University research gets boost from industry funds

In 1980 for the first time, industry's investment in R&D exceeded, by a narrow margin, Federal R&D funding in the US. In response to continuing changes in Federal spending patterns and their impact on the overall economy, industry is acting on many fronts to strengthen its connections with academic research. The latest wave of industry funds flowing into campus-based research in integrated circuitry and related fields is taking place in the wake of increasing competition from Japan. Frequently at the school's request, industrial investors are increasing or initiating their support of university research facilities and personnel. Similarly, in an effort to prevent future shortages of technically skilled manpower, corporations are offering fellowships, such as Exxon Education Foundation's recent commitment of $15 million for this purpose. Ongoing programs receiving industrial money are being expanded in many instances, in an attempt to compensate to some extent for reductions in Federal funding.

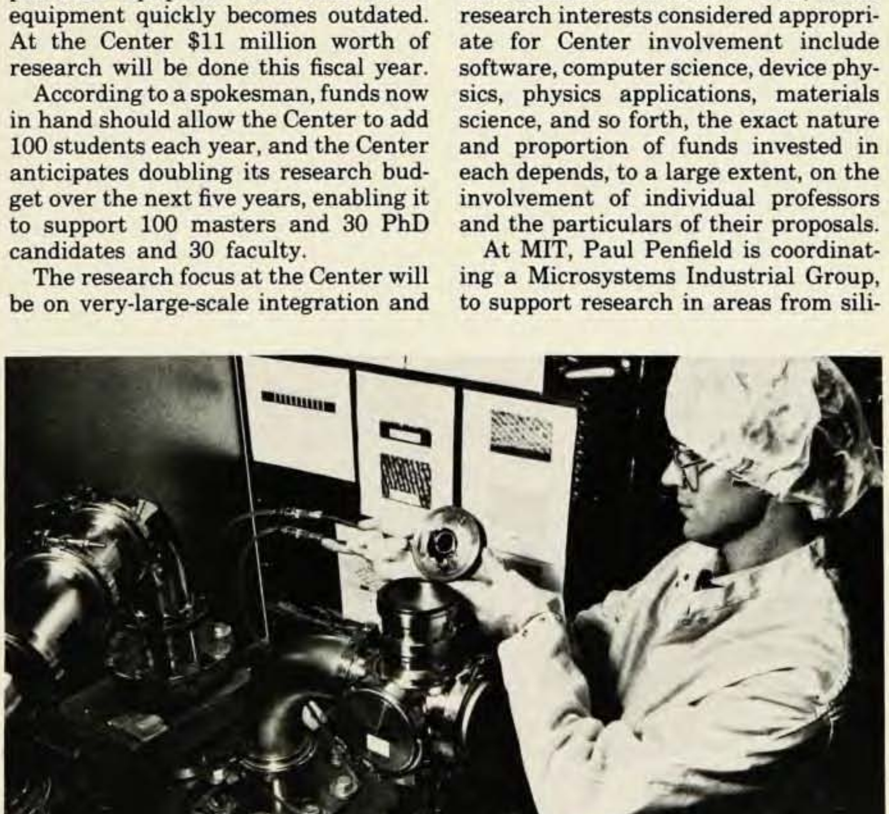
While this increasing support and interest of industry in the health of the academic research community is welcomed and actively sought by that community, there are limits to the ability of industrial funds to replace Federal money. This is particularly true for basic research support. George Pake (Vice President for Corporate Research, Xerox), speaking at the APS meeting in January, provided statistics for R&D spending: In 1980 the total US investment in R&D was $61.1 billion; of this, $8.1 billion was for basic research. In the same year, although universities performed only 10% of all US R&D, they performed 60% of all basic research. The principal supporter of university research was the Federal government, supplying 65.5%, with industry providing only 3.7%. Putting these statistics in a relevant framework for physicists, Pake said "Total university research in physics alone, $310 million for 1980, substantially exceeded the $222 million of industry funding for all fields of university research." Nonetheless industry's current commitments of substantial sums will provide and support many opportunities for physics research particularly in integrated circuitry and related areas.

Universities. This spring construction will begin on a new building to house Stanford's Center for Integrated Systems. The Center will be supported partially by a consortium that now consists of 17 industrial investors. Each member company has agreed to contribute $250 000 per year for three years. The industrial money is augmented by an $8-million grant from the Defense Advanced Research Projects Agency, half of which will be used to purchase equipment in a field where equipment quickly becomes outdated. At the Center $11 million worth of research will be done this fiscal year.

According to a spokesman, funds now in hand should allow the Center to add 100 students each year, and the Center anticipates doubling its research budget over the next five years, enabling it to support 100 masters and 30 PhD candidates and 30 faculty.

The research focus at the Center will be on very-large-scale integration and integrated circuit design. Participants will include researchers in electrical engineering, applied physics, physics, and computer sciences. Charles Williams, professor of electrical engineering at Stanford and assistant director of the Center, explained to us that while the initial participants will be primarily electrical engineers, at Stanford that includes solid-state physicists such as William Spicer, currently working on a Center-supported project. Additionally, Williams pointed out that due to the Center's organization, the faculty who make proposals and become involved in projects at the Center will ultimately decide the content of the research done there. Thus, while research interests considered appropriate for Center involvement include software, computer science, device physics, physics applications, materials science, and so forth, the exact nature and proportion of funds invested in each depends, to a large extent, on the involvement of individual professors and the particulars of their proposals.

At MIT, Paul Penfield is coordinating a Microsystems Industrial Group, to support research in areas from sili-



At the Submicron Structures Lab at MIT, the x-ray lithography station, shown above being loaded by Andrew Hawryluk (visiting from the University of Florida), is used to make structures on the order of hundreds of angstroms. An x-ray beam strikes a chip masked with a thin membrane of metal.

con systems design and architecture to computer applications. The group's original goal of $16 million to renovate a building for use as a very-large-scale integration laboratory, has been made easier by the recent decision by government auditors to allow them to spread the cost of the renovation over the university budget for the next eight years. Renovation will begin immediately. They plan to obtain the projected $8 million needed for the remainder of the construction, and $3 million needed for each year's operating and equipment replacement costs, from industry contributions. Many interested corporations have each committed $250 000 per year for from three to five years. In addition, local companies have pledged smaller amounts to provide sustaining funds for the lab. Penfield says that they are well on their way towards the $8-million figure.

The lab will not be a production facility; its primary goals will be to conduct original research in processing and fabrication and to study the interface between fabrication and design. Penfield says that computer scientists, electrical engineers and physicists will be involved. He cited his own undergraduate training in physics, that of Richard Adler (the associate director of the project) and the active involvement of Henry Smith, a PhD in physics. As an example of the type of problem considered under this program and the type of cross-pollination it could promote, Adler spoke of a current project to build an artificial retina. The goal is to make an array with information-processing circuits on the same chip as photosensors to test artificial intelligence theories; such theories give models for the way that neurons in the eye perform data reduction before the information is transmitted to the brain. Sophisticated fabrication techniques will be used to apply an opaque layer to prevent the information processors from being exposed to light and yet allow the photosensors to receive light.

In an attempt to encourage industrial support, the state of North Carolina has funded the Microelectronics Center in Research Triangle Park with $24.4 million for two years that began in July 1981. It is run by an independent not-for-profit corporation, and was established with the stated goal of enhancing the educational and research resources of the six participating institutions (Duke University, North Carolina State University, University of North Carolina-Raleigh, University of North Carolina-Chapel Hill, North Carolina A&T University-Greensboro and the Research Triangle Institute.) A new facility will be built with $10.5 million of the money, with groundbreaking to begin in May. Initial equipment for the Center will be pur-

PAKE

chased with $8.6 million, and $2.8 million will be used for operating expenses for the first two years. Of the $2.5 million alloted for program support, part is being used to support four graduate students at each of the five universities, and part has been used to pay for teaching labs in VLSI design and fabrication, to be used by physics and chemistry departments at universities.

Richard Fair, Vice President for Programs and Resources at the Center, told us that he anticipated that the initial support for universities would be primarily used for equipment purchases. The Center is beginning to seek industry money to offer further support for research projects, researchers and equipment needs. Research at the Center will focus on new design approaches with computer aids, establishing a baseline system for making integrated circuits, experimental work on new combinations of materials, new processes and studying devices. Physics departments at participating institutions will benefit both by the direct involvement of professors and graduate students, and by receiving funds to purchase their own equipment and the opportunity to share expensive equipment available through the Center. The facilities are being designed to accommodate 50–100 graduate students and an equal number of faculty working in computer science, electrical engineering, materials science, chemistry and physics. There will also be a permanent staff of approximately 50 technically trained people working on materials characterization, advanced processing development, software support for university research, different approaches to designing integrated circuits and production work in a class-100 baseline wafer fabrication area, to be set up at the Center.

The University of California, Berkeley, has various plans to improve its long-standing program in integrated circuit research. One plan calls for its facilities for very-large-scale integration research to be upgraded to have a "cleaner," class-100 status. (Class 100 means there are fewer than 100 particles bigger than 1 micron in every cubic meter of air.) Of $4.5 million needed for this work, part will come from the state ($2.3 million) and part from the Board of Regents ($500 000). The balance would be derived from a $1.7-million grant proposal now pending at NSF.

In addition, at the initiative of the governor of California, a program called Microelectronics Innovation and Computer Research Opportunities to encourage joint university–industry cooperation received $1 million from the state this year. This program was organized to stimulate investment by industry at universities in the University of California system in research related to the microelectronics and computer fields; this research is to be of a more long-term or basic nature than that normally conducted by industry. The program calls for matching funds, to be supplied by industry, for specific proposals made by academic researchers. Research projects are then reviewed by a committee with representatives from five campuses of the University of California system (Berkeley, Los Angeles, Davis, San Diego and Santa Barbara). This year 31 projects were funded, with industry supplying over $800 000 in cash, and $540 000 in brand new, state-of-the-art equipment to match state funding. Of the $1 million in state funds, $100 000 was earmarked directly for graduate-student support. George Turin, chairman of the Electrical Engineering and Computer Sciences Department and of the executive committee of MICRO, said that there were fewer proposals this year from physicists than from other reseachers. He hopes that the mix among fields becomes more diverse, for future projects. The projected FY 83 budget for California includes a recommended $2 million for this program, thus potentially representing at least $4 million, with industry's matching funds.

Another plan is to establish a Computer Aided Design/Computer Aided Manufacturing facility with industry-supplied funding. Berkeley is now actively soliciting $6 million to build this facility. Turin would not cite specific industrial commitments because he is still negotiating to achieve his investment goal.

The National Research and Resource Facility for Submicron Structures at Cornell was started in 1977 with a grant of $5 million from NSF and some additional industry money. The university affiliate program at Cornell now provides $200 000–$300 000 annually for the facility, representing contributions from approximately 20 companies. IBM donates an additional $100 000 per year, and significant individual contributions are received from Raytheon and Sperry.

The Facility supports microstructure science and technology research, with the focus on development of technology usable five to ten years hence. One group at the Facility, headed by Bernard Siegel, is building an ion-beam lithograph system. The group has already devised an intense source of molecular hydrogen ions, ten times brighter than previous liquid-metal field ion sources, thus providing a source bright enough to write patterns more quickly. If an ion beam could be made using heavier ions, it could be used in systems to fabricate microcircuits more simply by etching them selectively with the beam.

Industry groups. A newly formed Semiconductor Research Cooperative (under the auspices of the Semiconductor Industry Association) will allow industry to assist the advancement of integrated circuit research at universities, according to Erich Bloch, Vice President for Technical Personnel Development at IBM. He is organizing this cooperative research effort to bring together corporations involved in the semiconductor industry and the leading-edge users of semiconductors so they can contract for research to be done at universities. In 1982 this effort will support $5-million of research, with money coming from firms such as IBM, AMD, Signetics, Fairchild Semiconductor, Motorola, Intel, CDC, Rockwell and so forth. The goal for the next two years is to raise the funding level to $10 or $15 million.

This cooperative will select specific research projects to support, and the member companies will share the technical information derived from them. Bloch described the intention to make this "a long-term effort to support university research, to enable universities to graduate more qualified people in this area and to get basic research done that will contribute significantly to knowledge in this field." The cooperative will support the work of physicists, chemists, electrical engineers, and computer scientists.

Pake expressed to us his reservations about the ability of industry's contributions to solve university research budget problems. He explained that "industry cannot invest large sums of money in basic research primarily for two reasons. They would not know in advance whether, when or for whom [the sponsor or a competitor] the research would pay-off. And the amount of capital available to industry for investment in research is too little to contribute significantly to basic research efforts."

Nonetheless, many large corporations continue to spend some portion of their research budget funding physics-related university-based research. Xerox itself is a major contributor to several of the integrated circuit programs discussed above, including those at Stanford and Caltech. Industry invests in university research in two basic ways—by supporting specific programs or research projects undertaken by universities and by outright philanthropy to the university as a whole to support the scientific education and research endeavor. Like many of the companies we spoke to, Xerox was unable to identify how much of their overall investment in university R&D is for physics-related research. Pake cited contributions to semiconductor research, involvement with polymer research at MIT, and support given to the Stanford Synchroton Radiation Laboratory, as examples of Xerox's support of physics.

Exxon Research and Engineering Corporation, Exxon Corporation and the Exxon Education Foundation, all support science research. Dan Grafstein, senior research associate with Exxon R&E, told us that in 1981, they gave $700 000 in unrestricted grants to 58 university science departments; of these, 14 were physics departments. Similarly, out of their corporate research budget $300 000 went to 21 universities, of which four physics departments received approximately $50 000. Last year the Foundation gave $700 000 to support graduate students; this year a new program will provide $15 million. In addition, Exxon funds specific projects through contracts to universities. In 1981 this entailed $2.7 million in all areas of science; included among these contracts is support for such projects as the University of Rochester's Laser Fusion Program, which Exxon has been funding since about 1970.

Schlumberger-Doll Research Corporation in Ridgefield, Connecticut, employs 40 physics PhDs as part of its staff. Michel Gouilloud, Vice President and Director of Research with Schlumberger, told us that they are also supporting approximately 60 consultants, many of whom are professors at universities and now have about 20 research contracts with universities that support varying numbers of people, depending on the size and nature of the contract. All of these academic researchers are either physicists or computer scientists. Gouilloud also cited the extensive involvement of Fairchild, a company owned by Schlumberger, in supporting semiconductor research at universities.

Public utilities have also invested in energy-related research. Electric Power Research Institute has an R&D budget for 1983 of $250 million. Its staff includes approximately 400 technical persons with backgrounds in either physics or engineering. The funds are voluntarily contributed by utilities according to a formula determined each year by EPRI's Board of Directors, based on kilowatt-hour sales. In return for contributions, the utilities gain access to R&D results and field-testing services for new processes. One example of physics-related research supported by EPRI is a computer modelling project to simulate the behavior of the core, gas cloud, and other parts of nuclear reactor systems, to try to predict their behavior after an accident.

A similar arrangement for New York State utilities, called the Empire State Electric Energy Research Corp., has given support to approximately 80 projects this year. In 1980 they had an R&D budget of $20.3 million. —JC

Congress considers plan to dismember DOE

The Department of Energy is to be dismantled and the bulk of its responsibilities transferred to the Department of Commerce, if Congress enacts the plan recently proposed by President Reagan. The tentative plan calls for an independent agency within Commerce to handle "important research programs now operated by the DOE," according to Secretary of Energy, James Edwards. The new agency—the Energy Research and Technology Administration—is expected to operate under an Assistant Secretary of Commerce.

Now slated for inclusion in this agency are research and development programs in high-energy and nuclear physics. Defense work and related reseach would also be administered there; Edwards referred in particular, to the Atomic Energy Defense Program that develops and produces nuclear weapons as part of this new agency's responsibilities. Included as well, are programs for research in basic energy science and magnetic fusion, and R&D programs for alcohol fuels, hydropower, geothermal, solar and fossil energy. The Nuclear Reactor Waste Technology Program, as well as uranium enrichment activities now under DOE, will also be run by this agency.

Reagan's proposal also calls for the Department of Interior to become responsible for "those functions of the DOE that bear on the management of natural resources," such as the strategic petroleum reserve; the Department of Justice will assume control of the energy regulatory programs until they