronic based designs has spurred still more increases.

This industry includes automatic test equipment (ATE), microprocessor development systems, logic analyzers, instrumentation, and oscilloscopes. VLSI/LSI and linear IC test systems have the most promising market potential. For laboratory applications, microprocessor development systems use is looking up. Growth awaits standalone models of logic analyzers. Additionally, there is a favorable market for oscilloscopes for production uses, laboratory applications and computer-aided design/engineering systems.

Other

In 1983 the industrial electronics production reached $24.2 billion worldwide. This was a 18.7% increase over 1982. It is the fifth largest electronics market.

This user segment is just beginning to utilize semiconductors. As manufacturers strive for increased productivity and quality, factories are moving towards automation. Robotics play a key role in automation.

Medical electronics is one of the smallest segments. Medical electronics production amounted to almost $7 billion worldwide in 1983. This was up 16.2% from 1982. From thermometers to scanning electron microscopes, electronics continue to find more places in the medical field. Ever growing medical knowledge constantly requires more technologically advanced equipment.

Office electronics production was $19.6 billion worldwide in 1983. This is a 27.7% increase over 1982.

There are many types of office equipment. A rising star of this segment is electronic mail. As the need for instant information and instant communication of that information grows, so will the electronic mail market. Presently, there are four types of electronic mail technologies: facsimile, communicating word processors, computer based message systems and voice mail. Facsimiles transmit exact replicas of documents from point to point. Communicating word processors electronically transmit work from one word processor to another. They are commonly used for internal purposes though documents may be sent via telephone lines to other locations. Computer-based message systems involve computer to computer "talking". Typed messages may be sent or received via a computer terminal. Voice mail is the last type of electronic mail. It works by using a Touch-Tone type telephone and a computer.

In addition to electronic mail, copiers, calculators and typewriters are included in this segment. Equipment such as these are increasing office productivity effectiveness. As offices move toward more automation, equipment purchases should continue to increase at a fairly constant pace.

6.2.1.2 DEMOGRAPHIC ASPECTS

The U.S. leads the world in production of electronic products. The largest segment of the U.S. electronics industry is computers. Government electronics rank number two. This in part is due to the Reagan administration's increased military spending.

Japan's electronics industry has experienced rapid growth during the past 20 years. Today it is among Japan's leading industries. Japan continues to supply the world with new products. For example, VCR's are the brain child of Japan. VCR's are almost exclusively produced in Japan. Japanese electronics can be characterized as an export-dependent industry. Thus, there is a trend towards Japanese firms "setting up shop" in both the U.S. and Europe. Japan is a strong and formidable competitor and will continue to be so in the future.

The Old World, by comparison, is advancing much slower than her U.S. and Japanese competitors. Europe's numerous countries make it difficult to keep pace. The European Economic Commission is attempting to unify its 10 members. European electronics manufacturers are beginning to show signs of working together. A large and growing market, Europe still has a ways to go.

6.2.1.3 BUYER ISSUES

While growth is practically assured in the electronics industry, some uncertainty still prevails. First, in the automotive industry, somewhat of a communication gap poses a potential threat. One area concerns delivery dates. Semiconductor manufacturers propose tentative delivery dates which automobile manufacturers count on. Semiconductor manufacturers often can not make these dates. Automobile manufacturers are somewhat frustrated at this seemingly unreliability. In actuality, the two manufacturers are miscommunicating. Semiconductor manufacturers view these dates as targets, while automobile manufacturers view them as certain. Timing is critical in both industries. Both parties must understand delivery dates in equal terms. This communication problem is one issue that must be addressed by automobile and semiconductor manufacturers alike.

Next, the break-up of AT&T poses some uncertainty in the communications electronics industry. Worldwide, firms are trying to capture a piece of this wide open market. While the independent companies struggle for their niche, semiconductor manufacturers now have more potential markets. The break-up of Bell Operating Companies alone ushered in 22 new potential clients. The next few years will be a period of confusion and readjustment for semiconductor manufacturers and communication firms, as the market is restructured.

Lastly, 1984 is the year of presidential elections in the United States. Any potential change of government poses some uncertainty – uncertainty as to who will come to power and what their administration will do once in power. The United States is a world leader, and her decisions have consequences worldwide.

MARKET FORECAST

Table 6.2.1-2 shows the production forecast for each user segment. The overall market will reach $554.2 billion by 1988. The computer segment will continue to be the largest. By 1988, production will amount to $182 billion at a 16.7% compounded annual growth rate. The fastest growth will be experienced in the test and measurement electronics industry. It will grow at a 19.9% compounded annual growth rate.

6.2.2 MARKET SUPPLY

This section details factors surrounding the supply of semiconductors. It covers each of the major semiconductor product markets.

6.2.2.1 LOGIC IC

The market for logic integrated circuits is by far the largest. Table 6.2.2-1 shows worldwide logic IC sales for 1983. These totaled more than $10.9 billion worldwide. Logic IC sales account for 45% of total worldwide semiconductor sales. Sales by merchant semiconductor companies comprise 65.7% of the logic market. This amounts to 38.1% of the total worldwide merchant semiconductor market. The logic market is the largest segment for captive manufacturers. It accounts for over 69% of total worldwide captive sales. The North American sector is the largest. It amounts to 57.6% of the merchant logic market. As previously explained, the logic market can be broken into at least four

TABLE 6.2.1-2

ELECTRONICS PRODUCTION FORECAST
(in millions of $)

Segment	1983 US	1983 Japan	1983 Europe	1983 Total	1988 US	1988 Japan	1988 Europe	1988 Total	CAGR %
Automotive	3696	4143	1527	9366	8123	9105	3749	20977	17.50
Communications	26939	6755	11720	45414	53142	18010	14803	85955	13.61
Computers	50103	18707	15199	84009	102555	40444	39000	181999	16.72
Consumer	11350	15559	6532	33441	23839	33871	9975	67685	15.14
Government	34672	1045	11193	46910	53085	1690	16821	71596	8.82
Industrial	12804	5036	6350	24190	25530	8347	11852	45729	13.58
Medical	3977	1343	1638	6958	7469	2338	2969	12776	12.92
Office	8727	6545	4364	19636	13801	11677	9650	35128	12.34
Test & Measurement	2454	1904	1075	5433	7511	3868	2069	13448	19.87
Other	1133	478	708	2319	2153	908	1174	4235	12.80
TOTAL	155855	61515	60306	277676	297208	130258	112062	539528	14.21

Source VLSI RESEARCH INC

TABLE 6.2.2-1

1983 WORLDWIDE LOGIC SEMICONDUCTOR SALES

DEVICE TYPE	WORLDWIDE TOTAL		ESTIMATED CAPTIVE		MERCHANT SEMICONDUCTOR PRODUCTION: TOTAL		North America		Japan		Europe & ROW	
	($ M)	(units)	($ M)	(units)	($ M)	(units)	($ M)	(units)	($ M)	(units)	($ M)	(units)
MICROPROCESSOR	2172.6	351.8	526.6	34.3	1646.0	317.5	742.1	110.6	831.6	193.7	72.4	13.2
CMOS Microprocessors	742.2	112.4	247.0	10.0	495.2	102.4	82.0	14.2	413.2	88.2	0.0	0.0
4 bit	415.6	95.1	-	-	415.6	95.1	51.1	11.7	364.5	83.4	0.0	0.0
8 bit	73.1	7.2	-	-	73.1	7.2	24.4	2.4	48.7	4.8	0.0	0.0
16 bit	253.5	10.1	247.0	10.0	6.5	0.1	6.5	0.1	0.0	0.0	0.0	0.0
32 bit	0.0	0.0	-	-	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
N/PMOS Microprocessors	1300.2	219.4	180.8	9.3	1119.4	210.1	628.6	91.4	418.4	105.5	72.4	13.2
4 bit	136.5	65.0	-	-	136.5	65.0	21.2	10.1	111.5	53.1	3.8	1.8
8 bit	719.6	137.6	-	-	719.6	137.6	393.3	75.2	268.3	51.3	58.1	11.1
16 bit	356.6	14.5	93.4	7.0	263.3	7.5	214.1	6.1	38.6	1.1	10.5	0.3
32 bit	87.4	2.3	87.4	2.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Bipolar Microprocessors	130.3	20.0	98.8	15.0	31.5	5.0	31.5	5.0	0.0	0.0	0.0	0.0
4 bit	5.9	1.3	-	-	5.9	1.3	5.9	1.3	0.0	0.0	0.0	0.0
8 bit	44.4	13.6	22.8	10.0	21.6	3.6	21.6	3.6	0.0	0.0	0.0	0.0
16 bit	80.0	5.1	76.0	5.0	4.0	0.1	4.0	0.1	0.0	0.0	0.0	0.0
MICROPROCESSOR SUPPORT	469.9	183.9	0.0	0.0	469.9	183.9	322.8	124.1	114.7	46.5	32.5	13.3
CMOS	97.5	39.0	-	-	97.5	39.0	46.8	18.7	50.8	20.3	0.0	0.0
N/PMOS	335.3	137.4	-	-	335.3	137.4	238.9	97.9	63.9	26.2	32.5	13.3
Bipolar	37.1	7.5	-	-	37.1	7.5	37.1	7.5	0.0	0.0	0.0	0.0
CUSTOM	3984.5	2367.2	3126.7	2152.2	857.8	214.9	493.1	114.4	281.2	76.7	83.5	23.9
Full Custom	2342.3	1927.1	1932.2	1769.4	410.1	157.7	189.0	72.7	164.8	63.4	56.3	21.7
Standard Cell	1088.4	362.5	996.9	349.1	91.5	13.5	48.5	7.1	32.9	4.8	10.1	1.5
Gate Array	453.8	57.5	197.6	33.8	256.2	23.8	155.6	14.5	83.5	8.4	17.1	0.8
CMOS	228.7	48.6	80.5	27.4	148.2	21.2	89.5	12.8	55.1	7.9	3.6	0.5
N/PMOS	6.4	1.4	2.8	0.9	3.6	0.5	3.6	0.5	0.0	0.0	0.0	0.0
Bipolar	218.7	7.6	114.3	5.5	104.4	2.1	62.5	1.3	28.4	0.6	13.5	0.3
PLA	100.0	20.0	0.0	0.0	100.0	20.0	100.0	20.0	0.0	0.0	0.0	0.0
EPAL	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0				
MISCELLANEOUS	4352.4	6069.0	118.6	0.8	4233.8	6068.2	2596.7	4025.5	1040.9	1138.7	596.2	904.0
TTL	2287.1	3925.4	-	-	2287.1	3925.4	1461.0	2705.6	441.5	507.6	384.6	712.2
ECL	193.9	153.9	-	-	193.9	153.9	122.2	96.0	36.9	29.3	34.8	27.6
CMOS	1007.4	1700.5	-	-	1007.4	1700.5	551.3	1050.1	394.6	533.3	61.5	117.1
GaAs	157.6	0.9	118.6	0.8	39.0	0.1	39.0	0.1	0.0	0.0	0.0	0.0
Other	706.4	288.3	-	-	706.4	288.3	423.2	172.7	167.9	68.5	115.3	47.1
TOTAL	10979.3	8971.9	3771.8	2187.3	7207.5	6784.6	4154.6	4374.5	2268.4	1455.6	784.5	954.5

Source: VLSI RESEARCH INC.

submarkets. These, again, are as follows:

- Microprocessors
- Microprocessor Support
- Custom Logic
- Miscellaneous Functional Blocks

In 1983 total worldwide microprocessor sales equaled $2.2 billion. The biggest demand for microprocessors comes from the industrial, computer and consumer electronics markets. There is also significant demand from the military. The microprocessor market can be subdivided by type of process, and by bit size. N/PMOS is the largest microprocessor market followed by CMOS and Bipolar respectively.

NMOS has been the preferred technology for several years. It is well developed still dominates overall device volume. CMOS is typically used only in battery operated applications. Bipolar is used where speed is an essential requirement. NMOS chips are designed into most existing products.

Design-in's are the key to success in the microprocessor market. A company cannot merely be the first to introduce a new device type. The device must be included into product designs to be successful. Once designed-in, the part is ensured demand for the lifetime of the product. As a result, most microprocessor marketing tends to focus on the design-in period, since it determines future growth.

As next generation microprocessors are introduced, there will be a trend toward more CMOS use. The reasons are related to development of 32 bit microprocessors. Heat dissipation has become a major issue with this part. Designers have not been able to overcome this problem with conventional NMOS technology. Denser chips compound heat dissipation problems. Simply, more devices create more heat which causes reliability problems for the device. CMOS offers lower power consumption and therefore lower heat dissipation for solving this dilemma.

Nevertheless, there is an issue which concerns the very viability of 32 bit microprocessors. Since a 32 bit microprocessor performs on 32 bits of data at a time, they are much more powerful and can address more memory than existing systems. As usual, such power has created concern whether demand for such a powerful chip exists. Several leading market researchers question the viability of such chips.

This has not deterred industry giants such as Motorola, Intel, National Semiconductor, and Texas Instruments from plunging into this market. Semiconductor manufacturers are confident that a worthy demand will exist. They believe that potential demand should come from chip users who have found that 16 bit microprocessors do not provide enough performance. Probable applications include CAE/CAD stations, graphics, scientific usage, UNIX boxes, robotics and other high end applications.

VLSI Research's position sides with the semiconductor industry on this issue. Market research has consistently been wrong in projecting demand for new generations of computing power. The reason is quite simple: using market research to examine this problem is like trying to view a one micron line with the unaided eye. It simply can't be done. The accuracy of market research depends on the presumption that users know what applications they will need prior to having the tool. This presumption is usually not valid when one is on the cutting edge of technology.

This industry would not exist today if it solely used market research methods to determine market entry. It was market research that told IBM that there would only be worldwide demand for a mere handful of computers. It was market research that told Intel not to produce the microprocessor because only a few hundred would ever be needed. No one could ever have foreseen that the equivalent of mainframes would be used to control microwave ovens in households across the world. Some companies have even designed microwave ovens with 16 bit microprocessors.

The fundamental theme that driven the semiconductor industry over its entire history is an *unending thirst* for more computing power. Technology leads applications. Which leads demand. Which in turn drives new technology. This is a fundamentally unstable process which cannot be predicted by classical market research.

The custom logic IC market has been the focus of much attention in recent years. The custom chip market is composed of five segments. These are full custom chips, standard cells, gate arrays, PLA devices and EPAL devices. In 1983, sales of custom IC's reached almost $4 billion. Almost 80% of this was manufactured by captive suppliers.

Captive suppliers dominate the market for full custom and standard cell devices. They account for 82% of all full custom IC manufacture and 92% of standard cell IC manufacture.

The attention given to the custom chip market is largely unjustified for several reasons. However, this market came into Vogue around 1979 when a leading market research firm predicted that custom chip sales could reach as much as 50% of all semiconductor sales. In 1979 custom chip sales amounted to 16.7%. This prediction proved to miss the mark by a wide margin. In 1983, custom chip sales accounted for only 21.1%

of total merchant sales. The history of the custom chip market gives better insight into this trend. It is shown below:

	1979	1983	CAGR
Full Custom	1327.6	2342.3	12.0%
Standard Cell	535.2	1088.4	15.3%
Gate Array	58.0	453.8	50.9%
PLA	2.5	100.0	109.1%
Total	1923.3	3984.5	15.7%

This data clearly shows that competition standard products and custom products has intra-segmental rather than inter-segmental. Growth in the Gate Array and PLA segments has come at the expense of the full custom market.

The reason why this market has not overtaken all other IC markets can be traced back to the architecture of the electronic systems they go into. One must first recognize that the IC market is dominated by the computer market. Only so much of computer can use custom devices. The largest portion of the system is devoted microprocessors, microprocessor peripherals, and memory. Less than a quarter of the system can be customized.

The limited ability of custom chips to supplant the TTL market is another factor slowing its growth. Gate Arrays were originally conceived as a way to combine TTL gates onto a single chip. However, electronics equipment suppliers have always been reticent about scrapping existing designs for new gate array approaches. Moreover, the initial design costs for gate arrays loomed as a large barrier to approval.

The gate array market was founded in 1967 by Fairchild when it introduced a 32 gate circuit. However, it was not until 1978 before gate counts surpassed 500. This is much akin to a sound barrier since a typical board of TTL gates will hold 500 gates. Consequently, each chip design can be used to package an entire board design of TTL gates.

Another factor contributing to the growth of the gate array market was the advent of CAD systems in the late seventies and CAD workstations in the early eighties. This took the tedium out of IC design. It also allowed systems engineers the ability to design their own IC's with having to be a IC designer.

CAD also made the standard cell market possible. It is much easier to design a standard cell instead of a full custom circuit. So it wasn't long before the electronics industry began utilizing standard cell and gate array approaches in their designs instead of full custom.

Slow speed, high power consumption, and low gate density have historically been the bane of programmable logic arrays (PLA's). Until recently, this market has been a small niche segment with little growth. Their main overriding feature has been that users could easily program the device. Gate array's must be designed and processed. This takes time and money. PLA's can be programmed almost instantly by the user. If wrong, they can be thrown away a little cost. User programmable devices made their first real impact on the market last year when Monolithic Memories introduced PAL's which exceeded 500 gates. This put them into direct competition with gate arrays and standard cells. Today, PLA devices are available which reach 2,000 gates. As a result, the market has literally exploded reaching $100M in 1983. This has become a market to watch as most are predicting sales to surpass $200 million in 1984.

Originally, PLA emerged from PROM technology. Simply, the chip works on an "and/or" array matrix network. They perform arithmetic computations and comparisons. The "and" array is programmable while the "or" array is fixed. Fuseable links permit customization of the chip. This allows users to implant logic directly onto the chip.

During the recent semiconductor boom, the industry suffered from shortages of TTL logic parts. These devices are used virtually everywhere except where battery power is required. During this shortage, users started substituting PLA's. New and innovative applications are also expanding PLA use. This is creating more demand and more new products. Nearly every segment of the electronics industry makes use of PLA's. There tends to be the most substantial use in the computer, telecommunications, and industrial segments.

These chips are popular for many reasons. A key customer benefit of these devices is instant customization. Since PLA's can be pulled off the shelf and programmed specifically to a user's specifications, they can be incorporated into products more quickly than other custom methods. Hence new products can be introduced to the market sooner.

Additionally, PLA's offer PC board design simplification and flexibility to its users. Software has enhanced this benefit further. Today's software for programming PLA's does what was once done manually by engineers and the physical chip. Now, programs work with logic equations in order to determine which fuses to keep or discard. This makes them extremely flexible and easily changed at any point. Improved software capabilities will make it easier to program and troubleshoot them.

There is a trend toward higher pin counts in PLA's. Typically from 20 pin devices to 24 and 28 pin devices. This permits higher component density. Speeds will continue to increase encouraging new applications for PLA's. At the same time power consumption will decrease. PLA's currently utilize bipolar technology. PLA's are expected to be introduced in CMOS to cut power consumption.

Electronically programmable array logic (EPAL) are a new twist to the custom market. It is like the PLA market in that it emerged from PROM technology. The difference is that an EPAL utilizes E^2PROM technology. Hence, users can not only program it themselves, they can also program them in the field. The market for miscellaneous logic devices reached $4.4B in 1983. Almost 53% of this production was in TTL parts. Miscellaneous CMOS devices were the second largest portion accounting for 23% of the total. GaAs and ECL were similar in size. However, most GaAs production was captive.

6.2.2.2 MEMORY IC

The worldwide market for memory devices totaled $5.7 billion in 1983, as shown in Table 6.2.2-2. It is the second largest market next to logic IC's. Memory sales accounted for 23.3% of total worldwide semiconductor sales. The memory market is composed of 83% merchant sales and 17% captive sales. Merchant memory device sales comprised 24.9% of the total merchant semiconductor market. Captive memory IC sales was 17.7% of the total captive semiconductor market. The major segments, Random Access Memories (RAM) and Read Only Memories (ROM) and relatives, amounted to $3.8 billion and $1.2 billion respectively. The remaining sales were from other miscellaneous memory devices.

Japanese companies dominate the memory market with a 54% share of the merchant market. Their key areas of strength are in Static RAM's, Dynamic RAM's, and PROM's. They hold a 63% share in the Static RAM market. Their 83% share of the CMOS Static RAM market is their stronghold. Japanese suppliers also hold 58% of the Dynamic RAM market and 52% of the PROM market.

The Japanese share of the CMOS market is an important factor in their future success. CMOS is on the cutting edge of memory technology today. User demands for faster speeds and higher densities, but which also have lower power needs, are driving this trend. Additionally, CMOS provides an advantage particularly favorable to Dynamic RAM's. CMOS DRAM circuits are unaffected by soft errors induced by alpha particles. They also maintain noise immunity as geometries shrink.

User requirements other than design are usually the most important factors driving the memory market. For example, chip reliability is the most crucial factor determining the purchase of memory devices in computer subsystems. Following reliability are performance, power, ease of use, cost, and size requirements ranked respectively. There

TABLE 6.2.2-2

1983 WORLDWIDE MEMORY SEMICONDUCTOR SALES

DEVICE TYPE	WORLDWIDE TOTAL		ESTIMATED CAPTIVE		MERCHANT SEMICONDUCTOR PRODUCTION: TOTAL		North America		Japan		Europe & ROW	
	($ M)	(units)	($ M)	(units)	($ M)	(units)	($ M)	(units)	($ M)	(units)	($ M)	(units)
DYNAMIC RAMS	1898.3	717.5	213.7	78.5	1684.6	639.0	655.1	276.0	973.5	325.7	56.1	37.3
CMOS Dynamic RAM	70.0	2.0	70.0	2.0	0.0	0.0	0.0	0.0	0.0	0.0	-	-
256K	70.0	2.0	70.0	2.0	0.0	0.0	0.0	0.0	0.0	0.0	-	-
1 M	0.0	0.0	0.0	0.0	0.0	0.0	-	-	-	-	-	-
N/PMOS Dynamic RAM	1828.3	715.5	143.7	76.5	1684.6	639.0	655.1	276.0	973.5	325.7	56.1	37.3
32K	338.1	270.5			338.1	270.5	172.8	138.2	124.0	99.2	41.4	33.1
64K/125K	1380.8	439.9	97.4	73.2	1283.5	366.7	482.3	137.8	786.5	224.7	14.7	4.2
256K/512K	105.6	5.0	42.6	3.2	63.0	1.8	0.0	0.0	63.0	1.8	-	-
1 M	3.8	0.1	3.8	0.1	0.0	0.0	-	-	0.0	0.0	-	-
STATIC RAMS	1978.3	401.9	423.5	9913	1554.8	302.6	492.6	142.2	985.5	141.8	76.7	18.6
CMOS Static RAM	728.7	132.0	142.4	45.9	586.4	86.1	79.8	13.7	483.9	68.5	22.7	3.9
8K	30.0	12.5			30.0	12.5	10.8	4.5	16.1	6.7	3.1	1.3
16K/32K	674.6	117.1	124.8	43.8	549.8	73.3	69.0	9.2	461.3	61.5	19.5	2.6
64K/128K	24.2	2.4	17.6	2.1	6.6	0.3	0.0	0.0	6.6	0.3	0.0	-
256K/512K	0.0	0.0			0.0	0.0	0.0	-	0.0	-	0.0	-
N/PMOS Static RAM	816.6	143.3	199.2	38.8	617.3	104.5	128.0	44.8	449.8	55.4	39.5	4.3
8K	87.3	66.1	-	-	87.3	66.1	51.7	39.2	33.5	25.4	2.0	1.5
16K/32K	638.2	71.1	184.1	36.7	454.1	34.4	68.6	5.2	349.8	26.5	35.6	2.7
64K/128K	91.2	6.1	15.2	2.1	76.0	4.0	7.6	0.4	66.5	3.5	1.9	0.1
256K/512K	0.0	0.0	-	-	0.0	0.0	0.0	0.0	0.0	0.0	0.0	-
Bipolar Static RAM	432.9	126.6	81.8	14.6	351.1	112.0	284.8	83.7	51.7	17.9	14.6	10.4
8K	135.4	96.7			135.4	96.7	98.7	70.5	22.1	15.8	14.6	10.4
16K/32K	287.5	28.7	71.8	13.4	215.7	15.3	186.1	13.2	29.6	2.1	0.0	-
64K/128K	10.0	1.2	10.0	1.2	0.0	0.0	0.0	-	0.0	-	0.0	-
ROM	357.4	192.9	0.0	0.0	357.4	192.9	259.7	148.3	86.8	38.1	10.8	6.5
32K	87.5	67.3	-	-	87.5	67.3	82.9	63.8	0.0		4.6	3.5
64K	193.6	99.3	-	-	198.6	99.3	146.8	73.4	46.6	23.3	5.2	2.6
128K/256K	70.5	26.1	-	-	70.5	26.1	30.0	11.1	39.4	14.6	1.1	0.4
1 M	0.8	0.2	-	-	0.8	0.2	0.0	-	0.8	0.2	0.0	
PROM/EPROM	840.8	187.9	0.0	0.0	840.8	187.9	379.2	80.8	436.4	98.4	25.3	8.7
8K	5.3	3.5	-	-	5.3	3.5	3.5	2.3	0.0	0.0	1.8	1.2
16K	173.7	57.9	-	-	173.7	57.9	78.9	26.3	78.0	26.0	16.8	5.6
32K	207.2	59.2	-	-	207.2	59.2	98.7	28.2	101.9	29.1	6.7	1.9
64K	331.7	60.3	-	-	331.7	60.3	100.7	18.3	231.0	42.0	0.0	-
128K	100.5	6.7	-	-	100.5	6.7	82.5	5.5	18.0	1.2	0.0	-
256K	22.5	0.3	-	-	22.5	0.3	15.0	0.2	7.5	0.1	0.0	-
EEPROM	148.0	9.9	84.1	4.3	63.9	5.6	42.3	3.6	21.6	2.0	-	-
4K	13.2	2.2	-	-	13.2	2.2	8.4	1.4	4.8	0.8	-	-
8K/16K	53.3	4.5	7.1	1.2	46.2	3.3	29.4	2.1	16.8	1.2	-	-
32K/64K	48.0	2.4	43.5	2.3	4.5	0.1	4.5	0.1	0.0	0.0	-	-
256K	33.6	0.8	33.6	0.8	0.0	0.0	-	-	-	-	-	-
OTHER	464.0	13.5	253.2	3.2	220.8	10.3	175.8	7.8	45.0	2.5	0.0	0.0
Bubble	213.0	10.0	-	-	213.0	10.0	168.0	7.5	45.0	2.5	-	-
1 M bit	153.0	8.5	-	-	153.0	8.5	108.0	6.0	45.0	2.5	-	-
4 M bit	60.0	1.5	-	-	60.0	1.5	60.0	1.5	-	-	-	-
CCD	7.8	0.3	-	-	7.8	0.3	7.8	0.3	-	-	-	-
GaAs	243.2	3.2	243.2	3.2	0.0	0.0	-	-	-	-	-	-
TOTAL	5686.7	1523.6	964.5	185.3	4722.2	1338.3	2004.7	658.7	2548.7	608.5	168.9	71.1

Source: VLSI RESEARCH INC

are variations in this order depending on the market. Each of these tend to be crucial factors when deciding which device type to use when a new system is designed.

DRAM's are the most favored device where cost is at issue. DRAM's have an inherent cost advantage since their cell size is smaller. For instance, the graphics systems market is driven by a need for lots of low cost memory. Reliability is the second most important requirement for graphics systems. Personal computers are another area where DRAM's are the preferred chip due to their lower cost. Demand for DRAM's in the personal computer market continues increase due to ever increasing demand for more sophisticated application software.

Another issue concerning the DRAM market is the recent demand for memories which have high speed capability. Graphics software, in particular, is driving this demand. In graphics, their is a need for low cost but relatively high speed memory. Otherwise the system is tremendously slow. In order to meet these needs, new devices will have wait states, caching of data and instructions, interleaving memory, look ahead buffers, or many other techniques which allow the use slow memories with a fast clock.†

Additionally, there will be advancements in addressing modes to increase speed. These include static column, nibbles and page modes. Static column mode is a faster method of accessing successive bits. Nibble mode allows fast operation on 4 bits. Page mode provides continuous access in successive bits. There is an especially big movement toward static column decode source since it is easily utilized with CMOS technology.

The most popular Dynamic RAM's have a core size of 64K. The 16K DRAM market is the second largest market. It has been bouyed somewhat by shortages in 64K DRAM's. However, 64K DRAM capacity was significantly increased in the current year. It is expected that 16K DRAM demand will subside with this. 64K DRAM's are being succeeded by 265K RAM's, which are the third largest market. Already, the monthly shipping rate of 265K DRAM's is already exceeding five million units per month!

In the DRAM market, memory size increases are about as sure as the law of gravity. The existence of Moore's law atests to this. 1 megabit memories are moving into the spotlight of today's DRAM market. A 1M bit memory provides 16 times the storage density of a 64K, and 4 times that of a 256K. 1M bit memories will have cost benefits, increased storage and greater total system reliability. This makes them quite

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† VLSI Update White Paper, WP70, Advanced Associates, 1984.

attractive for use in main memories of mainframes and mini computers, in workstations, in portable computers, and personal computers. Packaging and pinout developments for the 1M bit DRAM will be driven by die size and complexity. The first Dual in-line packages will have 18 or 20 pins. Similarly, DIP widths will measure between 300 and 400 mils.

Xicors introduction of its NOVRAM is an important development in the DRAM market. It is the first nonvolatile Dynamic RAM. This is accomplished by designing a convention DRAM with an EEPROM shadowing it as a backup. This provides the relatively fast access time of a DRAM while giving the nonvolatility of an EEPROM.

While the DRAM always gathers the most attention. Most people have overlooked the fact that the Static RAM market has quietly become the largest memory market. It accounts for 35% of all memory sales. This has occurred mostly because of a Japanese explosion in CMOS SRAM's. These devices offer a relatively low cost alternative to DRAM's. Moreover, it takes very little power indefinitely store memory in a CMOS SRAM. This a resulted in demand for them in calculators and portable computers. These two markets are dominated by Japanese suppliers.

In the past Static RAM's have been typically used where low cost is not an issue. SRAM's typically require six components per bit as compared to 1.5 for DRAM's. Therefore, SRAM's cannot be produced as dense or at prices low enough to compete with DRAM's. However, NMOS and Bipolar SRAM's are typically much faster than DRAM's. Consequently, they are usually used in small, in key areas of a mainframe where core must be extremely fast.

The ROM market is the smallest of memory markets. It accounts for 6% of all memory sales. Until recently, the ROM market was fueled by the video game market. However, unfavorable trends in the video game market heavily impacted the ROM market. The gap is being filled somewhat by demand from personal computers and industrial controls.

Improvements in speed and density have made ROM's, EPROM's, and EEPROM's more popular. The choice between ROM's and EPROM's is still dictated by price. On a cost per bit basis, PROM's are less expensive than EPROM's, which in turn are less expensive than EEPROM's. In the near future EEPROM's are expected to become more advantageous for several reasons. One is that they are more flexible and reduce the difficulty of firmware updating in the field. EEPROM manufacturers also believe that they will be able to match the cost and speed of DRAM's with new cell designs. If this is the case, the DRAM market could be dramatically upset.

6.2.2.3 DIGITAL SIGNAL PROCESSING IC

Digital signal processing (DSP) is the smallest of the five semiconductor markets. A breakdown of 1983 sales for the DSP market is shown in Table 6.2.2-3. In 1983, worldwide sales reached $901.2 million. This amounted to only 3.7% of total worldwide semiconductor sales. Sales by merchant suppliers comprised 76.8% of the DSP market. While small, Digital signal processing is a new and fast-growing technology. The key driving force in its development, has been the merging of the telecommunications linear IC market with the microprocessor market. This has thrust it out into its own category.

As a relatively new market, the segmentation of DSP devices is still somewhat unclear. Generally, the devices fall into one of three major divisions:

- general purpose devices
- application specific devices
- custom devices

General purpose devices are those devices which may be used in a large variety of applications. Application specific devices include modems, codecs, DAC's, ACD's and speech synthesis devices. The last segment, custom devices, had no merchant sales in 1983.

Since its early beginnings, electronics has been dominated by analog applications. Electronics was almost entirely analog until the first digital computers became available in the early fifties. Since then digital applications have invaded analog electronics. At first, digital applications simply replaced analog ones. However, as digital applications evolved, they began to be incorporated into analog circuitry itself. This merging of digital and analog circuitry gave birth to digital signal processing (DSP).

Simply stated, DSP is the digital processing of analog signals. In its purest sense, an analog signal is converted into a digital data stream. The digitized data is processed to sort out noise from the signal and then returned to analog form. The process is illustrated in Figure 6.2.2-4 below:

Figure 6.2.2-4

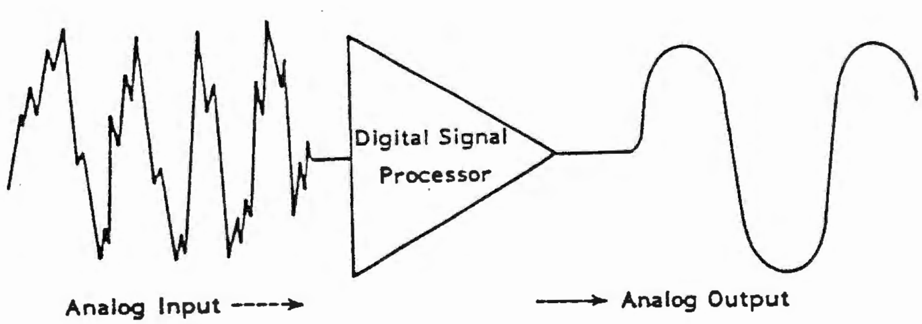

TABLE 6.2.2-3

1983 WORLDWIDE DSP AND LINEAR IC SALES

DEVICE TYPE	WORLDWIDE TOTAL		ESTIMATED CAPTIVE		MERCHANT SEMICONDUCTOR PRODUCTION							
					TOTAL		North America		Japan		Europe & ROW	
	($ M)	(units)	($ M)	(units)	($ M)	(units)	($ M)	(units)	($ M)	(units)	($ M)	(units)
DIGITAL SIGNAL PROCESSING	901.2	1019.9	209.0	328.0	692.2	691.9	390.8	332.4	186.9	234.4	114.4	125.0
General Purpose	37.2	3.7	22.8	3.0	14.4	0.7	10.3	0.5	3.4	0.2	0.7	0.0
Application Specific	826.0	1011.2	148.2	320.0	677.8	691.2	380.5	331.9	183.5	234.3	113.7	125.0
Speech Synthesis	165.3	40.6	47.9	21.0	117.4	19.6	69.8	11.6	43.2	7.2	4.4	0.7
Modems	31.0	0.9	0.0	0.0	31.0	0.9	17.2	0.5	10.3	0.3	3.4	0.1
Codecs	46.6	24.8	17.1	15.0	29.5	9.8	21.5	7.2	1.0	0.3	7.0	2.3
DAC's	199.8	228.1	31.4	75.0	168.4	153.1	115.7	105.2	14.8	13.5	37.9	34.5
ADC's	160.5	178.2	21.7	52.0	138.8	126.2	95.3	86.6	12.3	11.2	31.2	28.4
Other	222.8	538.6	30.1	157.0	192.7	381.6	61.0	120.8	101.9	201.8	29.8	59.0
Custom	38.0	5.0	38.0	5.0	0.0	0.0	-	-	-	-	-	-
LINEAR	2100.7	4029.7	144.9	520.0	1955.7	3509.7	777.4	1124.9	798.7	1835.5	379.6	549.3
Amplifiers	379.8	645.3	36.2	140.0	343.6	505.3	183.4	269.7	70.7	103.9	89.6	131.7
Consumer	1032.7	2161.5	70.8	230.0	961.9	1931.5	300.6	371.1	514.5	1379.2	146.8	181.2
Regulators	283.7	667.7	10.3	60.0	273.5	607.7	123.4	274.2	89.8	199.6	60.3	133.9
Other	404.5	555.2	27.7	90.0	376.8	465.2	170.0	209.9	123.8	152.8	83.0	102.5

Source: VLSI RESEARCH INC.

This is a good example of a general purpose DSP device. However, there are many specific application devices which have mixed digital and analog signal capability but don't meet this strict definition. Moreover, there are devices which are competitive in application but use only linear device technology. For example, there are a lot of analog interface devices which are directly competitive with DSP interface devices.

Demand for transmissions of digitized computer data fostered the need for one of the first DSP circuits, the modem (modulator-demodulator). Modems are used to convert digital bit streams into analog signals at the transmit level. Then a modem reconverts analog signals back into bit streams at the receiving end. In addition, implementation of digital networks generated a need for the second DSP application specific circuit called the codec (coder-decoder). Codecs basically perform the inverse function of modems. They are used to convert analog signals into digital codes.

Similar to modems, DAC's (digital/analog converters) convert digital signals into continuous electrical signals appropriate for input into an analog computer. While ADC's (analog-to-digital converters) are devices which produce digital outputs from analog inputs. The analog form can be that of physical motion or electrical voltages. Finally, speech synthesis devices are included among the application specific segment. These devices translate text into synthetic speech.

A partial list of DSP device manufacturers includes:

AMD	IBM
AMI	Intel
Analog Devices	Motorola
AT&T Technologies	NEC
Exar	Rockwell Int'l
Fujitsu	Texas Instruments
Hitachi	TRW

Digital Signal Processing circuits were originally developed for telecommunications use. However there has also been substantial demand to apply them elsewhere. Speech synthesis is probably the most well known. Both the industrial and the service sector has created an important source of demand for speech synthesis circuitry. Industry is demanding speech synthesis features so that equipment can verbally notify operators of changing process parameters, or warn them when a machine is malfunctioning. This will eliminate the need for continuous monitoring of gauges by the operator. The service industry will also demand voice recognition to reduce the tremendous amount of human interface required.

There are several other applications for speech synthesis chips. Most people know about Texas Instruments' Speak and Spell which helps children learn to spell. It was the first major speech synthesis product. TI has introduced several other learning tools since then. Tiger Electronic Toys now offers its Talking Learning Computer which has a 1500 word vocabulary. Matsushita sells microwave ovens that announce how long it is to dinner. Datsun and Chrysler now offer cars that talk. Some of Westinghouse's elevators talk. NCR has developed a talking automatic bank teller. AT&T is planning the introduction of an automated message center. It would allow text based messages to be converted into speech for phone accessibility. Applications are also found in seismic analysis, CAT-scanning, and interplanetary and satellite video reception. These are just a few of some of the more major products which are driving demand for speech synthesis.

In addition to speech synthesis, growing DSP applications are found in the automotive industry. Additionally, consumer electronics are using more DSP devices. For example, today's televisions and stereos employ DSP circuits.

Digital signal processing is increasing in popularity for several reasons. The technology lies at the heart of this popularity. As previously mentioned, in DSP, analog signals are converted to digital signals, processed and reconverted back to analog signals.

First the analog signal is sampled and filtered. These filtered analog signals are then converted to digital form via an analog to digital converter (ADC). The signals then pass to the processor. This unit consists of an arithmetic logic unit (ALU), a controller and sequencer, a multiplier, and the instructions, coefficient and data memories. At this point, the sequence of values (digital signals) are processed. There are two basic methods:

- Filtering
- Spectrum Analysis

There are two types of filtering methods for processing digital signals. The first type of filtering process is called Finite-Impulse-Response (FIR). The output of an FIR filter is basically a weighted moving average of the previous outputs. The second type of filtering process is referred to as Infinite-Impulse-Response (IIR). Here, output is a function of previous inputs as well as outputs. A weighted average summary of the most recent series of samples is used for the next calculations.

Spectrum analysis is the other basic method of processing digital signals. Spectrum analysis resembles decoding secret messages. In spectrum analysis, the sequence of values are analyzed to determine what pitches, frequencies etc. make up the spectrum of signals.

Finally, the signals are reconverted with a digital/analog converter (DAC) and smoothed by an output filter. Digital Signal Processing is usually labeled as real-time or non-real-time (off line). There is no clear cut distinction between the two. Generally, in real-time processing the data is collected and processed simultaneously. In non-real-time or off line, processing previously collected and stored data is processed.

Increased speed is a characteristic and an advantage of DSP. The architecture, or circuit design, is responsible for this. As with microprocessors, Von Neumann architecture is commonly used. Harvard architecture is a newer technology of design based on Von Neumann architecture. Von Neumann architecture uses a signal-instruction, signal-data stream (SISD) processor. The processor issues an address of an instruction. Then the data associated with the address is sequentially retrieved, processed and stored according to the instruction. One bus is used for both data and instruction. The Harvard architecture took this basic structure and made it faster by giving the data and instruction memory regions are given their own address paths. This design increases throughput since the data and instructions aren't required to share the same buses (paths).

Pipelining and parallelism are two commonly used DSP time saving techniques. In pipelining, the next instruction is retrieved while the current one is processed. While parallelism is the simultaneous processing of more than one instruction. Bandwidth also affects speed. In general, the greater the bandwidths are, the faster the potential processing speeds.

Digital signal processing offers several other advantages as well. Generally speaking, digital signal processing devices are easier to design than their analog counterparts. Many exiating device designs can be utilized. Hence, much of the complexity associated with high component count of DSP devices is reduced. Since devices can be altered with software, costs are lower compared to analog signal processing. This is because analog signal processing devices must be redesigned with each new application.

Additionally, DSP is more accurate, stable, reliable and than analog signal processing. Noise is primarily responsible for inaccuracy in analog devices. Since DSP eliminates much of the noise, it thus increases accuracy. Processing analog signals digitally eliminates many of the instabilities of analog signal processing: aging related drift, temperature, component variations and power supply changes. Furthermore, the absence of drift and fewer parts improves reliability.

Future DSP devices will strive for higher speeds, lower power and lower costs. For instance, CMOS is finding its way into digital signal processing. Since power requirements are lower, power supplies can be smaller. Favorably, these smaller power supplies are lighter, less expensive, and more reliable than larger ones. Additionally, low power dissipation permits denser packages yet maintains high reliability and requires less mechanical support. (Presently, the costs of these devices are still expensive. But there is a downward cost trend.)

As the evolution of DSP technology progresses, there will be more applications of existing technologies as well as further development in new technologies. For example, CMOS is one of those existing technologies, as is gallium arsenide.

Two new developments are the advent of systolic array systems and data flow architecture. Systolic array systems is a more advanced type of parallel processing. The design is often grouped as a single instruction multiple data stream (SIMD) architecture. Similarly, data flow architecture is a more advanced type of parallel processing, however, it uses a multiple-instruction, multiple data stream MIMD set up.

6.2.2.4 LINEAR IC

The market size for linear IC's was given previously in Table 6.2.2-3. The linear IC market is the fourth largest semiconductor market. The total market amounted to just over $2.1 billion in 1983. These sales accounted for 8.6% of total worldwide semiconductor sales. The merchant market comprised 93.1% of the linear market and 10.3% of the total worldwide merchant market. Meanwhile, captive production of linear accounted for only 2.7% of the total captive market.

The consumer segment of linear IC's was the largest segment. Its sales comprised 49% of the linear market. Amplifiers and regulators made up 18% and 14%, respectively, of linear sales.

6.2.2.5 DISCRETE & PHOTOELECTRIC

The discrete market is the third largest semiconductor market. The total market reached $3.5 billion dollars in 1983. This amounted to 14.4% of the total semiconductor market. The captive market is estimated to have accounted for 3.1% of total discrete sales. Meanwhile the merchant market comprised the vast majority of the total discrete market and 17.9% of the total merchant semiconductor market. The Japanese lead the world in discrete device sales.

Within the discrete market, transistors account for the largest portion of sales. They are responsible for 49% of all discrete sales. Rectifiers and diodes sales amount to 20% and 17%, respectively of this market.

The second smallest semiconductor market is the photoelectric segment. In 1983, this segment amounted to over $1.2 billion dollars. This represents 5% of the total semiconductor market. The merchant sales were responsible for 79.4% of total photoelectric sales. Photoelectric merchant sales were 5.1% of total merchant while captive were 4.6% of total captive. Table 6.2.2-5 lists 1983 worldwide sales figures for both discrete semiconductors and photoelectric devices.

TABLE 6.2.2-5

1983 WORLDWIDE DISCRETE & PHOTOELECTRIC SEMICONDUCTOR SALES

DEVICE TYPE	WORLDWIDE TOTAL		ESTIMATED CAPTIVE		MERCHANT SEMICONDUCTOR PRODUCTION							
					TOTAL		North America		Japan		Europe & Row	
	($ M)	(units)	($ M)	(units)	($ M)	(units)	($ M)	(units)	($ M)	(units)	($ M)	(units)
DISCRETE	3504.7	59768.2	108.0	1333.7	3396.7	58434.5	1058.1	9534.8	1290.7	24449.8	1047.9	10520.7
Diodes	606.8	29069.3	32.3	1145.6	574.5	27923.7	152.2	4201.8	253.5	11861.0	168.8	4659.9
Small Signal	150.1	4311.2	1.9	242.7	148.2	4068.5	66.9	3238.7	7.1	414.9	74.2	3591.9
Power	456.7	24758.1	30.4	902.9	426.3	23955.2	85.3	963.0	246.4	11446.1	94.6	1068.1
Rectifers	707.5	8341.8	-	-	707.5	8341.8	233.3	2234.5	261.9	3053.7	212.3	2033.3
Transistors	1730.7	21606.6	28.5	171.5	1702.2	21435.1	522.0	2841.8	635.4	9296.7	544.8	3475.8
Small Signal	1082.5	20174.8	1.9	53.3	1080.6	20121.5	218.6	2330.1	577.0	8895.7	285.0	3037.7
Power	648.2	1431.8	26.6	118.2	621.6	1313.6	303.4	511.7	58.4	401.0	259.8	438.1
Thyristors	247.3	464.2	-	-	247.3	464.2	96.7	100.4	88.3	181.9	62.3	64.9
GaAs	113.6	26.5	47.2	16.6	66.4	9.9	22.3	3.0	25.9	3.5	18.2	2.4
Other	98.8	259.7	-	-	98.8	259.7	31.6	153.3	25.7	53.2	41.5	284.3
PHOTOELECTRIC	1211.4	5430.0	250.0	1201.0	961.4	4229.0	266.3	469.5	484.1	3458.6	211.0	300.9
LED	449.6	4323.3	135.0	902.1	314.6	3421.2	85.0	293.1	186.7	2980.1	42.9	147.9
LCD	284.3	22.9	35.4	5.1	248.9	17.8	47.3	3.4	139.7	10.0	61.9	4.4
CCD	179.7	333.0	38.6	110.4	141.1	222.6	79.0	106.8	43.4	58.6	42.3	57.2
Laser Diodes	58.0	79.1	7.0	17.5	51.0	61.6	8.4	10.1	24.7	29.8	17.9	21.6
Solar	77.6	324.3	17.2	89.2	60.4	235.1	24.1	6.1	19.8	224.9	16.5	4.2
Other	138.6	347.4	16.8	76.7	121.8	270.7	22.5	50.0	69.8	155.1	29.5	65.6

Source: VLSI RESEARCH INC.

6.2.3 OVERALL SEMICONDUCTOR OUTLOOK & FORECAST

Table 6.2.3-1 summarizes the five device markets. Total semiconductor shipments are forecasted to grow at a 10.2% compound annual growth rate.

Tables 6.2.3-2 through 6.2.3-5 give a five year forecast of worldwide semiconductor shipments of logic, memory, DSP, linear, discretes, and photoelectric devices. The logic market is forecasted to grow at a 22.5% compound annual growth rate. Within this market, GaAs devices, PLA's, and 32 bit microprocessors are forecasted to grow the fastest. Similar to the logic market, the memory market shows a high compound annual growth rate of 29.9%. Within this market, CMOS technology will come to dominate over the next five years.

Digital signal processing is forecasted to have the fastest growing market. It is projected to grow at a compound annual growth rate of 52.1%. On the other hand, the slowest growing market is the discrete market. Its projected compound annual growth rate is only 4.3%.

VLSI Research uses commonly accepted terms in outlining the data. The source of data in these tables includes numerous individual reports, memos, and bulletins from various segments of the industry. It includes annual reports, financial reports, individual assessments by knowledgeable company representatives, and our own analysis and judgement as well. We believe that it is correct, and that it is as accurate as possible under the oftentimes adverse circumstances under which it is collected.

In some of the detailed sections, miscellaneous data is too numerous to be updated with each quarterly update of this section. Consequently, market subtotals given elsewhere may on occasion, differ from this section. The correct version is always the most recent update. This can be verified by the dated page code in the top right hand corner of each page. Please refer to the contents for an explanation of the code.

TABLE 6.2.3-1

SEMICONDUCTOR SHIPMENTS FORECAST SUMMARY
(worldwide in millions of units)

DEVICE TYPE	1983	1984	1985	1986	1987	1988	CAGR
Logic	8971.8	14182.7	15573.3	18523.3	21685.7	24716.1	22.5%
Memory	1523.6	2371.4	3051.3	3973.9	4743.4	5634.3	29.9%
DSP	1019.9	2060.7	3835.0	5308.9	6841.2	8296.9	52.1%
Linear	4029.7	6100.8	6725.5	7996.7	9515.7	11329.2	23.0%
Discretes	59768.1	62542.0	65315.9	68089.8	70863.7	73637.7	4.3%
Photoelectric	5430.0	5872.1	6314.2	6726.2	7168.3	7564.1	6.9%
TOTAL	80743.1	93129.7	100815.2	110618.8	120818.0	131178.3	10.2%

Source: VLSI RESEARCH INC

TABLE 6.2.3-2

LOGIC SEMICONDUCTOR SHIPMENTS FORECAST
(worldwide in millions of units)

	1983	1984	1985	1986	1987	1988	CAGR
MICROPROCESSOR	351.8	786.4	1081.3	1469.9	1654.3	1822.6	39.0%
CMOS Microprocessors	112.4	260.5	408.3	627.6	733.6	842.6	49.6%
4 bit	95.1	133.5	75.8	57.5	47.9	40.6	-15.7%
8 bit	7.2	86.2	188.7	329.2	316.0	196.0	93.6%
16 bit	10.0	40.3	139.1	209.5	261.9	347.2	102.9%
32 bit	0.0	0.5	4.7	31.4	107.8	258.8	-
N/PMOS Microprocessors	219.4	476.6	579.1	725.0	775.7	799.8	29.5%
4 bit	65.0	90.2	50.8	38.3	31.7	26.7	-16.3%
8 bit	137.6	334.8	445.7	536.8	503.6	468.5	27.8%
16 bit	14.5	45.7	68.7	118.6	168.5	218.4	72.0%
32 bit	2.3	5.9	13.9	31.3	71.9	86.2	106.4%
Bipolar Microprocessors	20.0	49.3	93.8	117.3	145.0	180.2	55.2%
4 bit	1.3	2.8	2.0	1.8	1.7	1.6	3.6%
8 bit	13.6	28.7	48.7	59.5	66.1	73.4	40.1%
16 bit	5.1	17.8	43.1	56.0	77.2	105.2	83.2%
MICROPROCESSOR SUPPORT	183.9	307.1	359.3	492.3	674.4	923.9	38.[illegible]
CMOS	39.0	98.3	136.5	196.9	269.8	286.5	49.0[illegible]
N/PMOS	137.4	191.9	201.2	263.4	357.4	568.1	32.8%
Bipolar	7.5	16.9	21.6	32.0	47.2	69.3	56.0%
CUSTOM	2367.1	3381.3	3427.3	4258.8	4924.3	5696.3	19.2%
Full Custom	1927.1	2386.8	2313.5	2855.5	3243.1	2459.5	5.0%
Standard Cell	362.5	869.0	925.3	1020.0	1119.8	2268.4	44.3%
Gate Array	57.5	82.1	102.8	212.9	246.2	370.3	45.1%
CMOS	48.6	69.5	87.4	188.6	218.2	339.5	47.5%
N/PMOS	1.4	1.8	2.1	2.4	2.7	3.2	18.0%
Bipolar	7.6	10.9	13.4	21.9	25.3	27.6	29.4%
PLA	20.0	40.0	68.5	127.8	241.3	427.2	84.5%
EPAL	0.0	3.4	17.1	42.6	73.9	170.9	-
MISCELLANEOUS	6069.0	9707.9	10705.4	12302.3	14432.7	16273.3	21.8%
TTL	3925.4	5871.3	6384.5	7259.1	8238.7	8970.2	18.0%
ECL	153.9	279.3	352.9	428.3	512.4	596.5	31.1%
CMOS	1700.5	3164.2	3538.0	4153.8	5142.9	6127.3	29.2%
GaAs	0.9	1.8	4.3	10.1	47.4	72.2	140.4%
Other	288.3	391.3	425.7	451.0	491.3	507.1	12.0%
TOTAL	8971.8	14182.7	15573.3	18523.3	21685.7	24716.1	22.5%

Source: VLSI RESEARCH INC

TABLE 6.2.3-3

MEMORY SEMICONDUCTOR SHIPMENTS FORECAST
(worldwide in millions of units)

	1983	1984	1985	1986	1987	1988	CAGR
DYNAMIC RAMS	717.5	1135.8	1484.4	1908.6	2132.5	2533.4	28.7%
CMOS Dynamic RAM	2.0	51.1	268.8	634.7	873.6	1331.8	267.0%
256K	2.0	47.6	176.8	396.1	429.0	703.4	223.0%
1M	0.0	3.5	92.0	238.6	444.6	628.4	-
N/PMOS Dynamic RAM	715.5	1084.7	1215.6	1273.9	1258.9	1201.6	10.9%
32K	270.5	422.2	429.7	401.6	360.9	301.4	2.2%
64K/125K	439.9	611.5	632.9	617.9	550.9	480.9	1.8%
256K/512K	5.0	48.8	121.4	157.2	201.3	214.3	112.0%
1M	0.1	2.2	31.6	97.2	145.8	205.0	-
STATIC RAMS	401.9	658.1	853.3	1226.8	1628.2	1944.0	37.1%
CMOS Static RAM	132.0	303.9	421.6	643.8	973.2	1236.6	56.4%
8K	12.5	11.2	9.9	8.7	7.4	6.1	-13.4%
16K/32K	117.1	208.4	238.7	242.4	253.3	267.5	18.0%
64K/128K	2.4	80.9	145.8	290.8	533.4	669.3	208.4%
256K/512K	0.0	3.4	27.2	101.9	179.1	293.4	-
N/PMOS Static RAM	143.3	169.5	230.9	294.9	344.7	372.7	21.1%
8K	66.1	42.3	29.4	24.7	21.1	15.3	-25.4%
16K/32K	71.1	108.3	144.9	162.4	139.5	80.3	2.5%
64K/128K	6.1	18.5	50.8	86.1	134.9	182.4	97.3%
256K/512K	0.0	0.4	5.8	21.7	49.2	94.7	-
Bipolar Static RAM	126.6	184.7	200.8	288.1	310.3	334.7	21.5%
8K	96.7	85.0	73.2	61.5	52.5	38.1	-17.0%
16K/32K	28.7	36.1	43.5	65.6	56.3	31.7	2.0%
64K/128K	1.2	63.6	84.1	161.0	201.5	264.9	194.3%
ROM	192.9	299.4	364.9	399.1	445.6	475.2	19.8%
32K	67.3	66.4	49.3	16.0	4.3	0.0	-
64K	99.3	162.6	187.8	205.9	193.6	148.1	8.3%
128K/256K	26.1	69.1	123.6	161.3	200.8	242.8	56.2%
1M	0.2	1.3	4.2	15.9	46.9	84.3	-
PROM/EPROM	187.9	241.4	288.6	322.8	353.8	430.6	18.0%
8K	3.5	3.1	2.7	1.5	1.2	1.0	-22.2%
16K	57.9	79.9	75.6	38.5	26.8	20.5	-18.8%
32K	59.2	68.8	73.7	76.2	82.0	84.9	7.5%
64K	60.3	78.1	117.1	167.6	188.0	238.1	31.6%
128K	6.7	10.5	17.0	27.5	36.6	49.8	49.4%
256K	0.3	1.0	2.5	11.5	19.2	36.3	160.9%
EPROM	9.9	14.4	21.1	27.0	36.1	50.3	38.4%
4K	2.2	2.1	2.0	1.3	0.7	0.5	-25.6%
8K/16K	4.5	6.2	7.8	4.0	2.8	2.1	-14.1%
32K/64K	2.4	3.6	4.7	5.7	7.1	9.4	31.4%
256K	0.8	2.5	6.6	16.0	25.5	38.3	116.8%
Other	13.5	22.3	39.0	89.6	147.2	200.8	71.6%
Bubble	10.0	15.6	25.3	59.4	86.3	113.5	62.6%
1M bit	8.5	13.3	19.7	44.5	64.7	68.1	51.6%
4M bit	1.5	2.3	5.6	14.9	21.6	45.4	97.8%
CCD	0.3	0.3	0.2	0.1	0.0	-	-
GaAs	3.2	6.4	13.5	30.1	60.9	87.3	93.7%
TOTAL	1523.6	2371.4	3051.3	3973.9	4743.4	5634.3	29.9%

Source: VLSI RESEARCH INC.

TABLE 6.2.3-4

DSP AND LINEAR IC SHIPMENTS FORECAST
(worldwide in millions of units)

	1983	1984	1985	1986	1987	1988	CAGR
DIGITAL SIGNAL PROCESSING	1019.9	2060.7	3835.0	5308.9	6841.2	8296.9	52.1%
General Purpose	3.7	14.9	37.3	74.5	119.2	157.3	111.7%
Application Specific	1011.2	2025.8	3747.7	5134.4	6572.0	7952.1	51.1%
Speech Synthesis	40.6	79.2	150.5	195.9	259.8	294.5	48.6%
Modems	0.9	2.0	7.5	28.8	46.0	60.4	131.9%
Codecs	24.8	56.7	104.9	164.3	230.0	309.4	65.7%
DAC's	228.1	457.3	845.4	1158.3	1482.5	1772.8	50.7%
ADC's	178.2	357.9	660.4	904.7	1158.2	1438.6	51.8%
Other	538.6	1072.7	1979.0	2682.4	3395.5	4076.4	49.9%
Custom	5.0	20.0	50.0	100.0	150.0	187.5	106.4%
LINEAR	4029.7	6100.8	6725.5	7996.7	9515.7	11329.2	23.0%
Amplifiers	645.3	1807.2	2078.3	2535.5	3093.3	3773.8	42.4%
Consumer	2161.5	2815.2	3068.6	3651.6	4345.4	5171.0	19.1%
Regulators	667.7	784.5	863.0	992.4	1141.3	1312.4	14.5%
Other	555.2	693.9	715.6	817.2	935.7	1072.0	14.1%

Source: VLSI RESEARCH INC.

TABLE 6.2.3-5

DISCRETE & PHOTOELECTRIC SEMICONDUCTOR SHIPMENTS FORECAST
(worldwide in millions of units)

	1983	1984	1985	1986	1987	1988	CAGR
DISCRETE	59768.1	62542.0	65315.9	68089.8	70863.7	73637.7	4.3%
Diodes	29069.3	30444.3	31819.3	33194.3	34569.3	35944.3	4.3%
Small Signal	4311.2	4346.4	4381.6	4416.7	4451.9	4487.1	0.8%
Power	24758.1	26097.9	27437.7	28777.6	30117.4	31457.2	4.9%
Rectifiers	8341.8	8702.5	9063.1	9423.8	9784.4	10145.1	4.0%
Transistors	21606.6	22599.9	23593.2	24586.6	25579.9	26573.2	4.2%
Small Signal	20174.8	21065.8	21956.8	22847.9	23738.9	24629.9	4.1%
Power	1431.8	1534.1	1636.4	1738.7	1841.0	1943.3	6.3%
Thyristors	464.2	488.5	512.8	537.1	561.4	585.7	4.8%
GaAs	26.5	32.8	39.1	45.3	51.6	57.9	16.9%
Other	259.7	274.1	288.4	302.8	317.1	331.5	5.0%
PHOTOELECTRIC	5430.0	5872.1	6314.2	6726.2	7168.3	7564.1	6.9%
LED	4323.3	4390.1	4456.9	4523.8	4590.6	4655.1	1.5%
LCD	22.9	25.0	27.1	29.1	31.2	33.3	7.8%
CCD	333.0	401.5	470.0	508.6	577.1	672.6	15.1%
Laser Diodes	79.1	101.0	123.0	144.9	166.9	188.8	19.0%
Solar	324.3	593.6	862.9	1132.1	1401.4	1599.7	37.6%
Other	347.4	360.8	374.3	387.7	401.2	414.6	3.6%

Source: VLSI RESEARCH INC

6.10 COMPETITIVE DATA BASE

6.10 COMPETITIVE DATA BASE

This section lists historical sales and capital expenditures for most major semiconductor manufacturers. Total semiconductor sales are segmented by product type. Total capital expenditures for each company as well as the proportion allocated to its semiconductor division are shown. The data covers a six year time span from 1979 to 1984E. The tables are segregated by demography - American, Japanese, and European firms are listed separately. In addition, we have also included a "Rest of World" (ROW) segment. ROW includes emerging companies in countries such as Korea, Taiwan, India, and China. Within each of these segments, companies are listed alphabetically.

The source of data in these tables includes numerous individual reports, memos, and bulletins from various segments of the industry. It includes data from annual reports, financial reports, individual assessments by knowledgeable company representatives, and our own analysis and judgement as well. We believe that it is correct, and that it is as accurate as can be under the oftentimes adverse circumstances under which it is collected.

The 1984 estimated data shown is based upon the currently available information. These estimates are based upon the historical performance of each company and our forecast of the total semiconductor market. Semiconductor capital expenditure estimates are based upon estimated semiconductor sales.

VLSI Research uses commonly accepted terms in outlining the data. All dollars are as reported year-by-year. Historical sales are consolidated for companies that have merged. Unless otherwise stated, foreign currencies have been converted on a year-by-year basis at standard conversion rates, as reported in regular financial journals. Year-by-year conversion rates are shown below.

Annual Foreign Exchange Rates
(in amount per U.S. dollars)

Country	1979	1980	1981	1982	1983	1984E
France (Franc)	4.37	5.06	5.36	7.00	7.62	8.80
Germany (Mark)	1.87	2.08	2.25	2.60	2.55	2.85
Japan (Yen)	223	200	220	260	240	230
Netherlands (Dfls.)	2.12	2.12	2.46	2.70	2.85	3.00
United Kingdom (£)	0.48	0.48	0.52	0.59	0.65	0.71

TABLE 6.10-1

REVENUE HISTORY OF NORTH AMERICAN SEMICONDUCTOR MANUFACTURERS

(worldwide in $M)

	Analysis Date	1979	1980	1981	1982	1983	1984E
Acrian, Inc. Total Sales	8/84	1.0	2.0	5.7	10.5	16.5	28.1
Total Semi Sales	8/84	1.0	2.0	5.7	10.5	16.5	28.1
Discrete	8/84	1.0	2.0	5.7	10.5	16.5	28.1
Total Capital Expenditures	8/84			1.1	2.8	1.9	3.0
Allied Corp. Total Sales	8/84	4160.0	5300.0	6142.0	6013.0	10022.0	11224.6
Total Semi Sales	8/84	-	-	0.0	1.1	5.9	11.7
Total IC	8/84	-	-	0.0	1.1	5.9	11.7
Total Capital Expenditures	8/84	409.0	533.0	609.0	524.0	607.0	684.0
Alpha Industries Total Sales	8/84	16.4	21.8	29.6	45.6	42.6	51.1
Total Semi Sales	8/84	7.8	9.7	12.5	16.0	15.5	18.6
Discrete	8/84	7.8	9.7	12.5	16.0	15.5	18.6
Total Capital Expenditures	8/84	1.2	2.5	3.8	5.0	4.9	5.9
Alphatron Total Sales	8/84				1.0	2.9	3.5
Total Semi Sales	8/84				1.0	2.9	3.5
Total IC Sales	8/84				1.0	2.9	3.5

Source VLSI RESEARCH INC

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	Analysis Date	1979	1980	1981	1982	1983	1984E
AMD Total Sales	8/84	225.6	309.4	281.6	358.3	583.3	1000.0
Total Semi Sales	8/84	225.6	300.1	276.0	351.1	571.3	980.0
MOS IC	8/84	108.4	144.0	132.4	154.1	262.4	430.0
Bipolar IC	8/84	99.6	132.7	122.0	171.0	248.0	386.9
Linear IC	8/84	17.6	23.4	21.6	26.0	61.0	163.1
Total Capital Expenditures	8/84	43.9	50.2	60.6	69.4	129.2	250.0
Semiconductor Division	8/84	43.5	49.7	60.0	68.7	127.7	247.5
Amdahl Total Sales	8/84	320.0	394.4	442.8	462.2	777.7	820.0
Total Semi Sales	8/84	1.0E	1.3E	1.5E	1.4	1.7	2.5
Bipolar IC	8/84				1.4	1.7	2.5
Total Capital Expenditures	8/84				123.3	157.4	166.0
AMI: See Gould							
Analog Devices Total Sales	8/84	100.3	135.7	156.2	174.0	214.0	290.0
Total Semi Sales	8/84	51.0	74.6	96.4	110.5	140.1	200.0
MOS IC	8/84	15.9	24.5	41.0	47.5	55.6	79.0
Linear IC	8/84	35.1	50.4	55.4	63.0	84.5	121.0
Total Capital Expenditures	8/84	7.6	19.6	16.5	19.0	19.0	22.2
Semiconductor Division	8/84	5.3	11.5	11.9	16.0	14.3	19.2
Analogic Total Sales	8/84	48.6	67.0	82.9	106.0	128.8	174.8
Total Capital Expenditures	8/84			6.3	14.4	12.7	17.2
Applied Microcircuits Total Sls	8/84	0.0	0.4	2.5	2.5	8.5	19.0
Total Semi Sales	8/84	0.0	0.4	2.5	2.5	8.5	19.0
Bipolar IC	8/84	0.0	0.4	2.5	2.5	8.5	19.0

Source VLSI RESEARCH INC

	Analysis Date	1979	1980	1981	1982	1983	1984E
AT&T Technologies Total Sales	8/84	10964.1	12032.0	13008.0	12580.0	11155.0	12580.0
Total Semi Sales	8/84	< 294 >	413.4	408.9	404.4	509.3	719.4
Total IC	8/84	192	302.9	299.9	296.9	393.6	590.4
Discrete	8/84	< 102 >	110.5	109.0	107.5	115.7	129.0
Total Capital Expenditures	8/84				570.4	675.2	761.5
Semiconductor Division	8/84	58.5	91.3	90.7	90.1	128.4	280.1
Avantek Total Sales	8/84	39.8	58.3	81.9	100.2	119.4	160.0
Total Semi Sales	8/84			8.3	10.2	12.2	16.4
Total IC	8/84			3.3	4.1	4.9	6.6
Discrete	8/84			5.0	6.1	7.3	9.8
Aydin Total Sales	8/84	64.2	102.9	100.4	124.3	152.9	184.0
Bell Canada Total Sales	8/84	5264.7	6037.1	7389.9	8411.3	8874.6	9666.7
Boeing Total Sales	8/84	11610.0	11831.0	11030.0	9501.0	11308.0	9611.8
Total Semi Sales	8/84		0.7	0.7	0.7	1.0	1.0
Total Capital Expenditures	8/84	569.0	668.0	545.0	331.0	223.0	300.0
Burroughs Total Sales	8/84	2831.0	2902.4	3405.4	4186.3	4389.7	5004.3
Total Semi Sales	8/84	32.2	33.6	39.4	23.7	11.8	15.6
Total IC Sales	8/84	32.2	33.6	39.4	23.7	11.8	15.6
Total Capital Expenditures	8/84	434.0	435.0	549.0	639.0	589.0	650.0
Semiconductor Division	8/84				0.0	0.0	

Source VLSI RESEARCH INC

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	Analysis Date	1979	1980	1981	1982	1983	1984E
California Devices Total Sales	8/84		0.8	2.6	4.9	8.7	19.9
Total Semi Sales	8/84		0.8	2.6	4.9	8.7	19.9
MOS IC	8/84		0.8	2.6	4.9	8.7	19.9
Cermetek Microelec. Total Sales	8/84			3.3	4.8	6.1	12.9
Total Semi Sales	8/84			1.8	1.6	1.2	1.4
Custom Hybrid IC	8/84			1.8	1.6	1.2	1.4
Total Capital Expenditures	8/84				0.7	1.5	3.2
Cherry Electronics Total Sales	8/84	88.0	90.2	89.9	87.6	103.6	134.7
Total Semi Sales	8/84	8.0	9.6	11.1	9.3	12.4	20.7
Bipolar IC	8/84		4.1	4.6	2.2	2.9	4.8
Linear IC	8/84		5.2	6.1	6.7	8.9	14.9
Discrete	8/84		0.3	0.4	0.4	0.6	1.0
Total Capital Expenditures	8/84	9.3	11.1	6.2	5.6	10.2	13.3
Semiconductor Division	8/84		1.9E	2.3	1.0	1.3	2.2
Comdial	8/84			7.4	59.7	147.3	200.9
Total Semi. Sales	8/84			0.7	2.2	3.0	4.1
MOS IC	8/84			0.7	2.2	3.0	4.1
Total Capital Expenditures	8/84			1.1	29.6	21.5	29.3
Commodore Total Sales	8/84	71.1	125.6	186.5	304.5	681.2	1315.0
Total Semi Sales	8/84		35.0	43.8	74.0	85.7	154.8
MOS IC	8/84		35.0	43.8	74.0	85.7	154.8
Total Capital Expenditures	8/84			16.2	25.4	46.4	89.6
Semiconductor Division	8/84			9.6	19.8	16.4	27.0

Source: VLSI RESEARCH INC

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	Analysis Date	1979	1980	1981	1982	1983	1984E
Control Data Corp. Total Sales	8/84	3183.2	3753.0	4126.7	4340.3	4582.8	5270.2
Total Semi Sales	8/84	15.0	16.9	13.8	15.3	17.5	19.4
Total IC Sales	8/84	15.0	16.9	13.8	15.3	17.5	19.4
Total Capital Expenditures	8/84	60.4	98.5	123.1	115.1	176.7	203.2
Semiconductor Division	8/84	3.0	3.3	3.6	4.0	6.2	7.0
Data General Total Sales	8/84	507.5	653.9	736.9	805.9	828.9	1080.5
Total Semi Sales	8/84	11.1E	14.3E	16.1E	17.6	34.4	45.1
Total Capital Expenditures	8/84	47.7	61.8	77.0	69.2	72.8	100.0
Semiconductor Division	8/84	1.6	2.1	2.4	2.6E	2.9	3.8
Delco (GM) Total Sales	8/84	66311.2	57728.5	62699.0	60025.6	74581.6	101942.5
Total Semi Sales	8/84	100.0	104.6	121.7	205.3	278.4	409.6
Total IC	8/84	65.0	71.0	93.3	162.1	219.8	323.4
Discrete	8/84	35.0	33.6	28.4	43.2	58.6	86.2
Total Capital Expenditures	8/84	3351.3	5160.5	6563.3	3611.1	1923.0	2364.7
Semiconductor Division	8/84	49.0	21.9	25.5	26.4E	38.0	55.9
Digital Eq. Corp. Total Sales	8/84	1804.1	2368.0	3198.1	3880.8	4271.9	5584.4
Total Semi Sales	8/84	18.0	23.0	31.1	37.7	63.7	95.8
Total Capital Expenditures	8/84	93.9	209.9	398.5	511.2	419.2	452.1
Semiconductor Division	8/84	2.8	3.6	4.9	6.0	10.1	15.3
Dionics Total Sales	8/84	2.4	2.2	3.4	1.9	2.5	3.3
Total Semi Sales	8/84			3.4	1.9	2.5	3.3
Total Capital Expenditures	8/84			.03	.07	.13	.17
Semiconductor Division	8/84			.03	.07	.13	.17

Source VLSI RESEARCH INC

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	Analysis Date	1979	1980	1981	1982	1983	1984E
Eastman Kodak Total Sales	8/84	8028.2	9734.3	10337.0	10815.0	10170.0	10780.2
Total Semi Sales	8/84		5.9	6.1	6.3E	5.1	5.7
Total Capital Expenditures	8/84				1500.0	899.0	1421.5
Semiconductor Division	8/84		1.2	1.3	1.3	1.1	1.2

Exar (Tokyo): See Rohm Fukuora

	Analysis Date	1979	1980	1981	1982	1983	1984E
Fluke Total Sales	8/84	108.1	133.9	139.6	154.4	172.7	201.3
Total Semi Sales	8/84			0.3	0.9	1.8	2.1
Total IC Sales	8/84			0.3	0.9	1.8	2.1
Total Capital Expenditures	8/84			19.1	8.6	9.5	11.1
Ford Total Sales	8/84	43513.7	37085.5	38247.1	37067.2	44454.6	57620.8
Total Semi Sales	8/84				2.5	2.9	3.9
Total IC	8/84				0.5	0.7	1.5
Discrete	8/84				2.0	2.2	2.4
General Dynamics Total Sales	8/84	3642.0	4383.0	4758.7	6154.5	7146.3	7276.2
Total Semi Sales	8/84			1.7E	2.2E	2.6E	2.7
Total IC	8/84			1.7E	2.2E	2.6E	2.7
Total Capital Expenditures	8/84			138.7	135.5	215.2	219.1

Source: VLSI RESEARCH INC

	Analysis Date	1979	1980	1981	1982	1983	1984E
General Electric Total Sales	8/84	22461.0	24959.0	27240.0	26500.0	26797.0	27600.9
Total Semi Sales	8/84	89.5	216.2	224.9	228.8	255.8	317.9
MOS IC	8/84		79.9	83.1	84.3E	98.2	129.8
Bipolar IC	8/84		12.6	12.6	12.8E	14.9	19.7
Linear IC	8/84		35.1	37.0	37.5E	43.7	57.8
Discrete	8/84	71.5	88.6	92.2	94.2	99.0	110.6
Total Capital Expenditures	8/84	1262.0	1948.0	2025.0	1608.0	1721.0	2324.2
Semiconductor Division	8/84	52.8	55.3	71.8	73.1E	81.7	101.6
General Instrument Total Sales	8/84	718.1	825.1	957.1	974.3	896.4	1082.4
Total Semi Sales	8/84	196.0	244.0	269.6	283.6	232.6	280.9
MOS IC	8/84	100.5	142.6	165.2	176.5	176.0	212.5
Linear IC	8/84			13.4	17.0	18.7	22.6
Discrete	8/84	85.5	101.4	91.0	90.1	37.9	45.8
Total Capital Expenditures	8/84			75.3	80.4	65.9	79.6
Semiconductor Division	8/84	62.0	68.4	46.3	40.5	33.0	39.8
General Semicon. Total Sales	8/84			16.7	19.6	21.0	23.7
Total Semi Sales	8/84			15.9	18.6	19.9	22.5
Discrete	8/84			15.9	18.6	19.9	22.5
Gould (AMI/Dexcel) Total Sales	8/84	805.4	941.4	1136.9	1252.8	1324.8	1543.8
Total Semi Sales	8/84	95.6	117.1	115.5	162.7	188.9	263.2
MOS IC	8/84	95.6	117.1	115.5	162.7	188.9	263.2
Total Capital Expenditures	8/84	76.1	83.9	100.8	124.0	118.8	178.4
Semiconductor Division	8/84	9.9	11.9	12.5	44.3	54.2	114.6

Source: VLSI RESEARCH INC

	Analysis Date	1979	1980	1981	1982	1983	1984E
GTE Total Sales	8/84		9979.0	10267.2	11280.5	12408.8	13899.6
Total Semi Sales	8/84		23.5	25.4	28.9E	30.1	38.8
MOS IC	8/84		23.5	25.4	28.9E	30.1	38.8
Total Capital Expenditures							
Semiconductor Division	8/84		4.9	5.3	6.0E	6.8	8.8
Harris Semicon. Total Sales	8/84	982.1	1300.9	1551.7	1311.7	1433.3	1876.4
Total Semi Sales	8/84	103.0	176.5	180.5	147.2	151.5	209.1
MOS IC	8/84	38.0	72.8	56.9	41.4	43.3	59.8
Bipolar IC	8/84	30.0	62.2	85.3	60.6	62.4	86.1
Linear IC	8/84	30.0	36.3	38.3	45.2	45.8	63.2
Total Capital Expenditures	8/84			98.5	119.3	81.4	150.0
Semiconductor Division	8/84	16.8	30.5	31.2	25.4	26.1	36.0
Hewlett-Packard Total Sales	8/84	2330.0	3046.0	3528.0	4189.0	4710.0	5934.6
Optoelectronic	8/84	119.8	159.5	151.5	137.6	135.3	128.7
Total Semi Sales	8/84	213.1	285.7	271.4	309.6	362.8	484.8
Total IC	8/84	181.7	243.9	231.7	264.3	306.9	415.8
Discrete	8/84	31.4	41.8	39.7	45.3	55.9	69.0
Total Capital Expenditures	8/84	191.0	297.0	318.0	362.0	466.0	587.2
Semiconductor Division	8/84	42.4	52.5	69.7	91.3E	101.1	126.6
Holt Total Sales	8/84				1.4	2.6E	4.1
Total Semi. Sales	8/84				1.4	2.6E	4.1
Total IC	8/84				1.4	2.6E	4.1

Source: VLSI RESEARCH INC

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	Analysis Date	1979	1980	1981	1982	1983	1984E
Honeywell Total Sales	8/84	4209.5	4924.7	5351.2	5490.4	5753.1	5914.2
Total Semi Sales	8/84	49.7	64.4	70.0	89.0	87.3	103.0
Total Capital Expenditures	8/84	182.1	274.2	331.3	351.4	350.4	360.2
Semiconductor Division	8/84	6.2	9.3E	10.1	9.7E	10.7	12.6
Hughes Total Sales	8/84			1759.1	1595.9	1157.3	1300.0
Total Semi Sales	8/84			22.3	26.5	31.2	37.8
MOS IC	8/84			22.3	26.5	31.2	37.8
IBM Total Sales	8/84	22862.8	26213.0	29070.0	34364.0	40180.0	47010.0
Total Semi Sales	8/84	753.3	984.7	1092.0	1166.5	1304.8	1601.6
Total IC	8/84	733.3	962.3	1066.1	1138.1	1291.9	1593.9
Discrete	8/84	20.0	22.4	25.9	28.4	12.9	7.7
Total Capital Expenditures	8/84	1779.0	2258.0	2235.0	2431.0	2578.0	3016.0
Semiconductor Division	8/84	137.2	205.9	228.3	243.8E	272.7	500.0
Intel Total Sales	8/84	661.0	854.6	788.7	899.8	1121.9	1761.4
Total Semi Sales	8/84	430.0	600.8	554.5	619.0	772.5	1215.4
MOS IC	8/84	405.0	565.3	521.7	582.4	723.8	1141.2
Bipolar IC	8/84	25.0	35.5	32.8	36.6	45.7	69.2
Digital Signal Proc.	8/84	-	-	-	0.0	3.0	5.0
Total Capital Expenditures	8/84	96.7	152.2	157.4	138.1	145.0	350.0
Semiconductor Division	8/84	93.5	150.0	152.7	134.0	140.0	340.0
Interdesign (Ferranti) Total Sales							
Total Semi Sales	8/84	9.0	10.0	12.0	25.2	35.6	47.6
MOS Logic	8/84			0.6	9.6	13.7	21.4
Bipolar Logic	8/84			4.1	6.2	8.7	11.6
Linear	8/84			7.3	9.4	13.2	14.6

Source VLSI RESEARCH INC

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	Analysis Date	1979	1980	1981	1982	1983	1984E
Int'l Microcircuits Total Sales	8/84		4.3	5.6	9.9	12.7	16.6
Total Semi Sales	8/84		4.3	5.6	9.9	12.7	16.6
Custom IC	8/84		4.3	5.6	9.9	12.7	16.6
Inter'l Microelec. Total Sales	8/84			0.2	2.7	14.0	20.2
Total Semi Sales	8/84			0.2	2.7	14.0	20.2
MOS IC	8/84			0.2	2.7	14.0	20.2
Intern'l Rectifier Total Sales	8/84	123.8	150.9	126.2	119.2	126.8	122.8
Total Semi Sales	8/84	< 69 >	83.7	89.6	86.6	88.6	116.7
Discrete	8/84	< 69 >	83.7	89.6	86.6	84.2	105.0
MOSFET IC Relay	8/84					4.4	11.7
Total Capital Expenditures	8/84				7.2	4.1	8.1
Semiconductor Division	8/84				4.2	3.3	6.5
Lincoln Semiconductor Total Sls	8/84				0.3	0.4	0.6
Total Semi Sales	8/84				0.3	0.4	0.6
Linear Tech Total Sales	8/84			4.8	4.7	6.9	10.6
Total Semi Sales	8/84			4.8	4.7	6.9	10.6
Linear	8/84			4.8	4.7	6.9	10.6
Total Capital Expenditures	8/84			1.7	2.1	1.5	1.3
	8/84			1.7	2.1	1.5	1.3
Lockheed Total Sales	8/84	4057.6	5395.7	5175.8	5613.0	6490.0	7584.6
Total Semi Sales	8/84			4.4	5.0	6.1	7.2

Source VLSI RESEARCH INC

	Analysis Date	1979	1980	1981	1982	1983	1984E
LSI Computer Sys. Total Sales	8/84			3.1	3.3	4.0	5.8
Total Semi Sales	8/84			3.1	3.3	4.0	5.8
MOS IC	8/84			3.1	3.3	4.0	5.8
LSI Logic Total Sales	8/84		0.0	0.0	5.0	34.9	101.3
Total Semi Sales	8/84		0.0	0.0	3.7	25.0	85.2
Total IC	8/84		0.0	0.0	3.7	25.0	85.2
Martin Marietta Total Sales	8/84		2619.3	3294.1	3526.5	3899.3	4809.3
Total Semi Sales	8/84		2.0E	3.0E	3.3E	4.0E	5.8E
Master Logic Total Sales	8/84			0.6	0.6	0.7	1.0
Total Semi Sales	8/84			0.6	0.6	0.7	1.0
Total IC	8/84			0.6	0.6	0.7	1.0
McDonnell Douglas Total Sales	8/84	5278.5	6066.3	7384.9	7331.3	8111.0	9895.4
Total Semi Sales	8/84		1.5E	1.8E	1.9E	5.1	8.2
MCE Semiconductor Total Sales	8/84	5.0	10.0	8.2	6.5	7.0	10.1
Total Semi Sales	8/84	5.0	10.0	8.2	6.5	7.0	10.1
Microcircuit Tech. Total Sales							
Total Semi Sales	8/84			1.0	1.1	1.3	2.5

Source: VLSI RESEARCH INC

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	Analysis Date	1979	1980	1981	1982	1983	1984E
Micron Technology Total Sales	8/84			0.0	0.5	13.1	39.6
Total Semi Sales	8/84			0.0	0.5	13.1	39.6
64K DRAMS	8/84			0.0	0.5	13.1	39.6
Total Capital Expenditures	8/84			6.8	2.5	10.6	50.0
Semiconductor Division	8/84			6.8	2.5	10.6	50.0
Micro Power Sys. Total Sales							
Total Semi Sales	8/84	12.0	14.0	16.1	19.8	27.7	38.4
MOS IC	8/84	7.0	8.0	4.0	10.3	15.1	21.9
Linear IC	8/84	5.0	7.0	12.1	9.5	12.6	16.5
Total Capital Expenditures							
Semiconductor Division	8/84	2.4E	2.8E	3.3E	3.1E	4.3E	6.0
Microsemiconductor Total Sales	8/84			7.9	13.2	24.4	33.4
Total Semi Sales	8/84			7.9	13.2	24.4	33.4
Discrete	8/84			7.9	13.2	24.4	33.4
Total Capital Expenditures	8/84			0.2	0.4	0.6	0.8
Semiconductor Division	8/84			0.2	0.4	0.6	0.8
Mitel Total Sales	8/84	36.9	92.3	169.4	206.6	262.0	525.4
Total Semi Sales	8/84	2.3	4.8	7.1	10.4	15.0	29.0
Total IC	8/84	2.3	4.8	7.1	10.4	15.0	29.0
Total Capital Expenditures	8/84	7.7	32.0	110.0	75.7	73.5	186.0

Source VLSI RESEARCH INC

	Analysis Date	1979	1980	1981	1982	1983	1984E
Monolithic Memories Total Sales	8/84	36.8	77.0	76.3	68.6	105.4	200.7
Total Semi Sales	8/84	36.8	77.0	76.3	68.6	105.4	200.7
MOS IC	8/84						5.1
Bipolar IC	8/84	36.8	77.0	76.3	68.6	105.4	194.9
Total Capital Expenditures	8/84			16.9	27.5	27.5	50.0
Semiconductor Division	8/84	8.4	13.7	16.9	27.5	27.5	50.0
Monosil Total Sales					11.4		
Total Semi Sales	8/84		6.3	5.9	6.1	6.4	9.6
Mostek (UTC) Total Sales	8/84		12324.0	13667.8	13577.1	14669.3	16282.9
Total Semi Sales	8/84	174.0	290.0	234.9	263.9	306.7	459.5
MOS IC	8/84	174.0	290.0	234.9	263.9	306.7	459.5
Total Capital Expenditures	8/84			577.2	576.2	624.8	787.3
Semiconductor Division	8/84	63.8	81.4	98.0	90.7	113.4	158.8
Motorola Total Sales*	8/84	2713.8	3098.8	3570.0	3786.0	4328.0	5823.0
Total Semi Sales	8/84	1007.6	1227.2	1278.0	1297.0	1601.0	2385.4
MOS IC	8/84	358.5	456.1	383.9	448.2	605.5	948.5
Bipolar IC	8/84	133.3	168.8	257.3	227.2	277.1	454.5
Linear IC	8/84	119.6	154.0	166.1	177.0	226.5	379.7
Discrete	8/84	396.2	448.7	471.2	444.6	491.9	602.7
Total Capital Expenditures	8/84	265.1	301.1	317.3	355.0	406.0	500.0
Semiconductor Division	8/84	162.3	180.4	184.0	160.0	174.2	354.7

Source VLSI RESEARCH INC

* Motorola acquired Four-Phase in 3/82. Figures shown for Motorola have been consolidated with Four-Phase.

	Analysis Date	1979	1980	1981	1982	1983	1984E
National Semicon. Total Sales	8/84	719.7	980.4	1104.1	1210.5	1655.1	1986.1
Total Semi Sales	8/84	518.4	799.5	746.0	785.0	1102.5	1315.2
MOS IC	8/84	168.4	276.2	262.1	275.9	387.2	463.1
Bipolar IC	8/84	214.0	306.5	266.6	280.4	393.7	470.9
Linear IC	8/84	120.5	195.7	197.4	207.8	291.7	348.9
Discrete	8/84	15.0	21.1	20.4	20.9	29.9	32.3
Total Capital Expenditures	8/84	71.8	155.0	129.6	110.5	278.1	331.8
Semiconductor Division	8/84	65.4	155.0	89.1	80.7	251.1	299.6
Naval Ocean Systems Cntr Total Sales							
Total Semi Sales	8/84	0.8E	1.0E	0.9E	1.2E	1.5E	2.25
NCR Total Sales	8/84	3002.6	3322.4	3432.7	3526.2	3731.0	4178.7
Total Semi Sales	8/84	< 21.8 >	35.8E	37.0E	57.7	69.6	104.4
MOS IC	8/84		35.8E	37.0E	57.7	69.6	104.4
Total Capital Expenditures	8/84	448.3	503.4E	139.0	124.9	127.9	161.8
Semiconductor Division	8/84	6.7E	7.5	7.8E	10.9E	8.0	23.2
Nitron Total Sales	8/84	6.3	8.3	7.8	10.8	5.5	6.7
Total Semi Sales	8/84	6.3	8.3	7.8	8.0	2.4	3.3
Total IC	8/84	6.3	8.3	7.8	8.0	2.4	3.3
Total Capital Expenditures	8/84			0.2	2.2	0.4	0.5
Northern Telecom Total Sales	8/84		2054.6	2570.9	3035.5	3304.0	4030.9
Total Semi Sales	8/84		14.0	17.5	20.9	33.1	40.3
Total IC	8/84			11.3	13.5	18.2	19.6
Discrete	8/84			6.2E	7.4E	14.9E	20.7
Total Capital Expenditures	8/84		225.6	209.6	252.6	376.9	541.2
Semiconductor Division	8/84		2.8E	3.6E	4.4E	7.0E	8.5E

Source VLSI RESEARCH INC

	Analysis Date	1979	1980	1981	1982	1983	1984E
Northrop Total Sales	8/84			1990.7	2472.9	3260.6	3667.5
Total Semi Sales*	8/84			0.1	0.2	0.3	0.4
Total IC	8/84			0.1	0.2	0.3	0.4
Total Capital Expenditures	8/84			189.7	376.7	293.1	329.7

* Does not include discrete sales.

	Analysis Date	1979	1980	1981	1982	1983	1984E
P.P.C. Prod. Corp. Total Sales	8/84			1.2	1.2	1.5	1.9
Total Semi Sales	8/84			1.2	1.2	1.5	1.9
Discrete	8/84			1.2	1.2	1.5	1.9
Penril Total Sales	8/84	22.7	33.3	40.1	39.6	38.7	37.9
Total Capital Expenditures	8/84			0.5	0.5	1.2	1.2
Raytheon Total Sales	8/84	3727.9	5002.1	5636.2	5513.4	5937.3	6799.1
Total Semi Sales	8/84	50.0	52.6	53.7	62.6	68.7	82.5
Bipolar IC	8/84	15.0	16.0	15.8	21.9	24.3	29.2
Linear IC	8/84	20.0	21.0	21.1	22.4	24.9	29.9
Discrete	8/84	15.0	15.6	16.8	18.3	19.5	23.4
Total Capital Expenditures	8/84	237.2	825.7	296.8	303.4	304.9	274.2
Semiconductor Division	8/84	8.3E	8.7E	9.3E	10.3E	11.3E	13.6

Source. VLSI RESEARCH INC

	Analysis Date	1979	1980	1981	1982	1983	1984E
RCA Total Sales	8/84	7454.6	8011.3	7798.7	8016.0	8977.3	10291.0
Total Semi Sales	8/84	251.1	269.9	277.3	272.2	304.8	379.3
MOS IC	8/84	100.3	109.1	108.5	108.2	124.2	158.5
Bipolar IC	8/84		5.0	4.0	5.5	7.0	8.7
Linear IC	8/84	60.8	61.1	68.6	71.7	81.6	101.5
Discrete	8/84	90.0	94.8	96.2	86.8	92.0	110.6
Total Capital Expenditures	8/84	1140.0	1233.0	448.8	430.3	495.2	562.1
Semiconductor Division	8/84	38.4	41.5	41.5	41.9E	46.9E	58.4
Rockwell Total Sales	8/84	6176.4	6906.5	7039.7	7395.4	8097.9	9218.4
Total Semi Sales	8/84	71.0	73.1	74.5	84.8	80.1	96.6
MOS IC	8/84	71.0	73.1	74.5	84.8	80.1	96.6
Total Capital Expenditures	8/84	275.8	281.1	316.7	539.4	479.4	545.7
Semiconductor Division	8/84	14.1	14.6	15.3	17.9	17.6	21.3
RSM Sensitron Total Sales	8/84			5.0	5.3	6.0	8.6
Total Semi Sales	8/84			5.0	5.3	6.0	8.6
Discrete	8/84			5.0	5.3	6.0	8.6
S-T Semicon Total Sales	8/84			3.8	3.4	2.9	3.9
Total Semi Sales	8/84			3.8	3.4	2.9	3.9
Discrete	8/84			3.8	3.4	2.9	3.9
Sanders Associates Total Sales	8/84			364.5	436.2	578.1	750.0
Total Semi Sales	8/84			1.0E	1.2E	1.6E	2.4
Total IC	8/84			1.0E	1.2E	1.6E	2.4
Sandia Nat'l Labs Total Sales	8/84			1.1E	1.3E	1.5E	2.0

Source VLSI RESEARCH INC

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	Analysis Date	1979	1980	1981	1982	1983	1984E
Schlumberger Total Sales	8/84	3641.4	5137.1	5978.0	6283.8	5797.5	6002.0
Total Semi Sales	8/84	469.0	581.6	476.1	419.0	481.8	746.8
MOS IC	8/84	105.0E	114.8	90.8	55.8	50.0	78.5
Bipolar IC	8/84	186.0E	259.9	205.5	198.0	243.5	394.5
Linear IC	8/84	74.0E	94.7	74.9	72.4	85.2	153.4
Discrete	8/84	82.0E	112.2	105.7	92.8	103.1	120.4
Total Capital Expenditures	8/84	1296.0	1534.0	2092.0	1094.3	517.0	790.2
Semiconductor Division	8/84	98.8	95.0	166.0	144.2	125.0	191.0
Seeq Total Sales	8/84			0.0	0.2	4.2	42.7
Total Semi Sales	8/84			0.0	0.2	4.2	42.7
Total IC	8/84			0.0	0.2	4.2	42.7
Total Capital Expenditures	8/84			1.1	13.9	13.6	6.8
Semiconductor Division	8/84			1.1	13.9	13.6	6.8
Semi Processes Total Sales	8/84		2.5	4.5	7.4	12.1	20.0
Total Semi Sales	8/84		2.5	4.5	7.4	12.1	20.0
Total IC	8/84		2.5	4.5	7.4	12.1	20.0
Senitron (EM&M) Total Sales	8/84	79.0	77.1	85.8	73.5	79.2	85.3
Total Semi Sales	8/84	35.0	36.0	34.2	27.4	33.5	36.1
Total Capital Expenditures	8/84			2.6	2.4	2.9	3.1
Sensor Technology Total Sales	8/84			6.0E	6.6E	7.5E	11.1
Optoelectronics	8/84			6.0E	6.6E	7.5E	11.1
Si Fab Total Sales	8/84			2.0	2.1	2.6	3.7
Total Semi Sales	8/84			2.0	2.1	2.6	3.7
Total IC Sales	8/84			2.0	2.1	2.6	3.7

Source VLSI RESEARCH

	Analysis Date	1979	1980	1981	1982	1983	1984E
Silicon General Total Sales	8/84			23.5	21.4	29.0	46.2
Total Semi Sales	8/84	20.0	24.0	23.5	21.4	29.0	46.2
Bipolar IC	8/84	10.0	12.0	11.3	10.3	13.9	22.2
Linear IC	8/84	10.0	12.0	12.2	11.1	15.1	24.0
Total Capital Expenditures	8/84			3.0	0.4	3.2	5.1
Semiconductor Division	8/84		4.8	3.0	0.4	3.2	5.1
Silicon Systems Total Sales	8/84			13.0	16.0	22.7	60.1
Total Semi Sales	8/84			13.0	16.0	22.7	60.1
MOS IC	8/84			13.0	16.0	22.7	60.1
Total Capital Expenditures	8/84			5.0	13.4	4.1	10.9
Semiconductor Division	8/84			2.9	10.3	2.7	7.0
Siliconix Total Sales	8/84	54.3	66.1	60.1	60.0	69.6	97.4
Total Semi Sales	8/84	53.0	63.5	59.0	60.0	68.9	96.4
MOS IC	8/84	15.0	16.0	11.2	10.9	12.1	17.0
Bipolar IC	8/84	0.0	2.3	1.0	1.0	1.1	1.5
Linear IC	8/84	13.0	26.0	24.4	23.7	26.4	36.9
Discrete	8/84	25.0	19.2	22.4	24.4	29.3	41.0
Total Capital Expenditures	8/84	6.7	3.3	4.5	3.9	8.1	11.3
Semiconductor Division	8/84	6.7	3.3	4.5	3.9	8.1	11.3
Siltronics Total Sales	8/84			3.4	4.1	4.8	7.0
Total Semi Sales	8/84			3.3	4.0	4.7	6.9
Total IC	8/84			3.3	4.0	4.7	6.9
Total Capital Expenditures	8/84			0.2	0.3	0.7	1.6
Semiconductor Division	8/84			0.2	0.3	0.7	1.6

Source VLSI RESEARCH INC

	Analysis Date	1979	1980	1981	1982	1983	1984E
Solid St. Scientific Total Sls	8/84			33.8	33.6	41.0	59.0
Total Semi Sales	8/84	23.0E	27.0	20.0	22.8	41.0	59.0
MOS IC	8/84	23.0E	27.0	20.0	22.8	41.0	59.0
Total Capital Expenditures							
Semiconductor Division	8/84	6.0E	6.9E	5.5E	6.2E	7.4	10.6
Spectronics Total Sales							
Optoelectronics	8/84			16.5	16.5	20.0	25.2
Optical Couplers	8/84			2.9	2.9	3.5	4.4
LED Displays	8/84			1.6	1.6	1.9	2.4
Sperry Univac Total Sales	8/84	4785.4	5427.2	5487.3	4823.5	4914.0	5454.5
Total Semi Sales	8/84	4.3E	5.6	18.1	30.3	43.6	56.9
Total Capital Expenditures	8/84			362.4	374.5	310.5	344.7
Semiconductor Division	8/84	0.9E	1.1E	3.7	6.4	9.3	12.2
Sprague (GK Tech.) Total Sales			1189.7				
Total Semi Sales	8/84		37.6	53.5	49.9	54.1	62.7
Linear IC	8/84		24.5	44.8	41.5	44.5	48.5
Discrete	8/84		13.1	8.7	8.4	9.6	14.2
Total Capital Expenditures							
Semiconductor Division	8/84		9.0E	7.4	6.9	7.5	8.7
Standard Microsys. Total Sales	8/84	14.9	18.6	19.3	27.0	44.4	79.4
Total Semi Sales	8/84	14.9	18.6	19.3	27.0	44.4	79.4
MOS IC	8/84	14.9	18.6	19.3	27.0	44.4	79.4
Total Capital Expenditures	8/84	2.1	6.5	4.2	4.5	12.8	22.9
Semiconductor Division	8/84	2.1	6.5	4.2	4.5	12.8	22.9

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Source VLSI RESEARCH INC

	Analysis Date	1979	1980	1981	1982	1983	1984E
Storage Technology Total Sales	8/84			922.0	1079.2	886.6	780.2
Total Semi Sales	8/84			-	0.0	0.2	0.4
Total Capital Expenditures	8/84			75.4	89.7	86.6	70.7
Supertex Total Sales	8/84			9.2	7.8	15.5	24.1
Total Semi Sales	8/84			8.7	7.4	14.7	22.9
MOS IC	8/84			8.7	7.4	14.7	22.9
Total Capital Expenditures	8/84			1.3	0.2	2.4	6.1
Semiconductor Division	8/84			1.3	0.2	2.4	6.1
Synertek (Honeywell) Total Sales				168.0			
Total Semi Sales	8/84	51.0	60.0	67.7	89.0	62.3	73.0
MOS IC	8/84	51.0	60.0	67.7	89.0	62.3	73.0
Total Capital Expenditures							
Semiconductor Division	8/84	10.1E	12.0E	13.9	16.3	5.2	5.9
Tektronix Total Sales	8/84	971.3	1061.8	1195.7	1191.4	1331.3	1557.6
Total Semi Sales	8/84		29.5E	33.2	38.9	43.5	46.7
Total Capital Expenditures	8/84			102.4	93.3	90.1	105.6
Semiconductor Division	8/84		5.9E	6.8E	8.2E	7.9	9.3

Source VLSI RESEARCH INC

	Analysis Date	1979	1980	1981	1982	1983	1984E
Teledyne Total Sales	8/84	2705.6	2926.4	3237.6	2863.8	2979.0	3656.6
Total Semi Sales	8/84		20.9E	23.6	24.2	26.2	32.2
MOS IC	8/84		8.4	9.4	10.7	11.6	14.3
Bipolar IC	8/84		4.3	4.7	3.0	3.3	4.1
Linear IC	8/84		2.6	3.1	2.8	3.0	3.6
Discrete	8/84		5.6E	6.4	7.7	8.3	10.2
Total Capital Expenditures	8/84	111.1E	120.2E	133.0	132.8	75.8	93.0
Semiconductor Division	8/84		5.0E	5.8	5.8	6.3	7.7
Teletype Total Sales	8/84			3.0	7.4	8.6	11.3
Total Semi Sales	8/84			3.0	7.4	8.6	11.3
MOS IC	8/84			3.0	7.4	8.6	11.3
Telmos Total Sales	8/84			0.1	0.7	2.3	12.0
Total Semi Sales	8/84			0.1	0.7	2.3	12.0
Custom CMOS	8/84			0.1	0.7	2.3	12.0
Total Capital Expenditures	8/84				0.4	3.8	8.0
Semiconductor Division	8/84				0.4	3.8	8.0
Texas Instruments Total Sales	8/84	3224.1	4074.7	4206.0	4342.6	4542.8	5663.2
Total Semi Sales	8/84	1349.0	1403.2	1353.4	1327.8	1665.0	2428.9
MOS IC	8/84		404.7	390.3	459.1	612.6	959.4
Bipolar IC	8/84		618.2	596.0	533.1	662.6	921.1
Linear IC	8/84		221.0	213.0	236.7	296.8	439.3
Discrete	8/84		159.3	153.5	98.9	93.0	109.1
Total Capital Expenditures	8/84	261.7	330.7	341.4	329.3	454.1	800.0
Semiconductor Division	8/84	118.8	150.1	155.0	140.0	232.0	525.6

Source: VLSI RESEARCH INC

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	Analysis Date	1979	1980	1981	1982	1983	1984E
TRW Total Sales	8/84	4560.3	4984.0	5285.1	5138.8	5493.0	6207.1
Total Semi Sales	8/84	50.0	60.3	79.0	87.1	111.1	145.4
Linear IC	8/84	15.0	22.3	21.8	31.5	44.3	66.5
Discrete	8/84	35.0	38.0	57.2	54.6	66.8	78.9
Total Capital Expenditures	8/84			263.0	299.2	309.9	375.0
Semiconductor Division	8/84	9.9E	12.1E	13.2E	12.7E	15.7	21.6
Unitrode Total Sales	8/84	81.6	103.6	118.1	113.1	159.6	210.2
Total Semi Sales	8/84	60.4	70.4	70.8	69.5	79.8	105.1
Linear IC	8/84	4.8	5.2	3.7	2.7	3.1	4.1
Discrete	8/84	55.6	65.2	67.1	66.8	76.7	101.0
Total Capital Expenditures							
Semiconductor Division	8/84	14.5E	18.9E	16.9	13.1	10.3	24.0
Universal Semicon. Total Sales	8/84					1.6	8.0
Total Semi Sales	8/84					1.6	8.0
MOS IC	8/84					1.6	8.0
Varian Total Sales	8/84	493.0	620.9	638.4	691.2	760.3	927.6
Total Semi Sales	8/84	14.0	15.8	14.4	17.1	18.2	20.4
Discrete	8/84	14.0	15.8	14.4	17.1	18.2	20.4
Total Capital Expenditures	8/84	20.5	33.2	39.1	29.9	33.7	41.4
Semiconductor Division	8/84	2.8	3.2	3.0	3.0E	3.8E	4.3

Source: VLSI RESEARCH INC

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	Analysis Date	1979	1980	1981	1982	1983	1984E
Varo Semiconductor Total Sales	8/84	94.2	83.1	77.3	88.4	100.8	105.8
Total Semi Sales	8/84			27.9	23.2	28.0	31.4
Discrete	8/84			27.9	23.2	28.0	31.4
Total Capital Expenditures							
Semiconductor Division	8/84			4.9	4.3	5.4	6.1
Veeco Total Sales	8/84	86.9	105.3	111.1	114.3	122.1	151.8
Total Semi Sales	8/84	8.7	10.2	10.8	10.2	11.4	17.1
Total Capital Expenditures	8/84	4.2	5.8	4.6	5.3	5.5	6.8
Semiconductor Division	8/84			0.6	1.8	3.4	5.1
VLSI Technology Total Sales	8/84	-	0.0	0.6	21.2	35.8	67.3
Total Semi Sales	8/84	-	0.0	0.5	18.0	28.3	53.2
MOS IC	8/84	-	0.0	0.5	18.0	28.3	53.2
Total Capital Expenditures	8/84			0.6	12.7	22.4	42.1
Semiconductor Division	8/84			0.6	12.7	22.4	42.1
Votrax Total Sales	8/84			3.8	3.4	3.3	6.6
Total Semi Sales	8/84			-	0.0	3.3	6.6
Digital Signal Processing	8/84			-	0.0	3.3	6.6
Watkins Johnson Total Sales	8/84		132.8	132.4	156.1	186.0	213.9
Total Semi Sales	8/84			55.6	65.1	73.5	84.5
Total Capital Expenditures							
Semiconductor Division	8/84			11.4	13.7	14.9	17.1

Source VLSI RESEARCH INC

	Analysis Date	1979	1980	1981	1982	1983	1984E
Western Digital Total Sales	8/84	10.3	20.6	26.7	34.8	50.6	112.3
Total Semi Sales	8/84	10.0E	17.8	23.2	30.1	43.8	97.2
MOS IC	8/84	10.0E	17.8	23.2	30.1	43.8	97.2
Total Capital Expenditures	8/84			8.1	9.3	6.4	14.2
Semiconductor Division	8/84			7.2	8.3	5.7	12.6
Westinghouse Elec. Total Sales	8/84	7443.1	8514.3	9367.5	9745.4	9532.6	10295.2
Total Semi Sales	8/84	49.8	73.0	69.7	62.6	68.8	75.7
Total Capital Expenditures	8/84		446.0	600.0	224.0	716.0	773.3
Semiconductor Division	8/84	9.9	14.6	14.3	12.8	14.1	15.5
Xerox Total Sales	8/84	7027.0	8196.5	8510.1	8455.6	8463.5	8971.3
Total Semi Sales	8/84			7.0	14.0	17.5	25.8
Total IC Sales	8/84			7.0	14.0	17.5	25.8
Total Capital Expenditures	8/84			320.6	328.7	325.3	345.0
Xicor Total Sales	8/84		0.1	0.4	2.8	15.7	46.0
Total Semi Sales	8/84		0.1	0.4	2.8	15.7	46.0
MOS IC	8/84		0.1	0.4	2.8	15.7	46.0
Total Capital Expenditures	8/84			10.4	5.5	11.5	12.6
Semiconductor Division	8/84			10.4	5.5	11.5	12.6
Zenith Electronics Total Sales	8/84	1075.0	1186.0	1275.0	1239.0	1361.0	1524.3
Division Sales	8/84	63.0	173.0	200.0	220.0	286.0	594.5
Total Capital Expenditures	8/84			59.8	32.4	31.4	35.2

Source VLSI RESEARCH INC

TABLE 6.10-2

REVENUE HISTORY OF JAPANESE SEMICONDUCTOR MANUFACTURERS

(worldwide in $M)

	Analysis Date	1979	1980	1981	1982	1983	1984E
Canon Electronics Total Sales	8/84	1412.5	2088.1	2142.1	2232.7	2933.8	3325.0
Total Semi Sales	8/84	-	0.0	1.0E	3.0E	3.7	5.5
Fuji Electric Co. Total Sales	8/84	1516.8	1971.0	1915.3	1695.4	1878.4	2072.1
Total Semi Sales	8/84	89.4	116.1	128.9	137.7E	203.9E	239.1
Total Capital Expenditures							
Semiconductor Division	8/84	11.5	14.9	16.5	17.6E	26.1E	30.6
Fujitsu Ltd. Total Sales	8/84	2688.1	3473.2	3637.7	3680.1	4842.8	6187.8
Total Semi Sales	8/84	354.5	448.3	452.5	527.8	702.4	958.3
MOS IC	8/84	208.1	263.2	265.5	296.6	394.5	525.3
Bipolar	8/84	97.6	123.4	124.5	139.1	185.0	241.4
Linear	8/84	13.4	17.0	17.2	19.2	25.5	63.3
Discrete	8/84	35.4	44.7	45.3	72.9	97.4	128.3
Total Capital Expenditures	8/84	180.0	330.4	346.0	352.0	407.7	837.4
Semiconductor Division	8/84	63.6	138.2	169.3	165.4	229.2	470.8
Hamamatsu TV Total Sales	8/84	27.2	36.2	29.2	34.6E	42.7E	63.0
Total Semi Sales	8/84	6.0	7.8	8.6	10.2E	12.6E	18.6

Source VLSI RESEARCH INC

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	Analysis Date	1979	1980	1981	1982	1983	1984E
Hitachi Total Sales	8/84	13208.0	16795.9	16812.4	15168.0	19088.8	21168.5
Total Semi Sales	8/84	750.3	1030.0	1136.4	1153.9	1457.3	1894.2
MOS IC	8/84	310.4	405.1	453.4	432.7	576.6	749.4
Bipolar IC	8/84	103.4	134.9	142.2	135.4	165.2	214.7
Linear IC	8/84	221.6	289.2	319.1	303.9	330.5	429.7
Discrete	8/84	115.0	200.8	221.7	281.9	385.0	500.4
Total Capital Expenditures	8/84	659.4	1073.0	1119.0	1279.5	1636.3	2134.1
Semiconductor Division	8/84	74.9	117.8	130.8	174.8	208.3	478.0
Hokuriku Elec. Ind. Total Sls	8/84			80.7	81.7	106.3	128.8
Total Semi Sales	8/84			55.7	56.3	73.3	89.0
Total IC	8/84			21.0	21.2	27.6	35.8
Discrete	8/84			34.7	35.1	45.7	53.2
Total Capital Expenditures							
Semiconductor Division	8/84				9.2E	13.4E	16.9
Japan Resistor Total Sales	8/84		23.5	23.7	20.9	33.2	43.5
Total Semi Sales*	8/84		4.7	4.7	4.2	6.6	8.7
Discrete	8/84		4.7	4.7	4.2	6.6	8.7
Koa Denko Total Sales	8/84	46.2	55.0	68.4	59.3	83.3	98.4
Total Semi Sales	8/84	41.8	50.1	64.3	55.8	78.3	92.5
Total IC	8/84	2.3	3.0	53.4	46.3	65.0	78.1
Discrete	8/84	39.5	47.1	10.9	9.5	13.3	14.4
Total Capital Expenditures	8/84	3.3E	4.0E	5.2E	4.5E	6.3	7.4
Semiconductor Division	8/84	3.3E	4.0E	5.2E	4.5E	6.3	7.4

* Does not include IC sales.

Source VLSI RESEARCH INC

	Analysis Date	1979	1980	1981	1982	1983	1984E
Kokusai Electric Total Sales	8/84	122.8	170.9	202.7	192.3	276.7	351.9
Total Semi Sales	8/84	39.2	54.5	84.5	83.4	117.3	158.8
Total Capital Expenditures							
Semiconductor Division	8/84	5.9E	10.0E	13.4E	14.8E	20.5E	27.8
Matsushita Total Sales	8/84	10594.4	14579.8	15687.9	14036.8	16618.8	17000.0
Total Semi Sales	8/84	248.1	340.0	458.4	423.1	595.6	936.4
MOS IC	8/84	32.2	45.1	77.9	119.6	161.6	296.0
Bipolar IC	8/84	4.0	6.7	8.6	5.4	14.1	22.7
Linear IC	8/84	43.8	106.2	150.6	143.2	204.8	370.0
Discrete	8/84	168.1	182.0	221.3	154.9	215.1	247.7
Total Capital Expenditures	8/84			920.8	619.4	602.0	722.4
Semiconductor Division	8/84	45.5	113.3	103.0	104.6	125.0	347.8
Meidensha Electric Total Sales	8/84	420.9	535.0	525.3	416.8	406.7	456.5
Minebea Total Sales	8/84					761.0	926.1
Total Semi Sales	8/84					0.0	0.0
256 KDRAMS	8/84					0.0	0.0
Total Capital Expenditures							
Semiconductor Division	8/84					0.0	52.3

Source: VLSI RESEARCH INC

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	Analysis Date	1979	1980	1981	1982	1983	1984E
Mitsubishi Total Sales	8/84	5333.9	6693.7	6550.9	5990.6	7271.9	8123.1
Total Semi Sales	8/84	191.0	312.2	375.8	338.5	581.3	760.9
MOS IC	8/84	25.0	125.0	138.9	138.0	208.3	278.8
Bipolar IC	8/84	14.0	57.9	67.3	53.0	68.9	89.9
Linear IC	8/84	29.0	48.8	58.5	51.0	146.6	186.9
Discrete	8/84	123.0	80.5	111.1	96.3	157.5	205.3
Total Capital Expenditures	8/84	92.0		299.9	279.9	303.3	472.2
Semiconductor Division	8/84	40.9	51.0	88.6	136.5	147.9	230.3
Moririca Electronics Total Sls	8/84		12.0	11.5	12.3E	12.6	13.9
Total Semi Sales	8/84		11.4	10.9	11.7E	12.0	13.2
Discrete	8/84		11.4	10.9	11.7E	12.0	13.2
NEC Total Sales	8/84	3865.8	5374.5	5816.9	5659.1	6994.5	8420.2
Total Division	8/84		1215.0	1372.7	1376.9	1444.5	2526.1
Optoelectronics	8/84					91.9	130.4
Total Semi Sales	8/84	666.7	1107.5	1200.0	1128.8	1604.2	2391.3
MOS IC	8/84	276.1	529.8	591.4	553.6	856.8	1341.9
Bipolar IC	8/84	51.3	98.4	102.2	90.1	128.0	192.9
Linear IC	8/84	101.8	195.3	214.8	192.1	305.6	471.5
Discrete	8/84	237.5	284.0	291.6	293.0	313.8	385.0
Total Capital Expenditures	8/84	125.0	1215.0	695.9	783.5	968.4	1165.7
Semiconductor Division	8/84	111.3	169.9	181.8	200.0	279.2	478.3
New Japan Radio Total Sales	8/84	38.6	55.0	65.0	64.5	76.3	99.2
Total Semi Sales	8/84	27.1	27.5	32.5	38.7	45.8	59.5
Linear IC	8/84		3.5	3.8	4.9	5.8	7.5
Discrete	8/84		24.0	26.2	33.8	40.0	52.0
Total Capital Expenditures							
Semiconductor Division	8/84	4.1E	5.0E	5.5E	4.8E	4.8E	5.0

Source VLSI RESEARCH INC

	Analysis Date	1979	1980	1981	1982	1983	1984E
Nippon Gaki Total Sales	8/84	1548.1	1868.7	1763.1	1511.3	1687.0	1785.9
Total Semi Sales	8/84	16.2	19.5	21.3	19.6E	28.8E	30.4
Nippon Prec. Circ.(Seiko) Total	8/84	22.7	25.2	30.1	28.2	29.7	47.8
Total Semi Sales	8/84	22.7	25.2	30.1	28.2	29.7	47.8
MOS IC	8/84	22.7	25.2	30.1	28.2	29.7	47.8
Nippondenso Total Sales	8/84	2113.7	2682.4	2744.8	2397.0	2819.5	3075.8
Total Semi Sales	8/84	171.7	219.8	232.0	214.2E	261.1	386.4
Total Capital Expenditures							
Semiconductor Division	8/84	40.3	45.4	46.7	44.8E	61.9E	100.2
Nissan Motor Total Sales	8/84	14869.5	18245.9	17732.8	15657.2	18251.1	19988.5
Oki Electric Total Sales	8/84	742.2	930.0	973.6	952.1	1250.0	1576.1
Total Semi Sales	8/84	60.0	120.2	139.0	173.1	291.7	434.8
MOS IC	8/84	47.1	95.7	108.4	137.9	245.6	372.9
Bipolar	8/84	6.2	12.3	12.2	13.5	14.8	18.9
Linear	8/84	1.3	3.0	2.7	3.3	6.0	15.4
Discrete	8/84	6.4	13.6	15.7	18.4	25.3	27.3
Total Capital Expenditures	8/84	145.4	136.0	115.5	97.4	108.4	174.0
Semiconductor Division	8/84	22.7	68.0	57.7	56.0	55.0	87.0
Omron Tateisi Elec. Total Sls	8/84	613.2	823.4	799.1	697.6	1006.3	1205.7
Total Capital Expenditures	8/84	52.9	71.0	68.9	64.9	105.5	126.4

Source VLSI RESEARCH INC

	Analysis Date	1979	1980	1981	1982	1983	1984E
Origin Electric Total Sales	8/84	51.2	70.0	74.2	69.9	79.2	87.0
Total Semi Sales	8/84	6.7E	9.1	10.4	10.5	12.7E	14.8
Discrete	8/84	6.7E	9.1	10.4	10.5	12.7E	14.8
Pioneer Electronics Total Sls	8/84	1041.5	1454.5	1433.5	1141.6	1286.4	1541.2
Total Semi Sales	8/84		1.0	1.1	1.0	1.1	1.3
Ricoh Total Sales	8/84	1176.0	1518.2	1589.4	1498.7	1625.0	1956.5
Total Semi Sales	8/84	0.0	0.0	22.7	30.8	41.7	65.2
Total IC	8/84	0.0	0.0	22.7	30.8	41.7	65.2
Total Capital Expenditures	8/84	90.2E	116.4	114.8	138.8	150.5	181.2
Semiconductor Division	8/84				6.2E	8.3E	19.6
Rohm Fukuoka Total Sales*	8/84	91.0	148.8	167.3	126.4	231.3	346.9
Total Semi Sales	8/84	91.0	148.8	187.5	151.6	272.9	398.7
Total IC	8/84	26.4	43.1	68.7	61.9	108.7	124.3
Discrete	8/84	64.6	105.7	118.8	89.7	164.2	274.4

* Exar was acquired by Rohm Fukuoka. Semiconductor historical sales for Exar have been consolidated; total sales have not.

	Analysis Date	1979	1980	1981	1982	1983	1984E
Sanken Electric Co. Total Sls	8/84	123.4	159.8	163.0	139.0	205.1	234.8
Total Semi Sales	8/84	87.3	100.8	100.6	89.0	128.9	147.9
Total Capital Expenditures	8/84			21.4	19.3	62.5	26.1
Semiconductor Division	8/84	13.3E	18.4E	17.1	15.4	50.0	20.9

Source VLSI RESEARCH INC

	Analysis Date	1979	1980	1981	1982	1983	1984E
Sharp Total Sales	8/84	2308.9	3119.3	3328.8	3454.0	4075.7	4829.7
Total Semi Sales	8/84	215.4	291.0	391.4	415.6	475.0	617.4
MOS IC	8/84			306.3	327.2	375.9	469.7
Linear IC	8/84			68.9	73.0	83.6	129.4
Discrete	8/84			16.2	15.4	15.5	18.2
Total Capital Expenditures	8/84	145.9	197.1	463.0	538.0	833.3	1304.4
Semiconductor Division	8/84	43.9	48.7	46.3	56.6	83.3	146.1
Shindengen Electric Total Sls	8/84	93.3	134.0	149.5	136.9	174.3	206.2
Total Semi Sales	8/84	31.9	48.2	76.2	68.5	88.9	105.2
Discrete	8/84	31.9	48.2	76.2	68.5	88.9	105.2
Total Capital Expenditures							
Semiconductor Division	8/84	4.8E	8.8E	12.9E	12.8E	16.6E	19.7
Sony Total Sales	8/84	2911.8	4501.0	4777.5	4283.9	4629.3	5329.6
Total Semi Sales	8/84	70.9	109.6	117.3	112.3	139.7	173.9
Total IC	8/84	26.7	41.3	44.2	42.3	52.6	65.5
Discrete	8/84	44.2	68.3	73.1	70.0	87.1	108.4
Total Capital Expenditures	8/84			445.9	431.1	236.0	288.2
Semiconductor Division	8/84	11.4	33.7	34.5	34.0E	55.2E	64.4
Stanley Electric Total Sales	8/84		355.0	372.3	330.1	389.8	428.8
Total Semi Sales	8/84		74.6	78.2	72.6	85.8	94.3
Discrete	8/84		74.6	78.2	72.6	85.8	94.3
Total Capital Expenditures	8/84			28.1	24.9	34.5	37.9
Semiconductor Division	8/84		13.6E	13.3E	11.8E	16.3E	17.9
Sumitomo Elec. Total Sales	8/84	2164.1	2798.6	2701.3	2115.3	2359.4	2691.0

Source VLSI RESEARCH INC

	Analysis Date	1979	1980	1981	1982	1983	1984E
Taiyo Yuden Co. Total Sales	8/84	96.3	151.6	198.9	160.7	212.8	257.6
Total Semi Sales	8/84	38.5	60.6	77.6	62.7	83.0	100.5
Total Capital Expenditures							
Semiconductor Division	8/84	2.8E	3.6E	5.7E	10.2	15.8	19.1
TDK Electronics Total Sales	8/84	703.6	1073.9	1226.8	1171.1	1444.1	1772.6
Total Semi Sales*	8/84	91.5	141.8	153.4	120.6	155.6	195.0
Discretes	8/84	91.5	141.8	153.4	120.6	155.6	195.0
Total Capital Expenditures	8/84	73.0	136.6	145.6	185.3	126.9	155.8
Teikoku Electronics Total Sales	8/84	97.6	122.7	112.9	96.8	120.9	140.7
Total Semi Sales	8/84	71.3	89.6	82.4	70.7	88.3	102.7
Discretes	8/84	71.3	89.6	82.4	70.7	88.3	102.7
Tokyo IC Total Sales	8/84	12.7	14.4	17.5	16.3E	16.7E	24.7
Total Semi Sales	8/84	12.7	14.4	17.5	16.3E	16.7E	24.7
Tokyo Sanyo Co. Total Sales	8/84	1005.9	1290.4	1219.5	1165.4	1146.3	1878.2
Total Semi Sales	8/84	104.0	209.2	233.3	209.6	316.7	471.6
MOS IC	8/84		26.9	25.8	27.3	63.7	98.5
Bipolar IC	8/84		9.2	10.6	8.8	15.0	24.6
Linear IC	8/84		62.2	89.2	62.4	142.0	233.5
Discrete	8/84		110.9	107.7	111.1	95.8	115.0
Total Capital Expenditures							
Semiconductor Division	8/84	20.3	40.8	56.6	47.9	50.0	86.9

* Does not include IC sales.

Source VLSI RESEARCH INC

	Analysis Date	1979	1980	1981	1982	1983	1984E
Toshiba Total Sales	8/84	8545.4	10498.0	10653.4	9234.7	10712.3	12533.4
Total Semi Sales	8/84	415.0	564.5	799.4	769.2	1125.0	2021.2
MOS IC	8/84		260.1	306.3	315.1	526.6	1049.6
Bipolar IC	8/84		33.6	35.1	37.0	73.4	146.9
Linear IC	8/84		145.5	168.5	169.6	269.3	538.9
Discrete	8/84	117.0	125.3	289.5	248.2	255.7	285.8
Total Capital Expenditures	8/84	187.0		636.5	517.4	520.0	933.3
Semiconductor Division	8/84	22.7	66.8	100.9	288.7	250.0	448.0
Unizon Corp. Total Sales	8/84	13.6	15.0	13.6	12.0	9.4	13.9
Total Semi Sales	8/84	13.6	15.0	13.6	12.0	9.4	13.9
Discrete	8/84	13.6	15.0	13.6	12.0	9.4	13.9
Yuasa Battery Co. Total Sales	8/84	239.1	312.7	289.4	239.4	256.1	280.4
Total Semi Sales	8/84	23.9	31.3	28.9	23.9	28.2	30.8
Discrete	8/84	23.9	31.3	28.9	23.9	28.2	30.8
Total Capital Expenditures	8/84				10.9	15.5	17.0

Source VLSI RESEARCH INC

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TABLE 6.10-3

REVENUE HISTORY OF EUROPEAN SEMICONDUCTOR MANUFACTURERS

(worldwide in $M)

	Analysis Date	1979	1980	1981	1982	1983	1984E
Bosch Total Sales			6505.9				
Total Semi Sales	8/84	7.3	8.8	10.6	12.8E	15.4E	21.9E
Total IC	8/84	7.3	8.8	10.6	12.8E	15.4E	21.9E
Eurosil Total Sales							
Total Semi Sales	8/84		15.0	14.0	14.0	15.0E	17.5
MOS IC	8/84		15.0	14.0	14.0	15.0E	17.5
Faselec (Philips) Total Sales							
Total Semi Sales	8/84	13.9	19.4	24.8	25.6E	26.6E	40.4
Favag Total Sales							
Total Semi Sales	8/84		0.8E	1.0E	1.2E	1.3E	2.0E
Ferranti Total Sales	8/84				450.0	600.0E	750.5
Total Semi Sales	8/84	53.8	76.9	79.5	81.8	99.1E	143.9
MOS IC	8/84	6.4	10.7	11.1	11.4	13.0	17.1
Bipolar IC	8/84	24.3	32.4	34.5	35.5	47.5	80.5
Linear IC	8/84	12.9	18.5	20.7	21.3	24.0	30.4
Discrete	8/84	10.2	15.3	13.2	13.6	14.6	15.9
Total Capital Expenditures	8/84				29.8	32.0	42.5
Semiconductor Division	8/84	6.5	9.7	9.5	10.5	11.1	17.5

Source VLSI RESEARCH INC

	Analysis Date	1979	1980	1981	1982	1983	1984E
ITT Total Sales	8/84	17550	18529.7	16495.4	15237.6	14155.4	14863.2
Total Semi Sales	8/84	185.8	205.7	209.4	213.7	251.7	331.3
MOS IC	8/84		41.0	40.3	51.4	54.7	86.0
Bipolar IC	8/84		40.0	37.7	19.6	22.8	32.8
Linear IC	8/84		16.7	23.5	31.8	43.4	69.7
Discrete	8/84	105.0	108.0	107.9	110.9	130.8	142.8
Total Capital Expenditures	8/84			1048.3	866.0	744.1	781.3
Semiconductor Division	8/84	36.0	44.4	42.0	46.0	46.1	60.7
Marconi Elec. Dev. Total Sales							
Total Semi Sales	8/84				1.2	1.3E	1.9
N.V. Philips Total Sales	8/84	15678.3	17234.0	17240.2	15922.6	16204.6	18790.0
Total Semi Sales	11/84		698.2	842.4	778.0	874.3	1219.3
MOS IC	11/84		121.9	112.4	103.8	162.5	265.0
Bipolar IC	11/84		323.2	283.4	261.7	290.9	352.2
Linear IC	11/84		220.8	218.4	198.5	202.2	343.9
Discrete	11/84		280.0	209.2	214.0	218.7	258.2
Total Capital Expenditures	8/84		1217.7	986.4	887.4	874.0	1013.4
Semiconductor Division	11/84				117.0E	123.3E	183.5
Plessey Total Sales	8/84	1622.2	1866.3	1723.9	1590.6	1755.2	1950.0
Total Semi Sales	8/84	42.0	55.0	52.8	48.8	47.3	70.1
MOS IC	8/84	10.3	13.5	13.0	12.0	18.9	23.5
Bipolar IC	8/84	15.0	19.7	18.9	17.5	10.3	32.4
Linear IC	8/84	11.7	15.3	14.7	13.6	13.5	7.7
Discrete	8/84	5.0	6.5	6.2	5.7	4.6	6.5
Total Capital Expenditures							
Semiconductor Division	8/84	7.7E	10.7E	9.7E	9.6E	7.6	13.8E

Source VLSI RESEARCH INC

	Analysis Date	1979	1980	1981	1982	1983	1984E
SGS-ATES Total Sales	8/84				158.0	225.0E	310.0
Total Semi Sales	8/84	127.4	149.0	147.0	145.6	179.3	272.6
MOS IC	8/84	24.4	28.5	25.4	30.7	41.0	62.3
Bipolar IC	8/84	36.0	42.2	30.6	23.6	39.0	72.3
Linear IC	8/84	47.2	55.0	48.6	49.3	60.7	80.9
Discrete	8/84	19.8	23.3	42.4	42.0	38.6	57.1
Total Capital Expenditures							
Semiconductor Division	8/84	23.4	28.9	26.9	28.7	28.7	51.7
Siemens Total Sales	8/84	16081.5	17950.3	16646.3	15425.4	15478.8	16345.6
Total Semi Sales	8/84	378.0	497.0	363.7	360.0	405.1	540.3
MOS IC	8/84	65.0	85.0	59.2	69.5	91.9	124.5
Bipolar IC	8/84	48.0	65.0	43.7	80.5	86.9	117.3
Linear IC	8/84	50.0	60.0	41.2	27.8	31.2	43.4
Discrete	8/84	165.0	287.0	219.6	182.2	195.1	218.9
Total Capital Expenditures	8/84				680.0	663.0	780.5
Semiconductor Division	8/84	60.3E	96.4E	66.6E	72.2E	97.6	204.1
TAG Total Sales							
Total Semi Sales	8/84	19.0	21.0	16.9	16.9	15.8	20.0
Telefunken Elec. Total Sls	8/84			122.1	125.7	141.2	186.4
Total Semi Sales	8/84	117.8	133.2	122.1	125.7	141.2	186.4
MOS IC	8/84	29.6	33.5	30.7	31.6	33.7	42.2
Linear IC	8/84	7.6	8.6	8.1	8.4	8.7	10.8
Discrete	8/84	80.6	91.1	83.3	85.7	98.8	133.4
Total Capital Expenditures							
Semiconductor Division	8/84	30.7	36.7	31.7	35.1E	11.3	14.9

Source VLSI RESEARCH INC

	Analysis Date	1979	1980	1981	1982	1983	1984E
Thomson CSF Total Sales	8/84	3692.7	4406.7	4680.8	3890.3	4040.7	5587.0
Total Semi Sales	8/84	178.0	211.0	166.2	170.8	198.7	299.6
MOS IC	8/84	34.2	40.6	32.0	32.9	38.3	92.0
Bipolar IC	8/84	38.0	49.0	36.4	37.4	38.8	57.5
Linear IC	8/84	11.0	14.0	10.4	10.7	11.1	16.4
Discrete	8/84	94.8	107.4	87.4	89.8	110.5	133.7
Total Capital Expenditures							
Semiconductor Division	8/84	32.7E	40.9E	30.4E	33.6	28.0	39.5
Thorn-EMI Total Sales	8/84				3548.2	3670.0	3853.5
Total Semi Sales	8/84				18.7	48.2	129.5
MOS IC	8/84				18.7	48.2	129.5
Total Capital Expenditures							
Semiconductor Division	8/84				4.3E	10.2E	26.7
Valvo Total Sales							
Total Semi Sales	8/84	29.0	34.6E	31.5E	32.5E	33.8E	50.0E
MOS IC	8/84	2.5					
Bipolar IC	8/84	6.3					
Linear IC	8/84	14.6					
Discrete	8/84	5.6					
Total Capital Expenditures							
Semiconductor Division	8/84	5.3E	6.7E	5.8E	5.9E	6.4E	9.5E

Source VLSI RESEARCH INC

TABLE 6.10-4

REVENUE HISTORY OF ROW SEMICONDUCTOR MANUFACTURERS

(worldwide in $M)

	Analysis Date	1979	1980	1981	1982	1983	1984E
Daewoo Electronics Total Sls	8/84					3000.0	3200.0
Total Semi Sales	8/84				0.7E	1.0	2.0
Goyo Electric Co. Total Sls	8/84				7.7	10.4	14.0
Total Semi Sales							
Hybrid IC							
ITRI/ERSO Total Sales							
Total Semi Sales	8/84				21.0	24.8	34.7
Korea Elec. Co. Total Sls	8/84					60.0	80.0
Total Semi Sales	8/84					30.0	42.0
Discrete	8/84					30.0	42.0
Meltron Semicon. Total Sls	8/84				1.0	0.8E	1.1
Total Semi Sales	8/84				1.0	0.8E	1.1
Symbol Semicon. Total Sls	8/84			–	0.0	0.7E	1.1
Total Semi Sales	8/84			–	0.0	0.7E	1.1
Linear IC	8/84			–	0.0	0.7E	1.1

Source VLSI RESEARCH INC

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	Analysis Date	1979	1980	1981	1982	1983	1984E
United Microelec. Total Sls	8/84				21.6	23.3E	38.8
Total Semi Sales	8/84				21.6	23.3E	38.8
MOS IC	8/84				21.6	23.3E	38.8

Source VLSI RESEARCH INC

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ROW Semiconductor Manufacturers Revenue History

THE WHITE HOUSE

WASHINGTON

June 19, 1985

MEMORANDUM FOR JOHN A. SVAHN

FROM: JOSEPH A. MASSEY

SUBJECT: Proposed Memo From You to Donald Regan on the Semiconductor 301

Attached is a draft memo to Donald Regan for your consideration. Mike Driggs suggested that I prepare the memo as a means for you to call Regan's attention to the semiconductor 301, explain its significance, and give him some background on the competitive challenge faced by the industry gleaned from my recent trip to Silicon Valley.

THE WHITE HOUSE

WASHINGTON

June 19, 1985

MEMORANDUM FOR DONALD T. REGAN

FROM: JOHN A. SVAHN

SUBJECT: U.S. Competitiveness in Electronics and the Semiconductor Industry's 301 Petition

This memo is to bring to your attention a potentially significant development in trade. Last Friday, the U.S. semiconductor industry filed with USTR a petition under Section 301 of the Trade Act of 1974 charging Japan with unfair trading practices. The gist of the charge is that Japanese Government targeting and protectionist polices prior to 1975 resulted in a market structure that continues to keep semiconductor imports to a minimum level of participation in the Japanese economy today. The petition charges also that those policies have led to over-capacity and export surges that disrupt the U.S. market. The remedy sought is for the President to direct that negotiations be undertaken with Japan to bring about parity in market share, so that by 1986 the share of the Japanese semiconductor market held by U.S. firms equals that held by Japanese firms in the U.S. The petition does not, in its present form, seek to restrict imports of Japanese semiconductors into the U.S.

This petition is highly significant in three respects. First, it is the first time that a major U.S. high technology industry has sought trade-law action against Japan. Heretofore, the pattern has always been for non-competitive smokestack industries, such as motorcycles or steel, to seek relief through the trade laws from Japanese imports. The semiconductor industry is a high-tech sector in which the U.S. has been the world leader. The Japanese now are challenging that lead, and there is reason to believe that if present trends continue they will displace the U.S. firms, probably permanently as happened in consumer electronics, in the next several years. For the first time, then, one of our high-tech manufacturing industries, which has begun to lose competitiveness, is seeking the Administration's help through the unfair trade laws. That decline in competitiveness may be due not to the semiconductor industry's own mismanagement or inadequate investment efforts to date, but to foreign government policies that have distorted the world market. What makes this petition different is that it is a call by an industry that is still competitive for the Administration to take action before rather than after that competitiveness has been eroded.

The petition is significant, secondly, because it does not seek to restrict imports. Rather, it aims at increasing U.S. semiconductor exports to Japan to a level equal to Japan's share of the U.S. semiconductor market. Although the market share parity formulation is troublesome, the goal of increasing U.S. exports is consistent with the Administration's overall trade policy objective of increasing access for U.S. products in the Japanese market. Moreover, the petition may provide us with some useful leverage in the "MOSS" negotiations with Japan, where little progress has been made so far on electronics issues.

Third, the petition is significant because it may offer an opportunity for the Administration to take a highly visible but non-protectionist action to demonstrate that we will defend the legitimate economic interests of U.S. industries. Once Congress finishes with taxes, it will turn its attention back to trade. There is, as you know, a spate of protectionist legislation pending, including several bills directed against Japan. Several of the bills would reduce the President's discretion and require retaliation, reflecting the widespread Congressional belief that the President will not use the retaliatory authority he already posesses. The semiconductor case could provide a way in which we can take the initiative and show that the Administration can and will use its trade-law authority. What is attractive about that possibility is that it would be used to aid a still-competitive but threatened industry to stay competitive by securing for it the opportunity to compete against its Japanese rivals in their own market. The situation is in marked contrast to the footwear 201 case, where the President will have to decide by August 30 whether to impose import quotas to protect an industry that will never again be competitive. If we decide <u>not</u> to protect the footwear sector, on grounds that it is economically irrational to do so, it could be politically very helpful to have a case, like semiconductors, in which we can and do take positive action.

Just a week before the petition was filed, Joe Massey of my staff took a two-day trip to Silicon Valley to meet and discuss competitiveness issues with executives of U.S. firms in the semiconductor and telecommunications industries. I thought you might find his observations and impressions on the situation of these two key U.S. electronics industries to be of value.

The major impression Massey brought back with him was that of a striking difference in the confidence of the two industries in the face of Japanese competition. Although the U.S. runs a deficit with Japan in both sectors, U.S. telecommunications firms seem significantly more confident of their ability to hold their own. The Japanese, and others including Koreans, Taiwanese, etc., have penetrated the U.S. market but mainly in the low-tech, low-profit sector of telephone hand sets. The U.S. firms believe they hold a significant lead in the more sophisticated technologies like digital switches and private branch exchanges. They evince a confidence in the quality of their hardware and in the superiority of their software - especially - that is impressive.

The problem that the U.S. telecommunications industry faces is having superior products that are unable to sell abroad because of the telecommunications trade policies of foreign governments or because of buy national attitudes (in Japan, particularly).

The semiconductor producers, on the other hand, are in deeper trouble. The race, here, unlike computers and telecommunications, is being decided not by software technology but by production technology. It depends less on innovation in research than on capital expenditure for new production facilities. As a result, while U.S. firms continue to hold a majority share of world semiconductor sales, their lead over their Japanese competitors is dwindling rapidly. In memory devices, the 64K and 256K "RAMS," they have already lost the lead - in the world and, most importantly, the U.S. market - to the Japanese. These so-called commodity chips are essential to driving both production technollogy and production costs. Each new and denser generation of memory chips requires significantly increased expenditures both for R & D and, most importantly, for cleaner and cleaner production facilities (ever more expensive "clean rooms" and sophisticated electronic machinery capable of imprinting on the chips circuits a fraction of a micron wide.) Industry experts claim that to go from producing 64K to 256K RAM memory chips would require a capital investment in <u>new</u> plant and equipment of about $200 million or more. Very few of the U.S. firms can afford to do that. Unless they do, however, they will increasingly be forced to retreat from the high volume market of commodity memory chips into the role of suppliers of custom products, particularly microprocessors where the U.S. still leads. But even that technology-based lead is narrowing and will narrow more rapidly, as the revenues produced by the high volume sales of memory chips are increasingly lost to the Japanese.

The trouble is that the Japanese firms have far deeper pockets. Not only are real interest rates lower in Japan, but the largest semiconductor makers (who are also the largest semiconductor users) are parts of large, integrated electronics firms who have the financial resources to fund the immense new capital expenditures required by the advances in the very large scale integration (VLSI) of memory chips. This fact is very likely the key element in world competition in semiconductors today and for the near future. Only the giants with deep pockets - the Japanese, Motorola, TI, and a very few others are going to prosper.

Unfair Trade Practices: Now High Tech Industries Seek Help

In recent weeks, two key U.S. industries, telecommunications and semiconductors, have begun to press the Administration to take action under our trade laws against unfair foreign trading practices. The telecommunications industry supports Senator Danforth's proposed legislation that would require the Administration to induce foreign countries to make their markets as open as ours or, failing that, to close the U.S. market. The semiconductor industry filed a Section 301 petition with USTR on June 14, charging Japan with unfair trading practices and calling on the Administration to get the Japanese Government to provide U.S. semiconductors by 1986 with a market share in Japan equal to that held by Japanese semiconductors in the U.S. These developments pose both a challenge and an opportunity for the Administration to maintain the initiative in U.S. trade policy.

Both of these high technology industries are facing intensified competitive challenges from foreign producers, especially the Japanese. But there is a striking difference in the confidence of senior executives in the two industries in the face of Japanese competition.

U.S. telecommunications firms seem significantly more confident of their ability to hold their own. The Japanese, and others, have penetrated the U.S. market mainly in the low-tech, low-profit sector of telephone hand sets. The U.S. firms believe they hold a significant lead in the more sophisticated technologies like digital switches and private branch exchanges. They evince a confidence in the quality of their hardware and in the superiority of their software - especially - that is impressive. The problem that the U.S. telecommunications industry faces is having superior products that are unable to sell abroad because of the protectionist trade policies of foreign governments or because of buy-national attitudes.

The semiconductor producers are in deeper trouble. The race here depends less on software than on capital expenditure. Each new generation of semiconductor memory chips in particular requires huge investments, estimated now at some $200 million plus, for totally new plant and equipment. This is because the increasingly high number of circuits on each chip, -- the latest have a mind-boggling 256 thousand to one million circuits -- demands exceedingly expensive "clean room" facilities and production equipment capable of working at sub-micron levels (smaller than the most powerful optical microscopes can resolve). Very few of the U.S. firms can keep up with the Japanese in making such huge expenditures. As a result, while U.S. firms continue to hold a majority share of world semiconductor sales generally, that lead is dwindling rapidly and has already been lost in memory chips to the Japanese.

Unless the U.S. firms can increase their sales and revenues in the high volume market of these "commodity" memory chips, they will be increasingly forced to retreat into the role of suppliers of custom chips, particularly microprocessors, where they still maintain a technology lead. But even that lead is narrowing rapidly, as the revenues produced by the high volume sales of memory chips are increasingly lost to the Japanese. The trouble is that the Japanese firms have far deeper pockets. Not only are real interest rates lower in Japan, but the largest semiconductor makers are parts of large, integrated electronics firms and huge conglomerates who have the financial resources to fund these immense new capital expenditures. This fact is very likely the key element in world competition in semiconductors today and for the near future. Only the giants with deep pockets - the Japanese and a very few of the largest U.S. firms - are going to prosper.

The call of these two U.S. high technology industries for trade-law action is highly significant in two respects. First, previously it was nearly always the declining "smokestack" industries that sought trade-law protection from import competition. Now, some of our presumably most competitive, high-tech industries are asking that we use the trade laws to help them overcome unfair advantages enjoyed by their foreign competitors. Although both the Danforth proposal and the semiconductor 301 petition contain elements inconsistent with our trade policy, the stated objective of each is not to restrict imports but rather to increase access for U.S. products in foreign markets, especially Japan.

The semiconductor case in particular could provide a way in which we can take the initiative and show that the Administration can and will use its trade-law authority. What is attractive about that possibility is that it would be used to aid a still-competitive but threatened industry to stay competitive by securing for it the opportunity to compete against its Japanese rivals in their own market. The situation is in marked contrast to the footwear 201 case, where you will have to decide by August 30 whether to impose import quotas to protect an industry that will never again be competitive. If you decide <u>not</u> to protect the footwear sector, on grounds that it is economically irrational to do so, it could be politically very helpful to have a case like semiconductors, in which we can and do take positive action.

Office of Policy Development
June 21, 1985

MAD

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Unfair Trade Practices: Now High Tech Industries Seek Help

On June 14, the U.S. semiconductor industry filed with USTR a petition under Section 301 of the Trade Act of 1974 charging Japan with unfair trading practices. Essentially, the charge is that Japanese Government targeting and protectionist polices prior to 1975 resulted in a market structure that continues to keep semiconductor imports to a minimum level of participation in the Japanese economy today. The petition charges also that those policies have led to over-capacity and export surges that disrupt the U.S. market. The remedy sought is for you to direct that negotiations be undertaken with Japan to bring about parity in market share, so that by 1986 the share of the Japanese semiconductor market held by U.S. firms equals that held by Japanese firms in the U.S. The petition does not seek to restrict imports of Japanese semiconductors into the U.S.

This is the first time that a major U.S. high technology industry has sought trade-law action against Japan. The semiconductor industry is a high-tech sector in which the U.S. has been the world leader. The Japanese now are challenging that lead, and there is reason to believe that if present trends continue they will displace the U.S. firms, probably permanently as happened in consumer electronics. This may not be due to the semiconductor industry's own mismanagement or inadequate investment efforts to date, but rather to foreign government policies that have distorted the world market.

The petition is also significant in that it does not seek to restrict imports. Rather, it aims at increasing U.S. semiconductor exports to Japan to a level equal to Japan's share of the U.S. semiconductor market.

The telecommunications industry has also begun to press for trade law action against what they believe to be unfair trading practices. This industry is supporting Senator Danforth's proposed legislation that would require the Administration to induce countries to make their telecommunications markets as open as ours, or, failing that, to close the U.S. market.

There appears to be a striking difference in the confidence of the semiconductor and telecommunications industries in the face of Japanese competition. Although the U.S. runs a deficit with Japan in both sectors, U.S. telecommunications firms seem markedly more confident of their ability to hold their own. The Japanese, and others such as the Koreans and Taiwanese, have penetrated the U.S. market but mainly in the low-tech, low-profit sector of telephone hand sets. The U.S. firms believe they hold a significant lead in the more sophisticated technologies like digital switches and private branch exchanges. They evince an impressive confidence in the quality of their hardware and in the superiority of their software.

The problem that the U.S. telecommunications industry faces is having superior products that it is unable to sell abroad because of the protectionist trade policies of foreign governments or because of "buy-national" attitudes.

The semiconductor producers, on the other hand, are in deeper trouble. The race here, unlike computers and telecommunications, is being decided not by software technology but by production technology. It depends less on innovation in research than on capital expenditure for new production facilities. Each new generation of semiconductor memory chips requires huge investments, estimated now at some $200 million plus, for totally new plant and equipment. This is because the increasingly high number of circuits on each chip -- the latest have from 256,000 to one million -- demands exceedingly expensive "clean room" facilities and production equipment capable of working at sub-micron levels (smaller than the most powerful optical microscopes can resolve). Very few of the U.S. firms can keep up with the Japanese in making such huge expenditures. As a result, while U.S. firms continue to hold a majority share of world semiconductor sales generally, that lead is dwindling rapidly and has already been lost in memory chips to the Japanese.

Unless the U.S. firms can increase their sales and revenues in the high volume market of memory chips, they will be increasingly forced to retreat into the role of suppliers of custom chips, particularly microprocessors, where they still maintain a technology lead. But even that lead is narrowing rapidly, as the revenues produced by the high volume sales of memory chips are increasingly lost to the Japanese. Only the giants with deep pockets - the Japanese and a very few of the largest U.S. firms - are going to prosper.

The call of these two U.S. high technology industries for trade-law action is significant. As you know, it has usually been the declining "smokestack" industries that have sought trade-law protection from import competition in the past. In this case, it is a call by industries that are still competitive for action to be taken before, rather than after, that competitiveness has been eliminated. Finally, although both the Danforth bill and the semiconductor 301 petition have objectionable provisions, their stated objective of increasing access for U.S. products in foreign markets coincides with our trade policy goal of equal access.

Office of Policy Development
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