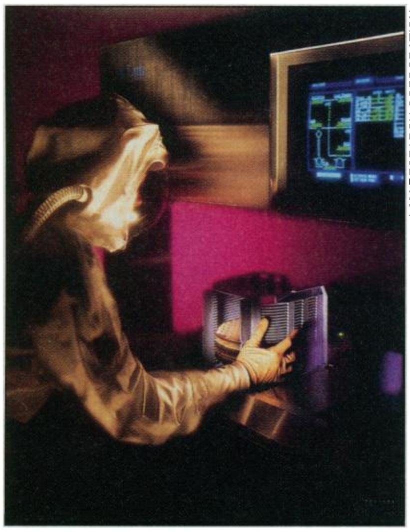
JOB MARKET

Semiconductors Open a New Niche for Plasma Researchers

LOUISVILLE, KENTUCKY—"Hitch your wagon to a star," Ralph Waldo Emerson counseled. For decades, plasma physicists followed that advice almost literally: Most of them hitched their careers to the Department of Energy's thermonuclear fusion program, whose goal is to produce energy in the same way the sun and other stars do. But after Congress slashed the fusion program by a third this year, thousands of plasma physicists whose jobs are in jeopardy or have been eliminated are wondering how to get their careers back on track. The answer, according to some physicists and engineers at a meeting of the American Physical Society's (APS's) division of plasma physics held here 2 weeks ago, could lie in a field whose star never seems to stop rising: the computer industry.

What drives the industry, after all, is the creation of computer chips with ever finer features. And semiconductor-makers are counting on improvements in a technique called plasma processing, in which a partially ionized gas is used to initiate the chemical etching reactions, to drive that progress. Such research, says Rebecca Gale, a manager in semiconductor R&D at Texas Instruments (TI), will be "extremely key" over the next decade. As a result, thousands of new technical and research jobs are likely to open in this area, says Earl Scime of West Virginia University, who helped organize career-placement services at the Louisville meeting.



LAM RESEARCH CORPORATION

Plasma goes to work. Semiconductor etching may open jobs for physicists.

Those who make the migration from research to industry won't find that their physics skills are wasted. "I've been able to find very good physics inside of this topic, which has generally been considered 'dirty,' " says Francis F. Chen, a plasma physicist at the University of California, Los Angeles. "You can apply all the fancy stuff we learned in fusion and space physics." And, as technical presentations at the meeting showed, the demand for "fancy stuff" is bound to increase as semiconductor features get even smaller.

Plasma processing began putting its mark on the computer industry by the early 1980s. Before then, says David Ruzic, a fusion and plasma-processing researcher at the University of Illinois, Urbana-Champaign, most integrated circuits were etched by fixing masks over the wafers and exposing them to wet acids. Not only was the method time consuming, but the acid also tended to undercut the masks, etching sideways as well as straight down and resulting in broad, shallow features.

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—Francis F. Chen

Plasma-based etch tools, or reactors, cut much straighter, finer features on many chips at once by exposing masked semiconductor wafers to a partially ionized gas that includes a reactive component, such as fluorine. Attracted by an electric charge on the wafer, the plasma ions rain down, tearing apart atomic bonds and pumping energy into the crystal lattice. That opens the way for the fluorine to react with the silicon and form silicon fluoride gas, which diffuses away. Because the charge draws the ions nearly straight downward, they cut much straighter trench walls than wet etching does. The result: chips that are more tightly packed with memory and logic circuits and are cheaper as well. "Plasmas, I feel, were responsible for ushering in the personal-computer revolution," says Ruzic.

But there is room for improvement. Collisions with neutral atoms can deflect the plasma ions while they are being accelerated, giving them a sideways kick that tends to widen the trenches. To minimize such effects, the most recent etch tools—designed to dig deep features just a fraction of a micrometer across—use gas at a lower pressure and ionize as much of it as is practicable. And that makes plasma physics even more important for controlling and refining the etching process. Under these conditions, says Noah Hershkowitz at the University of Wisconsin, "the physics overwhelms the chemistry."

That was the theme of results Hershkowitz presented in Louisville. The Wisconsin team studied etch rates in several kinds of industrial reactors, each of which pumps energy into the plasma by a different means—everything from low-frequency electric fields to microwaves. By measuring the ion energies and densities and monitoring the etch rate with laser interferometers, the team found ample evidence that in every case, the plasma was setting the tempo of the process. As long as enough fluorine was present to carry on the reactions, the etch rate depended only on the ions' energy and flux at the wafer.

So far, only a trickle of fusion researchers have migrated to the semiconductor industry to do such crossover science. But the field could be primed for a much bigger shift, says Barrett Ripin of APS, who helped organize a "Mid-Career Change Forum" at the Louisville conference. The forum, meant to help fusion and academic researchers assess the demand for their skills and experience on the open market, struck a "big resonance," he says. And the opportunity is waiting: Roughly 20 semiconductor fabs, or factories, should be opening each year over the next 5 years, says G. Dan Hutcheson, president of San Jose–based VLSI Research Inc., which follows the industry. Each fab, says Hutcheson, will create about 1500 jobs, of which 30% to 40% will be technical and a smaller fraction will focus on R&D.

Fusion researchers who seek these jobs shouldn't expect an effortless transition, says TI's Gale. "It depends on how willing [these researchers] are to do something much more applied," she says. "There's a lot of pressure because of the fact that you're in manufacturing." Agrees Chung Chan, a researcher at Northeastern University in Boston who has spun off his own plasma-processing company, called Waban Technology Inc.: "In the research world, all you wanted to do was get the best technology. In the business world, it's the best product and profit margin."

And seasoned fusion researchers applying for these jobs will face competition from young plasma physicists, who may have studied plasma processing in graduate school. Illinois's Ruzic, for example, is doing his best to prepare his students for this competition: "I make sure [even] the ones who do work in fusion have knowledge in plasma processing." With that kind of training, he hopes, his students will be equipped to stay on their feet no matter which way the funding landscape tilts in the coming years.

–James Glanz