Research Goes Online in Birck Nanotechnology Center 'Cleanroom'

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Vistec Semiconductor Systems technicians John Cunanan, (standing) a field simulation engineer, and Paul Whitwood, a final test engineer, conduct tests on a Leica Vector Beam photolithography machine in the cleanroom at the Birck Nanotechnology Center's Scifres Nanofabrication Laboratory. The $6 million instrument will help Purdue nanotechnology researchers write on computer chips ultra-high resolution lines that are as small as 6 nanometers. Photo: David Umberger

The Birck Nanotechnology Center at Purdue University on Monday, June 12 opened its $10 million Scifres Nanofabrication Laboratory to researchers.

The 25,000-square-foot cleanroom provides Purdue scientists with nanofabrication labs to advance research at the nanoscale level and

design the next generation of electronic devices similar to the transistors and circuits in computer chips.

"Several leading U.S. universities have large labs for nanotech research, but those facilities were designed primarily for semiconductor electronics," said George Adams, Birck's research development manager. "At Birck, the cleanroom and labs are the nation's first designed specifically for the breadth of nanotechnology research, making them better suited for this emerging science."

Initially, 44 faculty members and nearly 200 researchers and graduate students will use the $58 million Birck Nanotechnology Center, many working in the cleanroom and related laboratories. The Discovery Park cleanroom provides two types of research space:

• The particle-free environment needed for fabricating microscale and nanoscale devices.

• The biological-pharmaceutical-grade environment needed for work with pathogen-detecting biochips and other biological nanotechnology.

"A single nanoscale device may require processing in both of these incompatible environments," Adams said. "At Birck, the cleanroom is specially linked - something no other cleanroom in the world has."

Several companies and organizations have expressed an interest in using Birck's facilities, specifically the cleanroom and biocleanroom, to help gain a competitive edge in the $227 billion global semiconductor chip market.

"Now that the cleanroom is up and running, we expect interest from industrial and corporate partners in what research we will be able to do for them in the growing, dynamic field of nanotechnology," Adams said.

Although dust particles are microscopic, they're actually larger than many of the features in devices built through nanotechnology, making cleanrooms critical to any research at this tiny scale. Nano is a prefix meaning one-billionth. A nanometer is one-billionth of a meter, or only about 10 atoms wide.

Researchers in Birck's cleanroom will work with some of the most sophisticated equipment used for advancing research in the commercial nanofabrication process related to:

• Patterning. Researchers will use a $6 million ultra-high resolution Leica Vector Beam photolithography system. The new instrument, one of less than a dozen like it in the world, creates nanoscale patterns on wafers with an electron beam. The system can either draw these patterns directly on a wafer that has been spin-coated with an electron-sensitive material or can create very high-resolution masks that use optical technology to create the image on wafers. The narrowest line that can be drawn is about six nanometers, or about 20 atoms, wide.

• Masking. An optical pattern generator, donated by Raytheon Co., creates photo masks, which act like photographic negatives in patterning silicon wafers. This instrument rests on a 4,000-pound granite table in a Birck lab that is specially lit to protect photo-sensitive images on the chips.

• Etching. With a $2 million instrument, Purdue researchers can take the wafer image through the etching process. The image created in the patterning step is used as a mask to allow the surface below the pattern to be selectively etched. The instrument for this process, known as a reactive ion etcher, uses high-energy plasma to create ions to etch the pattern into the wafer.

• Deposition. Purdue has installed two atomic layer deposition systems

on campus, allowing Birck researchers to add thin films with atomic layer precision. These highly specialized films allow the fabrication of extremely high-performance computer chips and other novel nanomaterials.

• Diffusion. Furnaces that achieve temperatures of up to 1,200 degrees Celsius alter the electrical characteristics, or conductivity, in specific areas of the silicon wafer. Manufacturer LSI Logic Corp. has donated six furnaces for this function that will be installed over the next few months.

Researchers must wear gowns, gloves, masks, head and shoe coverings, and take elaborate precautions to cleanse themselves before entering the cleanroom, said Birck facility manager John Weaver. He said Birck's cleanroom has areas that are rated based on the number of particles allowed in each cubic foot of air.

The least-clean portion of the cleanroom, which is about 15 percent of the total area, is about 1,000 times cleaner than the average office and contains less than 100 particles the size of a micron, or millionths of a meter, per cubic foot of air. About 40 percent of the cleanroom is an additional 10 times cleaner, with less than 10 particles per cubic foot of air. The remaining 45 percent of the cleanroom is 10 times cleaner still, with less than one particle per cubic foot of air.

"It's a self-cleaning lab to a certain extent," Weaver said. "The continuous flow of clean air removes the small, aerosol particles. We still need to manually clean the rooms of the larger particles, and it takes a trained crew to do that."

Before coming to Purdue, Weaver spent 35 years designing, building and operating semiconductor manufacturing cleanrooms for RCA Corp., the former Hughes Aircraft Co. and most recently Delphi Corp., including facilities in nearby Kokomo, Ind.

Adams said another design feature makes the Birck Center unique among its collegiate peers. In bio-nano research, scientists and engineers are marrying biological molecules, such as proteins and DNA, with electronic devices.

The research promises to make possible a new class of portable detectors for a range of applications, such as sensors for quickly testing food for bacterial contamination and sampling the air for biological and chemical warfare agents, as well as advanced medical diagnostic devices for analyzing blood and bodily fluids.

But the biocleanroom must be sterile as well as free of particles, requiring a different type of air handling and design.

"The biological cleanroom and the nanofabrication cleanroom share a common boundary, and we can move materials back and forth between both labs," Adams said. "Nobody has done that before in a nanofabrication cleanroom anywhere in the world."

Researchers from both labs can work together on the same experiments by using "glove boxes" common to both labs. A researcher in the biocleanroom will reach into the glove box from one side, and a researcher in the nanofabrication room will reach in from the other side.

An example of how the nanofabrication cleanroom and biocleanroom can work together is illustrated in research led by Rashid Bashir, a professor of electrical and computer engineering. His team is creating devices called "biochip" detectors that combine proteins and other biological molecules with electronic components.

In addition, the biocleanroom is purposely located near the walkway that connects Birck with the Bindley Bioscience Center, the $15 million research facility that also opened last October for research in life science

and bioscience.

The Scifres Nanofabrication Lab is named for Purdue alumni Donald and Carol Scifres, who donated $10 million to the Birck Center.

The 187,000-square-foot Birck Nanotechnology Center, which opened Oct. 8, involves Purdue faculty, researchers, staff members and graduate students from 27 schools and departments.

When the Birck Center is fully operational by October, the facility will have a staff of 300 nanotechnology researchers addressing everything from super-small computers, spacecraft and microscopic machines to tiny life-saving medical devices and a plethora of new materials.

"Birck is a one-of-a-kind facility for nanotechnology research on a university campus in this country," Adams said. "And because of the facility and the advanced equipment and cleanrooms, we have been able to recruit top faculty and students in nanotechnology areas."

The Birck Center is named for Michael and Katherine (Kay) Birck, of Hinsdale, Ill. The Bircks contributed $30 million for the building. Michael Birck is a Purdue alumnus, member of the Purdue board of trustees and chairman of Naperville, Ill.-based Tellabs Inc.

Alumni William B. and Mary Jane Elmore provided $2 million toward the center's William and Mary Jane Elmore Advanced Concept Validation Laboratory.

The Birck Center is a cornerstone for Discovery Park, Purdue's $300 million hub for interdisciplinary research and home to 10 established research centers focusing on endeavors ranging from biosciences and manufacturing to oncological sciences and health-care engineering.

Birck Nanotechnology Center: http://www.nano.purdue.edu/

Source: Purdue University