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OFFICE OF THE
UNITED STATES TRADE REPRESENTATIVE
EXECUTIVE OFFICE OF THE PRESIDENT
WASHINGTON, D.C. 20506

November 12, 1985

MEMORANDUM FOR: SEE DISTRIBUTION

FROM: JAN ARCHIBALD JA/JIM GRADOVILLE

SUBJECT: U.S. SEMICONDUCTOR INDUSTRY PRESENTATION

Representatives from Texas Instruments and Intel will make a presentation to an interagency group involved in the Section 301 and anti-dumping semiconductor cases on Wednesday November 13 from 10:30 to 12:30 p.m. in Room 203. Their presentation will focus on the technological attributes of memory chip production (DRAMs and EPROMs) and their importance to the continued competitiveness of U.S. manufacturers in other semiconductor products. Enclosed are several documents related to the subject of the presentation.

Cleared by B. Wilson BW

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IMPORTANCE OF MEMORY TECHNOLOGY

A SEMICONDUCTOR COMPANY MUST PARTICIPATE IN MEMORY BUSINESS TO BE A WORLD CLASS COMPETITOR

TECHNOLOGY

- O MEMORIES DRIVE SEMICONDUCTOR TECHNOLOGY
  - O FEATURE SIZE:
    MEMORIES MUST BE SMALL TO BE COST COMPETITIVE
  - O PERFORMANCE:
    MANUFACTURING TECHNOLOGIES ARE PUSHED TO THEIR LIMITS TO ACHIEVE REQUIRED PERFORMANCE.
  - O QUALITY:
    HIGH VOLUME ENABLES SUBTLE FAILURE MODES TO BE IDENTIFIED AND CORRECTED.
  - O PACKAGING:
    MUST HAVE LOW COST PACKAGING TECHNOLOGY TO BE COST COMPETITIVE.

MANUFACTURING

- O MEMORY ARRAY IS EASY TO FAILURE ANALYZE
  - o PRODUCTION YIELD LIMITING PROBLEMS ARE EASY TO IDENTIFY AND CLARIFY
- O MEMORIES ARE HIGH VOLUME, COMMODITY PRODUCTS
  - o ENABLES MANUFACTURING AREAS TO DEVELOP EFFICIENT PRODUCTION METHODS
  - o PRODUCTION AREA COMES DOWN THE EXPERIENCE CURVE QUICKLY

IMPACT ON OTHER PRODUCTS

- O HIGH PERFORMANCE, MANUFACTURABLE TECHNOLOGY CAN BE APPLIED TO LOWER VOLUME PRODUCTS TO PRODUCE COST EFFECTIVE SOLUTIONS THAT WOULD BE IMPOSSIBLE WITHOUT THE MEMORY EXPERIENCE

IMPORTANCE OF MEMORY TECHNOLOGY (CONTINUED)

ECONOMIC

- PROVIDES BASE VOLUME TO ENABLE STATE-OF-THE-ART MANUFACTURING AREAS TO BE BUILT

IMPORTANCE OF EPROM MEMORY TECHNOLOGY

- O HAS ALL THE ATTRIBUTES OF ANY MEMORY TECHNOLOGY
- O HAS THE ADDITIONAL FEATURE OF A PROGRAMMABLE ELEMENT
- O IMPORTANCE OF A PROGRAMMABLE ELEMENT
  - O CUSTOMIZEABLE MICROPROCESSORS
  - O REMOTE FIELD UPDATES
  - O FAST IMPLEMENTATION OF NEW SOFTWARE AND HARDWARD CONCEPTS
  - O PERMITS HIGH LEVEL OF SECURITY DUE TO USER PROGRAMMING AND EASE OF ERASING.
- O IMPORTANCE TO FUTURE MEMORY TECHNOLOGY DEVELOPMENT
  - O BASIS FOR MORE SOPHISTICATED E^2 (ELECTRICALLY ERASABLE) MEMORY TECHNOLOGY
  - O PUSHES THE LIMITS OF FABRICATION AND PACKAGING TECHNOLOGY

WHAT'S NECESSARY FOR SUCCESS IN THE MEMORY BUSINESS

- LEADING ENGINEERING TECHNOLOGY
  - MINIMUM FEATURE SIZE
  - HIGH PERFORMANCE PROCESSES

- STATE-OF-THE-ART MANUFACTURING AREAS
  - LARGEST DIAMETER WAFERS
  - LOWEST DEFECT DENSITIES
  - TIGHT PROCESS CONTROL
  - LATEST GENERATION OF EQUIPMENT

- VOLUME PRODUCTS TO ESTABLISH MANUFACTURING TECHNOLOGY

- CASH FLOW IN ORDER TO CONTINUE TO INVEST
  - NEW GENERATION PRODUCT EVERY 1-2 YEARS
  - NEW FAB AREA EVERY 3-5 YEARS

USITC PRELIMINARY CONFERENCE
INV. 731-TA-288
EPROMS FROM JAPAN
OCTOBER 21, 1985

TESTIMONY OF GEORGE SCHNEER
INTEL CORPORATION

Good morning. My name is **George Schneer.** I am the Vice President and General Manager of the Memory Components Division for Intel Corporation. In that position, I have been heavily involved, on a day to day basis, in the design, manufacture, and marketing of Intel's EPROMs.

U.S. producers of EPROMs are a part of the larger U.S. semiconductor industry.

My testimony will cover the importance of EPROM production to a broad line semiconductor producer like Intel. Process development, cost reductions and automation development learned from EPROMs permeate other semiconductor product lines. I will also talk briefly about how Intel conducts its operations, and try to give you a sense of how the industry is structured. I will conclude by explaining what has been happening in the U.S. EPROM market over the past nine months, focusing particularly on the impact that Japanese dumping of EPROMs has had on Intel and the continuing threat that the Japanese predatory pricing strategy poses to Intel and to the entire semiconductor industry, an industry vital to the economic future of this nation.

EPROM is an acronym for Erasable Programmable Read Only Memory. An EPROM is a type of semiconductor memory chip which can be programmed by the customer (by electrical means) and then erased under ultraviolet light and then reprogrammed by the customer. I will pass around some samples of Intel EPROMs.

The life cycle of an EPROM consists of eight basic stages:

1) product design;
2) test technology development;
3) process development;
4) wafer fabrication;
5) wafer testing (also referred to as wafer sorting);
6) package development;
7) assembly; and
8) final unit test.

Stages one through six are extremely sophisticated and require a heavy investment in engineering talent. These critical stages are generally performed by U.S. based producers of EPROMs in the United States. Similarly, to the best of my knowledge, all Japanese producers conduct these operations in Japan. The mechanical steps of packaging the die and testing the final product are often performed outside of the United States, due largely to historical reasons, rather than current economics. In the past, the assembly and test operations were highly labor intensive but due to automation are becoming more capital intensive and less labor intensive. Consequently, the location of assembly and test plants in the future may be determined more by proximity to the wafer fabrication facilities, design engineers and customers than by the cost of labor.

I want to emphasize that the critical stages are stages one through six. They are the high technology stages of the semiconductor life cycle and provide barriers to entry into the EPROM market. Assembly and test operations, in contrast, require relatively low skilled labor and can be located anywhere. However, even when assembly and test are performed abroad, their critical engineering components, i.e. the development of state-of-the-art packages as well as state-of-the-art test technology, occur here in the United States. It is clear to anyone in the industry that the country in which the products and packages are designed and the wafers are fabricated is the country of origin of the product, regardless of where it is assembled. I understand that the Customs Service has a different view on the definition of the country of origin, but this should not obscure the reality of how the EPROM industry operates.

For example, at Intel, stages one and two, i.e. product design and test technology development, are generally performed in my operation in Folsom, California. Process development, which is generally applied to both memory and logic circuits, is done by the corporate process development group in Santa Clara. The EPROM wafer fabrication is performed in our facilities in Santa Clara, California, Albuquerque, New Mexico, and Chandler, Arizona. Corresponding wafer sorting is performed in Folsom, California and Albuquerque, New Mexico. Package development is performed in our Chandler facility. The assembly and final test operations are performed in the Philippines, Malaysia and Barbados, with some final test being performed in Folsom. As a general rule, Intel uses primarily foreign subsidiaries and some subcontractors to perform assembly and test operations.

I would like to explain the importance of a commodity memory product to any semiconductor manufacturer. The commodity memory product has three critical impacts:

1) It is used as a vehicle to develop and refine state of the art process technology.
2) It is used as a vehicle to drive the manufacturer down the learning curve by improving VLSI yields and thereby reducing manufacturing costs.
3) It is used as a vehicle to develop manufacturing automation techniques.

Let's look at each impact in more detail.

Memory circuits are the most sensitive to processing parameters and manufacturing defects. This is because the important attributes of the memory circuits (e.g. density and speed) require the devices to operate at the extreme capability of the manufacturing process. Logic products, on the other hand, are usually more design intensive than process intensive, and because of their complicated designs do not allow the Process Engineer to readily analyze the subtleties of the process and thereby maximize performance and manufacturability.

Memories, on the other hand, are designed with the memory cells in a regular array. It is possible to use simple electrical tests and very quickly locate a manufacturing or design defect in the array. Once a defect is located it can be evaluated and appropriate procedures can be developed to correct a problem or improve the manufacturing process. Conversely, the use of a logic product to debug a new technology is a slow and tedious process.

Semiconductor manufacturing can be analyzed using the so-called "learning curve". A simple interpretation of the learning curve is that as the cumulative number of units produced on a process increases, manufacturing costs decrease. In fact, historically every time the cumulative volume doubles, the manufacturer obtains a 30% reduction in the cost of a device produced on the process. So a company that produces a large volume of memory products will have a distinct advantage over a firm that has no memory volume. It is critical that any company that intends to manufacture semiconductor products maintain a large enough market share in commodity memory products such as DRAMs or EPROMs to enable it to derive the benefits associated with large volumes of production. For example, Intel used the 256K EPROM as the vehicle to debug the world's first six inch wafer facility which resulted in significant cost improvements. I will pass around a 4" wafer and a 6" wafer. You can see that there is significantly more area on the 6" wafer and consequently more potential good die per wafer. The result is a significantly lower die cost, once a company has mastered the more complicated manufacturing process.

The final impact of VLSI commodity memory production on a semiconductor manufacturer is in the area of factory automation. Efforts to reduce the overall cost of a product also depend upon factory automation. In the same manner that memory products can be used to develop process technology, they are an excellent vehicle to develop automation techniques. This has been clearly demonstrated in a number of industries where high volume products drive automation development that can be used by other, similar but low volume product lines. For example, robots developed for volume passenger car production can also be used to manufacture sports cars. The costs to develop robots for the sports car line alone would not be able to be amortized over the low volume without prohibitively increasing costs. There are many examples in the semiconductor industry of cost improvement through automation (lower labor content, better process control, lower defect densities because of the manufacturing cleanliness) and it is no coincidence that Intel's most automated factories are those manufacturing high volume commodity memory devices--now essentially only EPROMs.

The direct impacts I have just described also have a spillover benefit to other product lines. The process used to manufacture memory devices can be readily adapted to logic circuits such as microprocessors and microcontrollers. In fact, most integrated circuits contain a memory array somewhere in their internal structure (e.g. microcode in a microprocessor). In order to be able to effectively compete in the "non-memory" arena it is necessary to actively participate in the memory arena to develop the necessary process technology. It is impossible for a company to manufacture solely low volume, high value added logic products and expect to compete on a manufacturing cost basis with a manufacturer who also produces large volume memory devices. Without a high volume memory product a manufacturer does not have a vehicle to develop state of the art technology processes which can be used for logic products. It does not have a vehicle to drive it down the learning curve or to automate its factory.

Historically, the DRAM has been the high volume commodity memory product which provided these benefits. In fact, in 1968, Intel was founded on and for many years produced primarily DRAMs. Ever since the late 1970's and early 1980's Intel has been relegated to a niche supplier in the DRAM market. The Intel strategy had been to maintain limited participation in the DRAM market by designing and manufacturing DRAMs with value added features (e.g. using CMOS technology for lower power and higher speed circuits.) The

DRAM product line accounted for less than five percent of our revenues in 1985 but was a significant contributor to the $23 million dollar operating loss that Intel reported in the third quarter of 1985. We determined that we will never be able to make a profit in DRAMs given existing conditions. Consequently, on October 10, 1985, Intel announced that we are totally closing down DRAM operations.

Japanese semiconductor manufacturers recognize that establishing a dominant position in high volume commodity memory products will give them a competitive advantage in office automation and other end product applications. It appears that their marketing strategy has been to build up capacity and then flood the market with large volumes of low priced products in an all out effort to grab market share and drive U.S. producers out of the market. Ultimately they are looking to become the only remaining manufacturers of semiconductor devices. The Japanese success in dominating the DRAM market is encouraging them to pursue this strategy in EPROMs. In the late 1970's, Mostek was the world's premier DRAM manufacturer. In fact, the Japanese made their entrance into the semiconductor business by copying an earlier Mostek DRAM. You may have heard that last Thursday United Technologies closed Mostek's doors and took a $423 million after tax loss. Reportedly, Mostek had employed almost 10,000 people at the beginning of the year. For the reasons discussed earlier, the American semiconductor industry cannot allow the Japanese to violate U.S. laws and implement a similar strategy in EPROMs.

Every day newspapers report substantial losses being incurred by the American semiconductor manufacturers. Semiconductor manufacturers have been reluctant to reduce research and development or capital expenditures because we know that if we make cuts in those areas we are risking loss of our competitiveness in the next generations of semiconductor processes and products.

The newspapers also frequently report that a semiconductor manufacturer has instituted new cost cutting measures. At Intel, for example, in the first quarter we had a layoff. We had a second layoff in the second quarter of the year and in the third quarter we required our employees to take unpaid days off. In the fourth quarter we will again require employees to take unpaid days off and cut their salaries so that their net fourth quarter compensation may be cut by as much as 13 1/2%. We have basically sacrificed our current financial performance for long term capability.

But there is a limit to our resources. Our industry was built by U.S. entrepreneurs who played a vital role in technological innovation. The industry is largely made up of companies whose main revenue is obtained from semiconductors and related product lines. We are not able to subsidize large losses for long periods of time in the same manner as large Japanese companies with profits from their other diversified operations. The reduced revenue and profits in EPROMs due to the illegal pricing practices of the Japanese has been a significant cause of the corporate injury described above.

I want to stress that Intel, in particular, and the U.S. EPROM industry in general are doing everything that can be done to maintain our leadership in the EPROM market place. We continue to maintain a high level of investment in R & D and capital expenditures; we have many programs aimed at reducing our manufacturing costs and trimming our expenses. Our answers to the ITC questionnaire show that unit volume in EPROMs is not decreasing. Certainly, the volume is increasing in the highest density products such as the 256K EPROM. The dramatic drop in profitability that we are experiencing is a function of the rapidly declining prices of EPROMs caused by Japanese predatory pricing. The net result is that for the first time since it went public Intel reported a net loss for the third quarter of 1985. We had an operating loss of twenty-three million dollars, and as the predatory pricing continues, we anticipate that Intel will experience even larger losses in the fourth quarter of 1985. In our petition we have shown that this is a pricing recession and have estimated a loss of some $203 million for the U.S. EPROM industry from the middle of 1985 to the middle of 1986.

Central to the Japanese strategy is the knowledge that denying the U.S. EPROM manufacturers the revenues needed to fund the very high research and development expenditures necessary to stay competitive in this industry will ultimately drive American manufacturers out of the semiconductor manufacturing business. We need over $50 million to develop a one megabit EPROM and a typical facility to fabricate EPROMs costs over $100 million. The Japanese intention is to drive us out of the market for the most sophisticated semiconductor devices very quickly. At that point, our customers (e.g. the computer manufacturers, office automation equipment manufacturers, many defense contractors who purchase military versions of these semiconductors) will be dependent entirely upon the Japanese for these semiconductor products. Once the American semiconductor manufacturers are no longer a factor in the market, the Japanese will be free to control both the prices and the availability of future generation products.

I am most familiar with the Japanese strategy in the 256K EPROM market because this is a leading edge product with a significant impact on my operation. It appears that by late 1984 the Japanese had developed the ability to manufacture the 256K EPROM. In early 1985 the distributor cost (i.e. the price at which the manufacturer ships to its distributor) was in the high teens for most U.S. manufacturers. Suddenly, it was reported that a Japanese manufacturer was quoting a distributor cost of $6.40. At the same time, the Japanese were stocking their U.S. distributors with significant quantities of 256K EPROMs and began submitting price quotations which undercut Intel price quotes. It was in this environment in which the memo from Hitachi documenting the 10% rule was distributed. The key impact was that now that their inventory was in the distributor channel, Hitachi wanted the distributors to find any Intel business and go get it at any price. The actual cost of the EPROM was not a consideration, and in any event the distributor was guaranteed to make a 25% margin on any sale. The net result was a precipitous price collapse in the market place unlike any we had ever seen before in any density of EPROM.

Before long the Intel salesmen were being notified by EPROM customers that they had to meet the Japanese price for all future business and in fact must renegotiate existing orders and long-term contracts. If the salesmen were not willing to renegotiate existing orders and contracts, they were informed that the vendor/supplier relationship would be damaged for the long term.

A typical situation which occurred with an Intel customer demonstrates the problem. Intel had signed a contract to deliver EPROMs in 1985 at a fixed price. The customer notified Intel that the Japanese were offering substantially lower prices. With a gun to our head we were forced to lower contract prices and ended up shipping 256K EPROMs at $8.50 a unit, instead of the contract price of $16.50.

The 10% Hitachi rule is symptomatic of the general Japanese pricing strategy. They generally manufacture a product based on their capacity, and then determine what price it takes to sell their inventory. Cost is not an important factor in their pricing decisions so quoting a price 10% below whatever Intel is quoting is an acceptable pricing strategy to capture market share.

Intel, on the other hand, has a much more carefully controlled procedure for making price quotations. A Field Sales Engineer is not permitted to make a quote lower than a pre-approved factory authorized minimum price without obtaining approval from the factory. This factory authorized minimum price is updated periodically. If the salesman needs to quote below the factory authorized minimum he must call the factory for a special price quotation. Salesman must supply the factory with the customer name, part number, quantity, delivery time frame, competitive information and any other pertinent data on the competition. If appropriate, the factory management will authorize the quote giving the salesman a quote number which is tracked to ensure that the appropriate factory approvals have been obtained. Depending on the extent to which the desired quotation is below the factory authorized minimum, various levels of Intel management must approve the quotation. Because of the predatory pricing, a significant number of quotations required the signature of my Marketing Manager as well as myself.

I want to leave you with the thought that we do not intend to allow the EPROM market to follow the DRAM scenario. We cannot give up EPROM revenue, profits or manufacturing jobs. The EPROM market is simply too important to the heart of the semiconductor business. American EPROM manufacturers are doing everything possible to maintain their competitive edge over the Japanese EPROM manufacturers and we are asking you to make the Japanese manufacturers compete fairly within the confines of the U.S. dumping laws.

Thank you.

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Electronics

TI TURNS TO EPROMs AS TECHNOLOGY DRIVER

COMMODITY CHIPS COULD HELP TI'S SHIFT TO SPECIALIZED ICs

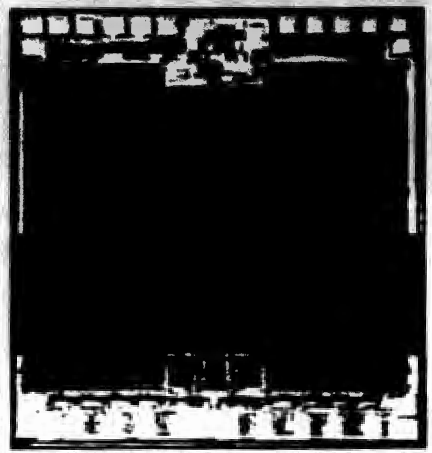
HOUSTON

Texas Instruments Inc. slipped nearly out of sight in leading-edge EPROMs five years ago, but is now viewing ultraviolet-erasable programmable read-only memories in a totally different light. The Dallas-based company is jumping back in because it sees this commodity part as a technology driver in its shift to specialized ICs.

This week, TI is rolling out 128- and 256-K EPROMs made with a new high-voltage CMOS technology. The 2-µm HVCMOS, as the technology is called, is considered a cornerstone in the efforts to shift the bulk of TI's chip portfolio from low-cost commodity products to more profitable unique integrated circuits [*Electronics*, Aug. 12, 1985, p. 22].

To fight the nose-diving EPROM prices, TI is holding down die sizes with a new X-shaped cell layout for the storage array. The technique—popular in mask-programmed ROMs—cuts spacing between active transistors and metal contacts by wrapping the gate of the storage cells around the contacts. The result is a serpentine pattern resembling rows of Xs, allowing the cells to be packed closer together. Furthermore, source and drain contacts can be shared among 4 bits, rather than the 2 bits of conventional layouts. Intel researchers, however, warn that about four years ago they identified a problem with EPROM X-shaped cells that could not be easily overcome (see "X-cells spell trouble, says Intel," right).

But for TI—which says it has overcome the hurdles—the X-cell layout results in a 15% silicon saving over conventional EPROM designs made from the same design rules, says Pradeep Shah, advanced EPROM product manager in Houston. The combination of TI's 2-µm HVCMOS and the X-cells has resulted in a 100-piece price of $6.96 each for the TMS27C256 256-K, and $5.85 each for the 27C128 128-K chip. Control over both the virtual ground and source of the X-cells also helps keep the power dissipation low, says Shah: ratings are 1.4-mW standby and 220-mW active.



VEHICLE. TI's 256-K EPROM is fabricated with a new high-voltage CMOS technology.

The launch of CMOS-based EPROMs places TI squarely on a new dual process-development track. The new nonvolatile memory thrust is now supplementing TI's older and still larger efforts to drive fine-line processes with dynamic random-access memories. Like other chip producers, TI will fan out developments from EPROMs and DRAMs into other product lines.

"In the late 1970s, we made a strategic decision to emphasize DRAMs, putting most of our focus there," explains Timothy B. Smith, Semiconductor Group senior vice president in Houston. "That caused our position [in EPROMs] to wane a bit. Our business level never went down from the high 1977-78 levels. Others just grew more than we did."

TI quietly began its CMOS EPROM activity several years ago in an attempt to launch a second process driver. DRAMs will continue to be TI's main process-development driver, but EPROMs are to push capabilities for fine-line geometry in the high-voltage process, as well as those for field programmability through floating-gate transistors.

DRAMs and, most recently, EPROMs have suffered severe price erosion in the current downturn. The 1,000-piece price of 256-K EPROMs has tumbled 40% since January, to well below $5 each, and many U.S. producers are charging Japanese competitors with dumping in U.S. markets. The stormy business climate has caused market analysts to question commodity memory-development strategies. But TI maintains that DRAMs and EPROMs are a must to remain competitive in advanced ICs.

"The commodity products are the price tag you pay to have the technology," Smith says. "And the differentiating

X-CELL SPELLS TROUBLE, SAYS INTEL

Texas Instruments Inc. has chosen the controversial X-shaped cell layout to build its new erasable programmable read-only memories. The layout wraps the gate of the storage cells around the contacts and reduces the size of the array by about 15%. But several active EPROM producers have explored X-shaped array layouts, and to date, none has been highly successful, says William Spaw, design manager for EPROMs at Intel Corp. in Folsom, Calif.

The "design trick buys a smaller array but adds to the complexity of decoding addresses," says Spaw. The X-cells are connected to a virtual ground, which, along with the column-bit line, must be selected. Conventional EPROM cells have a shared common ground, and only the column must be decoded.

Spaw declines to detail what he believes is a widely unidentified problem with X-cell EPROMs. Not wanting to tip off the competition, he says only that Intel stumbled across the trouble while working on X-cells in a 64-K EPROM testbed four years ago. "It results in certain pattern sensitivities that are difficult to overcome during read and mostly programming of EPROMs," he says. Intel, which introduced a CMOS 256-K part in April and a 512-K n-MOS EPROM last December, has chosen to concentrate strictly on processing advancements to reduce die sizes.

—J. R. L.

products are where you should make money. What we have done is put in place the vehicle for a broader range of noncommodity chips," he says, responding to concerns that TI's EPROM introduction is an entry into yet another turbulent market. Benefits from the EPROM work will likely first show up on a new CMOS 8-bit microcontroller under development. TI also hopes to use the technology to produce CMOS field-programmable logic, new electrically erasable PROMs, low-power linear products, and "smart" power ICs.

Like competing high-density EPROMs already on the market, TI's chips use a programming algorithm that speeds up the writing of software into the 256-K nonvolatile memories from as much as 6 minutes to a typical 182 seconds. Read-access time is 170 ns. From the same HVCMOS technology, the company plans to soon add 64-K and 512-K chips to the EPROM product line, offering access speeds comparable to the market standards. However, TI is working on an advanced version of HVCMOS that could result in faster, less power-hungry EPROMs, using silicides to lower interconnect resistance. *–J. Robert Lineback*

BUSINESS

IS THE THIRD QUARTER THE LOW MARK FOR ICs?

NEW YORK

As semiconductor executives scratch their heads and scan the entrails of chickens in attempts to augur the future of their industry, they agree on one thing: business in the just-ended third quarter probably hit the low point in the current recession.

An upturn in semiconductor shipments is not imminent, despite the indefatigable optimism of industry trade associations (see p. 11). Most executives and industry watchers still speak of low inventory levels at customer sites as a reason why business should improve soon, as if to indicate that things can't stay bad forever. But nothing is being taken for granted.

"Until we experience a sustained improvement in booking rates, business will continue to be very difficult," says Gary Arnold, vice president of finance for National Semiconductor Corp., Santa Clara, Calif. Semiconductor executives will probably be very happy when the third quarter is behind them, says Jack Beedle, president of In-Stat Inc., a market-research company in Scottsdale, Ariz. He says the industry will register worse losses for the quarter than in any other three-month period in history.

Echoing these feelings, Michael Stark, an analyst with investment bankers Robertson, Colman & Stephens in San Francisco, notes that "no large semiconductor company will have operating profits from their semiconductor operations" in the third quarter.

Earlier this month, for example, National Semiconductor disclosed that it had already lost $44.3 million in the first quarter (excluding the results of its National Advanced Systems unit), though sales for the first half of the period were only $175.7 million. Some industry analysts think National could lose as much as $50 million to $60 million in the third quarter.

And Advanced Micro Devices Inc., Sunnyvale, Calif., had operating losses of $14.5 million for the quarter ended last June, though it showed a profit for the quarter of $700,000 because of a tax credit. This quarter, "our losses will be larger," a spokesman says.

In-Stat predicts third-quarter U.S. and worldwide chip sales will drop between 8% and 9%. The industry has now had five consecutive quarters of business declines, but it will likely see an end to the fall in the fourth quarter, for which In-Stat forecasts a slight 3% to 4% dollar-volume rise due to traditional scrambles to clear out vendor backlogs.

"We'd like to think there will be an upturn in the first quarter," says John Stratford, merchandising manager of NCR Corp.'s Microelectronics Division in Dayton, Ohio. "But we have seen very little evidence that it's going to happen.

"My own personal belief is that we'll see some small upturn in the first quarter and that the remainder of 1986 should see some quarter-by-quarter growth. But it's going to be a pretty slow year in 1986, I think. If anything, it will only be a few percentage points over the previous year."

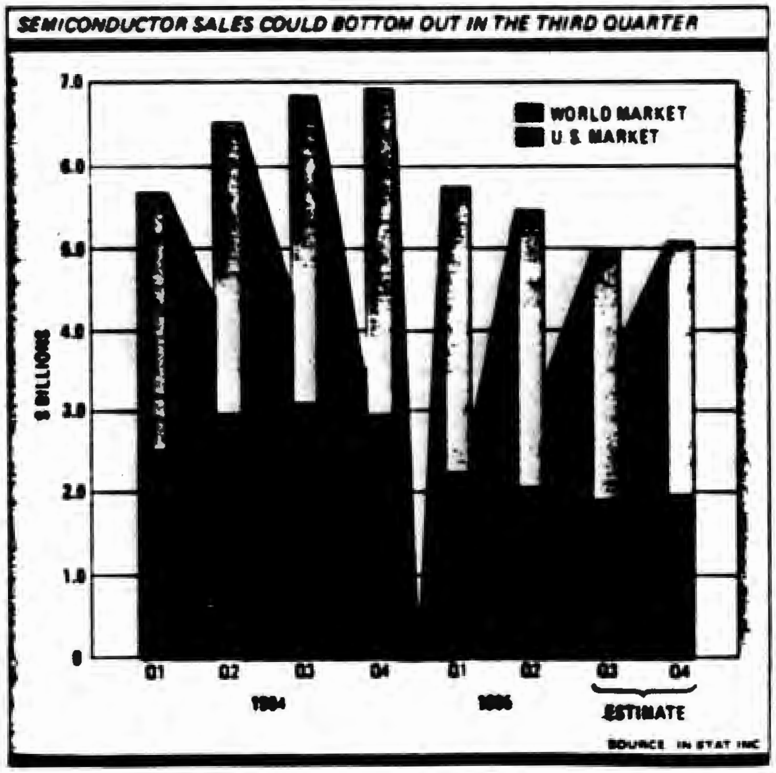
TRICKLE OF ORDERS. There is some evidence that orders are starting to trickle in, according to James L. Barlage, an analyst at Smith Barney Harris Upham & Co., New York. "The small- and mid-size users, the ones who couldn't build inventory up as high as the larger customers, are back in the market placing very small, short-term types of orders." Some larger companies also are starting to place small orders, he adds.

But Barlage sees a repeat of 1982's first quarter, when a large influx of orders following the 1980-82 recession falsely indicated an industrywide boom. "There will be an aborted recovery in the first quarter of 1986. Orders will build up and then tail off [because] the economy won't come through strong enough" to sustain a chip-business upturn, he says.

Order rates for the industry have stopped plunging, and shipments by distributors—who generally feel business trends five to six months before manufacturers—have risen slightly, notes Charles M. Clough, president of Wyle Laboratories' Electronics Marketing Group in Irvine, Calif.

One reason for losses by semiconductor companies is too much capacity, says industry consultant Matt Crugnale of Crugnale & Associates, Mountain View, Calif. "Somewhere along the line, the volume

SEMICONDUCTOR SALES COULD BOTTOM OUT IN THE THIRD QUARTER



SOURCE: IN-STAT INC.

OVERVIEW PAPER -- SEMICONDUCTORS

The Product

Semiconductors are so named because their electrical characteristics fall between those of insulators and conductors. This allows them selectively to store, generate, or process electricity as signals--that is, to handle information.

Silicon is the main semiconductor material in use today. It is formed into thin, circular wafers, each of which is divided into a checkerboard of roughly 100 rectangular "chips". On each chip is etched a tiny pattern of circuitry that determines the function and performance of the eventual semiconductor device. Once this processing is complete, the wafer is tested and sliced into its individual chips. The good chips are then packaged in plastic and bonded to metal wires that will plug the semiconductor into the larger electronic system (see "Applications" below).

Its Manufacture

Semiconductor production is a highly sophisticated process. The lines of circuitry printed on each chip are as little as one micron (1/1000 of a millimeter) wide. An individual chip, roughly 10 millimeters on a side, can feature as many as 100,000 "gates" of circuit functions.

The manufacture of such precise structures requires technology ranging from an ultra-clean environment (since the smallest dust particle can incapacitate a circuit) to the highest-resolution optical equipment (to transmit complex designs from the "drawing board" onto the chip, error-free). Because of these extreme demands, a modern semiconductor fabrication plant can cost $200 million.

Semiconductor Applications

Semiconductors are used in a fast-growing variety of electronic equipment, whose eventual applications make semiconductors important to both the service and manufacturing sectors of the economy. They made possible the computer; they are at the heart of telecommunications hardware and consumer electronic items (calculators, VCRs). They are the solid-state, microelectronics revolution that has so improved the performance of these products, miniaturized them, and reduced their cost.

But semiconductors now pervade our entire economy. In heavy industry, they enable robots to weld automobiles, which in turn double their semiconductor content (for purposes of engine control, braking, passenger comfort/security) each year. They provide precise control of oxygen flows and temperature conditions for steel plants. In services, the banking and insurance industries depend completely upon semiconductors' ability to process data in great volume and at incredible speed.

Semiconductor Types

The simplest of semiconductors are called "discretes" because each chip incorporates only a single electrical junction and therefore can perform only one function. For example, a light-emitting diode--a discrete device used in electronic displays--can only be on or off, and its "choice" is determined by the incoming electrical signal. (But that apparent ability to "choose" indicates that it is a semiconductor.)

Another type of discrete semiconductor is the transistor, whose invention in 1948 by William Shockley of Bell Labs launched the electronics age. Eleven years later, engineers succeeded in placing several transistors onto a single chip--the first integrated circuit (IC)--which could thereby perform more complex tasks. Today, ICs dominate the semiconductor world, and progress in microelectronics is generally tied to this very exercise, packing more and more transistors onto a single chip without sacrificing speed or consuming more electricity. Here begins the miniaturization that we eventually see in more compact and powerful electronic products.

There are two basic roles that an integrated circuit can play--memory or logic. Memory devices simply store information (electronic signals) and return it on demand. Their primary features are their capacity and their response time. The 256K DRAM is a memory device that can store some 256,000 "bits" of data; most of these chips require less than 250 billionths of a second to access a stored cell. Although their design is less sophisticated, they incorporate the finest geometries, making them difficult to produce. They are standard, high-volume products, and the lessons learned from their manufacture improve a firm's production capabilities across a much broader range of devices.

Logic chips, on the other hand, actually process data. Included in the this family are the "brains" of electronic systems, the microprocessor. The performance of logic chips is measured in terms of their speed per step and the amount of information (e.g., 16-bit) that they can handle at once. Their layout can be far more complex, but leading-edge products are consumed in much smaller volumes that for memories.

The US Semiconductor Industry

Historically, the US semiconductor industry has been the world's leader. Only five years ago, US manufacturers supplied some 65 percent of the world semiconductor market. Since then, they have lost roughly 10 points of market share to their Japanese competitors.

And 1985 has now brought the worst market conditions in over a decade--Japanese dumping, restricted access to their market, and a slump in computer demand will combine to drive US output down this year by 18-20 percent. This squeeze has hit independent American firms hardest because of the longer-term need to continue devoting tremendous resources to R&D and plant modernization. Despite the grim semiconductor business environment, chip-makers will spend over 10% of sales on R&D and another 25% of sales on plant and equipment in 1985.

Key Market Features

The long-term trend for semiconductor prices is down. This results from rapid technological progress in the lab and on the production line. Product lifetimes can be as short as 3 1/2 years. Over the last decade, the average cost per function dropped 17% annually. But in 1985, the final figure will fall between 35 and 40 percent.

This year's unusually steep decline was driven by some striking developments at the product level. The largest single market segment, random access memories (RAMs), was valued in 1984 at nearly $6 billion. In 1985, another explosive increase in Japanese production capacity, stimulated by industrial targeting efforts, helped to drive prices of leading edge 64K and 256K dynamic RAMs down by over 80 percent.

But a presence in the memory market is critical for the US industry despite difficult competitive circumstances. Because companies manufacture here in greatest volume, this is where they can best advance their production and engineering skills. These capabilities are then transferred to other product segments, bringing greater efficiency to their manufacture as well. For this reason, memories are considered "technology drivers", fundamental to one's overall competitiveness in semiconductors.

Nevertheless, the collapse of memory prices has induced most American companies to withdraw from the mainstream RAM market. Four firms dropped out with the previous (64K) generation. Only Texas Instruments, Micron Technology, and Motorola are likely to produce standard 256K DRAMs. AT&T manufactures primarily for internal use and has had difficulty marketing its device in the open market. IBM is strictly an in-house supplier, and even then it sources some 40% of its requirements from outside suppliers. They will now try to hold their ground in the other large memory field, electrically programmable read-only memories (EPROMs).

International Competition
For the US industry, semiconductor competition can be summed up in one word--Japan. The European market is significant, but features no domestic manufacturers of consequence. Japanese firms now supply 60 percent of world demand for the 64K DRAM and control 90% of the market for the latest device in this targeted product area. If current Japanese overinvestment and dumping practices continue, they will also dominate the coming 1-Megabit market.

As noted above, US exclusion from this market has serious implications for American companies' ability to compete in other areas. At the same time, the Japanese have begun to branch out from this base in commodity memory to attack more specialized memory products as well the logic field, two remaining areas of US leadership. Recent Hitachi dumping of EPROMs indicates that they will consider this practice in their drive for market share in other segments as well.

The Japanese Strategy
The Japanese challenge in semiconductors was shaped by a concerted program of industrial targeting, aimed at a dominant world market position and similar to that used in shipbuilding and steel. This policy structure, and the economic/financial environment it fostered, encouraged the six major electronics firms in Japan to pursue semiconductor development aggressively. These companies, as integrated producers of end-use equipment as well as their semiconductor components, enjoyed the buffering effect of steady internal demand, face no competition from independent Japanese companies, and feel minimal domestic interference from the US industry. Their initial concentration on core products and technologies will now spread to include a broader range of devices.

The Unfair Trade Practices--A History
The Japanese semiconductor program began in 1958 with passage of legislation that directed MITI to develop and implement a comprehensive promotion scheme. This includes plans for creating an industry, providing financial support, suspending antitrust regulations, and coordinating R&D activity. For the next fifteen years, the Japanese market was formally protected by prohibitive quotas, tariffs, and foreign investment controls. Only Texas Instruments, in settlement of a Japanese violation of its semiconductor patents, was able to establish production in Japan, and even this occurred subject to MITI monitoring that limited their market share to 10 percent.

In 1974, the first market-opening measures were immediately neutralized by a "counter-liberalization" program, which included buy-Japanese provisions along with the continuation of subsidized research and inter-firm cooperation. By the late 1970s, more formal barriers had been lifted, but the legislation enabling government promotion was renewed and a landmark industry-wide R&D effort (the VLSI project) was launched with guidance and financing from MITI. This commercial project centered on dynamic-RAMs, now the competitive stronghold of the

Japanese semiconductor industry. Typically, this product-specific focus, supported by the safety-net of protective legislation for depressed sectors, encourages overinvestment, overcapacity, and ultimately, dumping.

Meanwhile, despite the ostensible openness of the Japanese market, US chips retained only a 10-15% share, frustrated by the vertically integrated and horizontally coordinated Japanese electronics establishment.

In the early 1980s, negotiations began, aimed at improving US participation in the Japanese chip market. The inability of US firms to compete with emerging Japanese rivals on the latter's home turf clearly weakened their overall strategic position. But even Cabinet-level agreements to pry open opportunities in Japan and refrain from illegal pricing practices had no apparent results.

Old problems intensified while new problems came to the fore. As the Japanese pushed to export in greater volumes, dumping became a more problematic aspect of their relentless drive for market share in targeted product lines. Also, with more production experience behind them, the Japanese focused increasingly on upgrading their technological base. NTT continued to circulate its advances selectively to Japanese manufacturers. MITI organized new commercial research programs for semiconductor advancement--opto electronics, new materials, and microelectronics work for its 5th generation and supercomputer projects. And unauthorized Japanese duplication of semiconductor designs and processes, a problem early on for the inventors of the integrated circuit (Texas Instruments), boiled again to the surface for American developers of the microprocessor as the Japanese industry sought to diversify into new product areas.

The Current Situation

Today, semiconductor trade frictions continue in both new and traditional forms. Negotiations continue (MOSS talks), yet the US share of the Japanese semiconductor market has fallen again to 10%, giving no indication that foreign access has improved. The Semiconductor Industry Association filed a 301 case directed at this problem; USTR plans a recommendation to the President in December. US firms have filed two dumping cases, both against Japanese memory producers. The Justice Department also began its own predatory pricing investigation of a Japanese semiconductor firm; a separate, private case was filed shortly thereafter.

The Implications for the United States

The fate of the US semiconductor industry will have far-reaching ramifications. It will directly determine our competitiveness across most high-tech industries, since semiconductors are their foundation. It will profoundly affect the capabilities of traditional manufacturers that have relied on electronics and automation to modernize facilities and maintain their business position. It will influence the cost effectiveness of our information-based service sector, from financial institutions to retailing. In addition, the entrepreneurship that has always characterized a healthy semiconductor industry attracts and cultivates a wealth of technical talent here in the United States, ensuring our position as a global technological leader.

Semiconductor-based electronics contribute directly to our economic efficiency and productivity as a nation. The growth, profitability, and employment that ensue are critical to our long-term economic well-being.

THE UNITED STATES
TRADE REPRESENTATIVE
WASHINGTON

November 15, 1985

To: Michael Driggs

From: Jim Gradoville

Although you were unable to attend the Texas Instruments briefing on semiconductors, you may be interested in reading the attached report.

Attachment

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