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Linking local nanotechnology companies and researchers into a chain that stretches across the country

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rian Lim, Chairman and CEO of Atomate Corp., reels off a long list of reasons why, when he started the nanotechnology company in 2003, he did so in Santa Barbara. The first he listed was that he had already had positive experiences working with the school at his previous company, NanoDevices (acquired by Veeco Instruments in 2003), finding strong synergy in working with the California NanoSystems Institute (CNSI).

He has nothing but praise for the Sciences and the College of Engineering at UCSB. “There were a great many resources and programs that benefited us—and I’d definitely include UCSB graduates among them,” he commented. “We’ve hired many of them.”

In 2006, the company relocated to Simi Valley in order to be closer to the larger pool of talent available at places like UCLA and Caltech, and to a host of research labs in the proximate area. Despite now having so many other choices, however, Atomate remains
a key user of the UCSB Nanofabrication Facility.

“We’re still very much plugged into UCSB and Nanofab,” said Lim. “We sincerely appreciate Jack Whaley and his team’s efforts in running an incredibly useful lab for both academic and industry R&D. We have a lot of options now, but we still choose to use UCSB—the team’s support makes it an easy decision for us.”

Jack Whaley is manager of Nanotech, the UCSB Nanofabrication Facility and testing lab. Commonly referred to as “the cleanroom” or “Nanofab,” this truly state-of-the-art facility moved into its new location, occupying the entire ground floor of the then-new Engineering Science Building, in 2005. Nanofab represents years of collaborative development among UCSB faculty members in identifying and gathering the finest tools and fabrication processes available to create structures and devices at the nanoscale.

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Nanofab originated as “the cleanroom” in 1989. Its existence made UCSB an early, major player in the development of nanoscience and nanotechnology, and led to the establishment of the California NanoSystems Institute, a joint venture between UCSB and UCLA, in 2000. Nanofab now focuses on semiconductor-based technologies, but will soon have complementary fabrication facilities in Elings Hall that will extend nanofabrication to novel device materials from biology and chemistry.

The current cleanroom facilities cover about 13,000 square feet, with half as much additional space dedicated to infrastructure support—heating and ventilation equipment, filters, cooling equipment, vacuum plants, compressed air, gases and liquids, special water facilities and waste treatment systems.

“What makes it a cleanroom,” explained Whaley, “is that there are very few particles in the constantly filtered air, and the temperature and humidity are very precisely controlled. Access is also tightly controlled.”

Whaley estimates the cleanroom lab itself represents an investment of around $20 million, with another $25 million to $30 million in cutting edge fabrication tools and equipment for researching, developing, and testing the latest in nanotechnology.
The university’s Nanofabrication Facility effectively links local nanotechnology companies and researchers into a chain that stretches across the country. In addition to supporting on-campus researchers and local companies, Nanofab is also part of the National Nanotechnology Infrastructure Network (NNIN), a National Science Foundation-funded integrated partnership of user facilities at 13 institutions across the U. S., including Cornell, Stanford, the University of Michigan, Georgia Tech, the University of Washington, Penn State, the University of Minnesota, the University of New Mexico, the University of Texas, Harvard, and Howard University.

Atomate is far from alone in taking advantage of Nanofab. In the first quarter of this year, the facility had users from more than 40 external organizations, about half of them small firms like Atomate seeking to commercialize nanotechnology.

UC Santa Barbara’s Nanofab supports a broad line of lithography, thin-film deposition, reactive ion etching, and characterization tools for device fabrication with a variety of materials, in both Class 100 and Class 1000 cleanroom areas. The light in most of the cleanroom areas is filtered to remove all ultraviolet spectrum, because of the extensive use of UV-sensitive photo-resist materials?the result is the characteristic yellow light.

Of the remaining outside users, about 10 were large companies, (defined as those with 500 or more employees) and roughly the same number were academic institutions. More than 200 UCSB graduate and post-graduate researchers also use the Nanofab, making a total of well over 300 individuals each quarter.

The level of Whaley’s professional services and the availability of knowledgeable, helpful staff and post-graduate fellows at the lab, are clearly part of the draw for outside users. Capital costs, however, are often the biggest factor in drawing users to Nanofab: the costs of duplicating the facility, or even part of it, can be prohibitive for both start-ups and established companies.

“That’s certainly the case for Freedom Photonics,” says Jonathon Barton, founder and president of the three-year-old optoelectronics company based in Goleta. Barton, who earned his PhD at UCSB, said his early-stage company (with just three staff right now...) is using the cleanroom to make prototypes of integrated circuits for fiberoptic communications. The Nanofabrication Facility offers his company a very desirable option?paying by the hour instead of having to spend millions of dollars to buy nanotechnology equipment. “That’s a huge benefit for a start-up company like ours,” he said.

Not having to make a major capital investment is also helping another Goleta start-up,
Transphorm. ?It?s definitely very useful at this early stage,? said chief operating officer Primit Parikh. Transphorm is in the business of clean energy, and uses the Nanofabrication Facility to develop the semiconductors that are part of its technology for generating hydrogen for fuel and for industrial purposes.

Parikh said Transphorm typically has four researchers in the cleanroom for 20 to 30 hours each week. While this involves some trade-offs?no individual company has priority in their use of the facility or access to equipment?the advantages outweigh the disadvantages. ?Nanofab is great for all the start-up companies in town. It?s good synergy and good for UCSB. It?s a real win/win,? he said.

Lim?s company, Atomate, is working at the cutting edge of electrical device creation, a field in which carbon nanotubes and other nanowire materials are being utilized to produce what he expects to be the ?next generation of electronics.?

The company is developing micro-electro-mechanical systems, or MEMS, working at a scale of less than two nanometers. (A nanometer is one billionth of a meter, a measurement so small it is difficult to visualize. One highly non-scientific comparison to a nanometer is how much a man?s beard grows between his picking up the razor and starting to shave.) ?Despite their incredibly small size, Lim said ?Atomate?s devices can provide much higher performance than similar micrometer-scaled (1,000 times larger) devices.?

As companies like Atomate carry out research and development in building their minute components, they take full advantage of highly sophisticated instruments in the cleanroom, and of complementary resources in the UCSB?s Materials Research Lab and in CNSI. Available instrumentation includes atomic force microscopy, scanning electron microscopy, secondary ion mass spectrometry, and X-ray spectrometry, all used to test and characterize materials and devices and for process control.

Ongoing research in the Nanofabrication Facility ranges from evaluating different types and thicknesses of film coatings to the relative performances of materials including ceramics, glass, polymers, metals, and semiconductors. Researchers are building and testing devices and circuits made from new types of semiconductors, including compound semiconductors used for very fast transistors and a wide variety of optoelectronic devices. The one thing Nanofab users are not allowed to do is manufacture product for sale.

As lab manager, Whaley supervises about a dozen staff and is responsible for
operational policies and procedures and equipment purchases. He also meets each new user and ensures that he or she is properly trained.

He describes the facility as dynamic and constantly changing. ?We?re always adding new tools and looking at new processes, he said. ?It?s very important to continue to add new processing capability.? 

The lab has a capital equipment advisory committee and talks with users to determine their needs. ?We want to look at what people are doing and try to support the broadest number of users,? Whaley said. This emphasis on customer service is not entirely altruistic: the Nanofab also benefits UCSB, and it?s a business that has to be run like any other business, with attention to the bottom line.

Nobody knows this better than Mark Rodwell, professor of electrical and computer engineering and director of Nanofab, who is responsible for, among other things, the facility?s $5 million budget. About $1 million of that total comes in an annual grant from the National Science Foundation (NSF). The rest is collected from users: academics pay a little over $32 per hour, and industrial clients are charged $120 per hour.

The most recent full year data show 461 users of which 285 were from within UCSB. Of the 176 ?outside? users, 42 were from other academic institutions, 55 were large companies, and 77 were small companies. Among the larger users, Rodwell listed technology and defense giants Lockheed Martin and Raytheon, and Cree, which has converted its expertise in semiconductors and materials to pioneer new forms of LED (light-emitting diode) solid-state lighting.

?We make our facilities available to any qualified academic or corporate user,? Whaley commented. That?s in accord with NSF requirements which, in return for government funding, require members of the national nanotechnology network to make their facilities as accessible as possible to academic and industrial researchers. ?We try very hard to make it a simple, easy and fast process,? he continued. ?We want to get as many people as possible working in the lab as quickly as possible.?

John Bowers, professor of Electrical and Computer Engineering, is also director of UCSB?s Institute for Energy Efficiency. Both roles have given him a keen interest in the properties and potential of thermoelectric materials.

Bowers and other researchers have been developing thermoelectrics in Nanofab, and then looking at ways in which they can generate electrical power when there is a
significant temperature differential from one side to the other. Bowers said this technology has applications in powering everything from satellites to car batteries to refrigerators.

?It may someday be possible to replace our bulky, relatively expensive refrigerators in our home with compact, solid state thermoelectrics and substantially reduce the power consumed in cooling our food,? he noted recently.

Bowers characterized Nanofab as a ?huge deal? for his graduate students, who can prove their ideas by making things in the cleanroom and measuring and testing them in the laboratory. He also sees the facilities at UCSB as an important asset for local high-tech companies.

?UCSB has a responsibility to the community to help it become successful,? he said, noting the influence of institutions like Stanford and MIT on their respective communities. Bowers believes that if the university can help create a favorable environment for high-tech industry, more companies will establish here, stay here and do their research here. ?That?s the advantage of being a research university.?

Relevant links:

Nanotech?The UCSB Nanofabrication Facility
nanotech.ucsb.edu [2]

NNIN--The National Nanotechnology Infrastructure Network
nnin.org [3]

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