

A Fierce New Era of World Competition

Robert N. Noyce

It's a pleasure to be here and an honor to speak at the Plenary Session of the MRS Fall Meeting. I'm delighted to have the chance to discuss some issues that I believe are of deep concern to all of us engaged in technical or scientific endeavors. I'd like to start by giving you a brief update on Sematech. Then, I want to try to explain why I believe Sematech is important—and why you should think so as well.

Establishment of Sematech

I'm sure most of you recall, back in 1984, when Japanese firms began selling semiconductors in this country at less than cost. In fact, the price of some chips fell as much as 80% in a one-year span. That exercise cost U.S. semiconductor companies \$2 billion. It cost Japanese industry \$4 billion. When it was done, many U.S. manufacturers had abandoned the business—and Japan is now the world's leading supplier of semiconductors. It's worth pointing out that U.S. companies gave up the fight even though they had suffered losses only half as large as those in Japan.

About the same time, the Defense Science Board formed a task force to assess the U.S. military's growing dependence on advanced electronics. Given what had just happened to the U.S. semiconductor industry, the armed forces were looking at the unsettling prospect of being dependent on overseas suppliers for critical elements of their weapons systems. These developments were brought to the attention of the U.S. Congress in February 1987 when the task force outlined the issues and suggested some solutions.

The result was Sematech... a cooperative effort between the U.S. Defense Department and 14 members of the U.S. semiconductor industry. It was founded in 1987, charged with helping to restore American leadership in semiconductor manufacturing.

And just since then, the task has become more difficult. There has been rapid and steady erosion among American suppliers of equipment and materials used in making semiconductors. If this vital infrastructure fails, Sematech will fail. So we are

moving forward as rapidly as possible.

We occupied our site in Austin, Texas 19 months ago and immediately started work on a world-class clean room facility, where we will develop the tools and techniques to meet our goals. We built that clean room in just 32 weeks...and less than four months later—using American-made equipment and American processes—we finished our first memory chip, from raw silicon to finished wafer. That gave us the baseline we need to be about our business.

Sematech does not
produce computer chips
for sale—we produce
knowledge, which we
share with our mem-
bers, who put it to work.

Define, Develop, Demonstrate, Transfer

The method we use for managing our projects can be summarized in four words: define, develop, demonstrate, and transfer.

We have now defined our technical goals. We must be able to produce chips with 0.50 micron circuit widths by 1991...and 0.35 microns by 1993...if we are to reach parity with overseas competitors.

The development process is under way now. We are working to develop the materials, tools and techniques the industry will need to reach those defined goals.

The third step is demonstrating that those materials, tools and techniques make up a robust tool set that will give us efficient, high-volume manufacturing capability.

Just being able to do something is not enough—we must be able to do it efficiently and often if we are to be competitive.

The critical final step is transferring the knowledge we have gained to our member companies and the Defense Department.

Sematech does not produce computer chips for sale—we produce knowledge, which we share with our members, who put it to work.

There currently are 57 individual projects under way. Eighteen are in the planning and program definition stage, 25 in development, 14 in demonstration, and so far, we have conducted 41 seminars and workshops and two transfer sessions to share knowledge with our members. These confidential sessions have been well received by our member companies and the U.S. government.

Show-Stoppers, Key Enablers, and High-Risk, High-Return Projects

Since Sematech is time-driven, not profit-driven, we are focusing our resources on three basic areas that are best handled by a cooperative effort such as ours. We call them "show-stoppers," "key enablers," and "high-risk, high-return projects."

Show stoppers are tools, materials and processes critical for world-class competition, but also areas in which the United States has lost or is about to lose access or leadership.

Key enablers are the tools and methods that will produce the largest competitive gains in the shortest amount of time.

And high-risk, high-return projects, by definition, are better done by a consortium than a single company, simply because the risk involved might represent unacceptable exposure for individual companies.

We consider strategic materials to be show-stoppers. This country has lost a number of domestic materials suppliers, and we are exploring ways to re-establish production of these materials. Some examples are silicon wafers, sputtering targets, mask blanks and plastic molding compounds. I'll address in more detail this industry's materials situation shortly.

In addition to our internal projects, we have signed 11 joint development or equipment improvement contracts involving cooperative efforts between Sematech and 13 suppliers. By the end of 1989, we will have committed about \$106 million to joint development contracts and outright equipment purchases. For 1990, that spending will likely increase to about \$130 million.

We have also founded 10 centers of excellence to support manufacturing research at a number of leading universities and national laboratories. We have engaged Sandia National Laboratories to establish a national tool design center. We expect to complete another contract—with the national lab at Oak Ridge—within a few months.

Competition in the Semiconductor Market

So you can see that we have made a lot of progress in a short time. However, we have several significant technical challenges ahead and not a lot of time to meet them. In fact, some people think we've bitten off more than we can chew, and they may be right. On the other hand, I remind myself of the newspaper man who once wrote about the Kennedys: "They bite off more than they can chew, and then they chew it." We hope to make those words apply to Sematech.

But the challenge is formidable. As I mentioned earlier, the United States has surrendered its global leadership in semiconductors. In 1984, America's global market share in semiconductors was nearly 60%; today it's 39% and falling.

The United States has also lost worldwide leadership in resist processing and stepping aligners. Japanese industry passed the United States in both categories two years ago, and the U.S. lead in testing equipment is eroding steadily. In addition, the U.S. domestic semiconductor industry has become alarmingly dependent on suppliers abroad for many critical materials. The table shows the result of some research we did at Sematech regarding selected critical materials. We found that in these key categories, at least 78% of the supply is imported. The best the U.S. can do is a 22% share in molding compounds.

And in almost every category, the trend is toward continued deterioration. By the way, this table reflects the recent sale into non-U.S. hands of the last major domestic supplier of high quality silicon...our basic raw material...giving the U.S. a market share in silicon wafers of just 3%. So the current situation is troubling and the future holds little prospect of improvement.

Even more worrisome is the result of a survey we recently conducted among our own members concerning their plans for purchasing manufacturing equipment, both now and in the future. At 1.5 micron circuit widths, the least advanced level of technology in wide use today, the 14 member companies of Sematech say 80% of their capital equipment dollars are being spent in this country. At one micron, their spending on domestic equipment falls to 60%. And at submicron levels—the technology of the future—Sematech members plan to spend less than 40% of their capital equipment funds on U.S.-made products.

The Product of National Goods

But the technical challenge we face is only part of a larger issue. Let me share with you a quote from an interesting new

book. It has not been published here but it's a best-seller in Japan. The book is called *The Japan That Can Say No*. It was written by Shintaro Ishihara, a former candidate for Japan's Prime Minister, and Akio Morita, chairman of Sony.

In one chapter, Ishihara proposes that the world is rapidly becoming dependent on Japan for the vast majority of high-quality semiconductors. Then he writes, "Should Japan decide to sell its chips to the Soviet Union instead of the U.S., that would instantly alter the balance of military power."

Where is U.S. industry going to get the flexible, well-prepared workers it will need to keep pace with its global competitors?

A sobering thought. Ishihara's implication illustrates why we at Sematech feel our public mission is of national importance. Public opinion polls consistently find that Americans today are more worried about the economic threat from Asian competitors than the military threat from the Soviet Union, by as much as a 3-to-1 margin. At the same time, the United States is the only developed country in the world where the national standard of living is declining.

Why has this occurred? Are Americans no longer smart enough or energetic enough to control their own destiny? I don't think so. I believe we have reached this situation largely because of firm, clear national goals that were outlined four decades ago. During the past 40 years, the United States and Japan have engaged in single-minded pursuit of their respective global missions. I believe America's has been the defeat of world communism...Japan's has been to become the world's leading economic power.

Both countries have succeeded. Marxist-Leninism is now being repudiated across the world, thanks, I think, largely to U.S. policies. On that battlefield, the United States has won. On the other battlefield, Japan continues to win. Japan now dominates world markets in many vital technologies, including a number that are critical to the semiconductor industry. And Japan's model is being adopted by many other Asian nations—because it works.

Accepting the Responsibility

In light of that, and the Ishihara quote, I think the question we must answer is clear and simple: Are we willing to see competitors abroad control U.S. access to vital resources? If the answer is no, it is clear what the United States as a nation must do. We must address a pitiful national savings rate that is choking our economy. Over the past eight years, American savings have averaged about 5.5% of gross national product—lower than in any developed country in the world. The result is scarce, expensive investment capital.

Last year, of the 138 U.S. equipment and material suppliers who work with Sematech, 20% had to get their growth funding overseas. U.S. financial institutions would not lend them the money and invest in their future.

The U.S. educational system also must be repaired. On standard achievement tests, American students consistently rank at the bottom among developed countries. In 12th-grade algebra, for example, the only country that scored worse than the United States was Thailand.

Other results are just as bleak. In the teaching of 12th-grade biology, Singapore now ranks first in the world. The United States is dead last.

In Canada and Norway, 25% of 18-year-olds have taken two years of physics and two years of chemistry. In the United States, that number is 1%. And today's Japanese high school graduates have taken more math than the average U.S. college graduate.

With a foundation like this, where is U.S. industry going to get the flexible, well-prepared workers it will need to keep pace with its global competitors?

Critical Materials List		
U.S. Global Market Share (1988)		
Materials	Share	Trend
Molding compounds	22%	↔
Multilayer packages	16%	↓
TAB tape	15%	↓
Mask blanks (U.S. share only)	9%	↑
Bonding wire	5%	↓
Lead frames	5%	↓
Ceramic packages	4%	↓
Sputter targets	4%*	↓
Ceramic substrates	3%	↓
Silicon wafers	3%*	↓
*Reflects 1989 acquisitions		
Sources: VLSI Research, Inc., DataQuest		

A New Dimension

in Light Microscopy



Zeiss Axiovert

A new range of inverted microscopes is now available from Carl Zeiss, featuring a new geometry and newly computed optics.

One impressive example: the Axiovert 405 M which meets the most critical demands on materials testing in industry laboratories.

New ICS optics with markedly improved performance guarantee bright, perfect images.

Ergonomic SI design: easy integration of all attachments. No difficult conversions required, no reduction in performance. The Axiovert series of inverted microscopes and the Axioskop, Axioplan, Axiophot and Axiotron pyramids from Carl Zeiss open up promising possibilities for the future.

For more information call: 1-800-233-2343, or write to Carl Zeiss, Inc., One Zeiss Drive, Thornwood, NY 10594.



Carl Zeiss

= Quality + Customer Care

ST 35 steel,
perlitic, ferritic structure
Axiovert 405 M,
Epiplan-Neofluar 50x/0.75 HD-DIC

A completely ineffective trade policy must be re-examined. "Trade" means exchanging products. That definition does not apply to what Americans are doing today. Thanks to a voracious appetite for consumer goods, Americans are making a devil's bargain, selling off accumulated wealth for consumables.

In 1988 alone, Japanese interests bought a \$13 billion stake in various U.S. companies and more than \$16 billion worth of American real estate. And that makes Japan only the second-largest overseas owner of U.S. assets.

When investors from abroad have acquired all the bank buildings, record companies and television studios they want, what will they buy next? To put it another way, if the United States continues to import billions of dollars worth of cars, cameras, VCRs and TV sets, how will they be paid for?

Obviously, I don't say for a moment that anyone has the right to tell any country how to conduct its business. But one does have the right to stop buying imported products until reciprocal purchases of one's own goods occur. For example, U.S. semiconductor sales in Japan have not varied more than five percentage points in the past decade and have declined as often as they have improved. At the same time, Japan's market share in this country has grown almost tenfold.

We fully intend to succeed at Sematech. But when that happens, it would be a shame if as a nation, the United States is so capital-poor, so educationally unprepared, and so deep in overseas debt that Sematech's effort would count for nothing.

A recent Texas newspaper article called me a "Japan-basher." This is not correct. I admire the way Japan has rebuilt its economy. I'm an "America-basher." I don't think Americans have given enough serious thought to what must be done.

One significant element in this discussion is the accusation that America is its own worst enemy. Some highly respected

people claim American management can be faulted for America's economic decline. There may be some truth in that accusation. I can't speak to the advanced materials research many of you engage in, but I

We fully intend to succeed at Sematech...it would be a shame if as a nation, the U.S. is so capital-poor, so educationally unprepared, and so deep in overseas debt that Sematech's effort would count for nothing.

can speak as a customer of the materials industry. What I see—not just in the materials industry but throughout American manufacturing—is a refusal to own a problem. We're busy pointing fingers. Engineers point at the designers...designers point at the CEO...CEOs point at Wall Street...Wall Street points at Congress...and the dodging goes on. Nobody owns the problem. And if you don't own the problem, you aren't looking for the solution.

Action Required Now

The technical challenges we have to solve become more complex by the day, and if we don't respond, we won't win. In the 1960s, it took 30 separate steps to turn a silicon wafer into a transistor. Today, it's closer to 500 steps. Soon, 1,000 unique processes will be required, just to produce one finished product.

What can you do? Start demanding more of yourself. If you're given a task with a 1%

margin of error, don't assume that 1% is good enough. If each of those 1,000 steps I mentioned meets a tolerance of 1%, there's a very good chance the end result is going to be worthless.

There's no such thing as an "acceptable" quality level. The only level of quality we should "accept" is perfection.

Without a commitment to quality output and quality processes...owning and solving problems...it will be very difficult keeping pace with this fierce new era of world competition.

But there's another side to this argument. My own view is that the best U.S. companies are at least as well-managed as any companies in the world, yet they continue to lose market share. That says to me that forces other than management skill are determining success in global competition.

Author Fred Warshofsky postulates the United States is now in a state of economic war. In fact, his book is called *The Chip War* and it contains this assertion: "What is at stake in the chip war is more than the possible loss of yet another industry to the Japanese. The very future of America as a great nation may be the ultimate prize."

If we agree that this is an economic war—and I do—then the United States should remember the words of General Douglas MacArthur, "It is fatal to enter *any* war without the will to win it."

My message is simple—the battle has been joined, and the United States is not winning.

Robert N. Noyce, a pioneer in the electronics industry, is president and CEO of Sematech and vice chairman of Intel Corporation. He presented this address at the Plenary Session of the MRS Fall Meeting, Boston, November 27, 1989.

Editor's Note: For more information on the status of technology development in Japan, see "Aerospace Industry is Major Focus at Composites Research in Japan" elsewhere in this issue. □

Do You Have An Opinion?

The MRS BULLETIN wants your comments and views on issues affecting materials research.

Send your comments to: Editor, MRS BULLETIN
9800 McKnight Road
Pittsburgh, PA 15237
Telephone (412) 367-3036
Fax (412) 367-4373