New NSF Research Centers Will Focus on Biomaterials and Semiconductors

The National Science Foundation has announced plans to fund 5 new Engineering Research Centers, bringing the total to 25. Among the new centers are the University of Washington Engineered Biomaterials ERC and the ERC for Environmentally Benign Semiconductor Manufacturing, based at the University of Arizona. Like the existing ones, the new centers will pursue applications-oriented, cross-disciplinary research in close collaboration with industrial sponsors and with strong backing from their host institutions.

The Arizona center, a joint initiative between NSF and the Semiconductor Research Corp, was announced in late April. The review process for the four other awards—which, in addition to the Washington biomaterials center, went to the Integrated Media Systems Center at the University of Southern California, the Center for Competitive Product Development at MIT and the Reconfigurable Machining Systems Center at the University of Michigan—was delayed by last winter's government shutdowns, and the award announcement finally came in late May. The five centers will receive about $12 million each over the next five years; funding may be extended to eleven years.

The ERC program was established by the NSF Directorate for Engineering in 1985, with the aim of fortifying US industrial competitiveness. To this end, ERC projects encompass basic research, development of applications, testing of products and technology transfer. NSF also requires the centers to engage in student training and educational outreach. The Center for Computational Field Simulation at Mississippi State University, for example, cohosts a two-week summer camp for junior high and high school students; the topic this summer was the physics of amusement parks.

Although the broad goals and guiding principles are common to all 25 centers, their research objectives span a wide range of fields (see the table).

> New engineering research centers will draw on their ties with government, academe and industry to boost US industrial competitiveness.

Tricking the body into healing

The University of Washington Engineered Biomaterials ERC, or UWEB, will focus on understanding and engineering healing processes in the human body. The center is the brainchild of Buddy Ratner, a professor of bioengineering and chemical engineering, who will be its director. UWEB will have 25 participating faculty members, and the university will create two new faculty positions as part of its $8 million contribution to the center.

"Our goal," says Ratner, "is to engineer materials that, on a molecular level, look like normal body parts and induce a natural healing response." Normally, inflammatory cells migrate to a wound site and release cytokines, proteins that facilitate communication between cells. This is a signal for other cells to produce fibrous collagen, which forms scar tissue. When a foreign object, even one made of material currently used in medical implants and considered biocompatible, is introduced into the body, scar tissue continues to build up. Such tissue eventually encapsulates the object and, in many cases, disrupts its intended function. People who have intraocular lens implants, for example, must undergo operations to remove accumulated tissue about once a year.

Research at the center will be conducted by three divisions. The materials division, led by Patrick Stayton, an assistant professor of bioengineering, will include biochemists, materials scientists, chemists, biophysicists and physicists. They will engineer various molecules—proteins, lipids and polymers, for example—and use them to modify materials such as silicon, Dacron, Teflon, gold, titanium and polyurethane. The resulting surface structure and chemistry will be characterized using a number of surface analytical techniques, including solid-state nuclear magnetic resonance, x-ray photoelectron spectroscopy, Brewster angle microscopy, second harmonic generation, time-of-flight secondary ion mass spectrometry and electron microscopy. "The trick," says Stayton, "will be to discover which combinations of parameters—the degree of surface order, the type, density, orientation and patterns of incorporated proteins and other molecular triggers—work."

Researchers in the medical applications division will conduct studies of natural healing that will guide the materials engineering. "We have a model," says Joan Sanders, an assistant professor of bioengineering who will head the division, "but we need to identify the specific cytokines and their roles in wound healing."

The cell biology division, headed by bioengineering professor Thomas Horbett, will study how engineered materials affect the production of cytokines and other molecules in cultured cells. Through comparisons with the natural healing studies, researchers will estimate the expected rates of fibrous collagen production. Cells grown in engineered porous materials will also be subjected to applied mechanical stresses. Such stresses, intended to mimic conditions in the body (for example, the forces on an implanted heart valve), can have a significant effect on the cytokine response, says Sanders. Ultimately, the materials will be tested in laboratory animals, and the findings used to further guide Stayton and his colleagues in their engineering of materials.

Materials with improved biocompatibility have enormous commercial potential, says Ratner, and UWEB is having no difficulty attracting industrial partners. There are 30 so far, and each will ante up an annual fee of $15 000 to get "a seat at the table," as Stayton puts it—meaning access to the latest research and consultation with scientists at the center, résumés of graduating students and postdocs, participation in an industrial advisory board and the opportunity to invest additional funds in the center that can be earmarked for specific research. Already, investments from external commitments are expected to match funds from NSF. The main applied focuses of UWEB will be on diabetic treatments, bone healing, ear and eye implants, and devices used in skin and cardiovascular treatments.

UWEB's partners are enthusiastic. "We develop products for diabetics," explains Tim Piwonka-Corle, a physicist and the chief technology officer of National Applied Sciences in Portland, Oregon, "and we hope that this partnership will lead to the development of glucose monitors that can remain in the body for extended periods of time."

NSF Engineering Research Centers

Year Est.	Center	Institution
1996	Environmentally Benign Semiconductor Manufacturing	University of Arizona
1996	Integrated Media Systems	University of Southern California
1996	Competitive Product Development	MIT
1996	Reconfigurable Machining Systems	University of Michigan
1996	Engineered Biomaterials	University of Washington
1995	Neuromorphic System Engineering	Caltech
1995	Low Cost Electronic Packaging	Georgia Institute of Technology
1994	Particle Science and Technology	University of Florida
1994*	Collaborative Manufacturing	Purdue University
1994*	Biotechnology Process Engineering	MIT
1994*	Systems Research	University of Maryland at College Park
1990	Computational Field Simulation	Mississippi State University
1990	Biofilm Engineering	Montana State University
1990	Data Storage Systems	Carnegie Mellon University
1989	Interfacial Engineering	University of Minnesota
1989	Advanced Electronic Materials Processing	North Carolina State University
1989	Offshore Technology	Texas A&M University and University of Texas at Austin
1989	Plasma-Aided Manufacturing	University of Wisconsin at Madison
1987	Optoelectronic Computing Systems	University of Colorado at Boulder and Colorado State University
1987	Emerging Cardiovascular Technologies	Duke University
1986	Compound Semiconductor Microelectronics	University of Illinois at Urbana-Champaign
1986	Net Shape Manufacturing	Ohio State University
1986	Advanced Technology for Large Structural Systems	Lehigh University
1986	Engineering Design Research	Carnegie Mellon University
1986	Advanced Combustion Engineering	Brigham Young University and University of Utah

*These centers were originally established in 1985 and were renewed in a competitive award in 1994.

"We are very excited about UWEB," says Cliff Holmes, a research director at Baxter Health Care in Deerfield, Illinois, who works on improving the body's acceptance of catheters in kidney treatment. "It is very attractive for an industry to work with just one group rather than with a collection of universities," he says. "It seems serendipitous—a really good match."

Making cleaner chips

As its name implies, the ERC for Environmentally Benign Semiconductor Manufacturing will foster research on safer, less polluting, more water- and energy-efficient ways of producing integrated circuits and other semiconductor devices. The overall emphasis will be on new processes, tools and protocols, rather than abatement or cleanup, says Farhang Shadman, the center's director and a professor of chemical and environmental engineering at the University of Arizona.

The center itself will be housed at Arizona, with work spread among research groups there and at MIT, Stanford University and the University of California, Berkeley. Like the other ERCs, the new center will draw on an interdisciplinary mix of workers—materials scientists, optical scientists and chemical and electrical engineers.

The funding scheme differs somewhat from that of the other new ERCs. Over the next five years, NSF and the Semiconductor Research Corp, an industry-supported research group that sponsors projects at more than 50 universities, will each contribute a total of $5 million. Additional start-up funds of $750 000 will be contributed by Sematech, the Austin, Texas, consortium that's been working with US companies to develop advanced chip-making techniques and equipment.

Although semiconductor manufacturing has generally enjoyed a reputation as a clean industry, it is not without its problems. Several years ago, there were widely publicized reports of groundwater contamination from semiconductor plants and higher miscarriage rates among women workers. Soon afterward, Congress took the unusual step of mandating that Sematech dedicate one-tenth of its budget to environmental research. (Sematech gets half of its funding from the Defense Department—$50 million this year.)

Since then, the semiconductor industry has been phasing out the most harmful chemicals, including ethylene-based glycol ethers, the agents believed to cause the miscarriages, and ozone-depleting CFCs and PFCs, Shadman says. Researchers with the Arizona center will look for safer chemical alternatives, including water-based resists and less toxic solvents, as well as new techniques for recycling and otherwise minimizing the use of chemicals.

The industry's voracious consumption of water—used to clean the semiconductor wafers at various stages during processing and also to cool equipment—creates another environmental strain, particularly since chip manufacturing in the US is concentrated in the arid Southwest. Shadman estimates that the typical production-scale wafer fabrication plant uses 3.5 to 4 million gallons of water per day, and water recycling is not widely practiced. Using existing technology, companies could reuse about one-fourth of their water, but new research will be required to go beyond that. The water used in chip making is highly purified, Shadman explains, and the challenge is to repurify the dirtiest waste water using a minimum of energy and chemicals. "In principle, we could aim to recycle 70–80% of the water in the near future," Shadman says.

Another thrust of the center will be to develop undergraduate and graduate courses that treat environmental, safety and health issues as an integral part of the design and manufacturing process. "This will be a fundamental change in the way students are trained," says Ben Kittner, a Semiconductor Research Corp spokesperson.

Henry Mirsky, a process engineer at Anadigics, which makes gallium arsenide integrated circuits, believes cleaner chip making will save money in the long run. "Increasingly, companies are regarding effluent as a form of inefficiency," he says, because chemicals and other materials can be reclaimed rather than thrown away. "If you can decrease your waste stream, you increase your profitability."

"The semiconductor industry is very fast-moving," notes Shadman. "Old processes are thrown out and new ones are adopted all the time." And so he is fairly confident that the ideas he and his colleagues put forth will be implemented rapidly.

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