New Stanford center probes nanoscale material

October 5 2004

The National Science Foundation (NSF) has awarded $7.5 million over five years to establish **the Center for Probing the Nanoscale** (CPN) at Stanford. Kathryn Moler, associate professor of applied physics and of physics, and David Goldhaber-Gordon, assistant professor of physics, will be co-directors. The CPN is one of six new centers that the NSF is funding to support science and engineering at the scale of the nanometer - one billionth of a meter, roughly the size of atoms and molecules. Through nanoscale advances in manufacturing, biotechnology, electronics, medicine and more, nanotechnology may account for a $1 trillion annual market and employ 2 million people within 10 to 15 years, according to an NSF report.

“There's a huge effort in this country in nanoscale research, but we don't have the tools,” Moler said. “We want to engineer what's at the nanoscale. We need to be able to see it, and we need to be able to handle it in order to engineer it, and that's what our center's all about.”

The CPN, which will have offices and a teaching lab in the Geballe Laboratory for Advanced Materials, is a partnership between researchers at Stanford, IBM and other companies to develop novel nanoprobes and apply them to answering fundamental questions in science and technology.

“What's different about our [center] is that we're developing new tools to enable nanoscale science and technology, and we're excited to see what possibilities these tools will open up,” Goldhaber-Gordon said.

The probes will enhance the capabilities of the nanotechnology community to observe, manipulate, measure, image and control nanoscale phenomena. Researchers hope to develop probes with revolutionary capabilities, such as mapping a single electron's behavior in a semiconductor and controlling a single electron's magnetic orientation, or “spin.”

The probes will help researchers address questions such as: At what length scale does quantum mechanical behavior become classical diffusive behavior? How does the spin state of an electron vary over time and distance? What are the mechanisms of high-temperature superconduction?

The center also includes a summer institute, led by a full-time education director, to train middle-school teachers and, through them, inspire tens of thousands of young students. Modeled after programs at Cornell and Rice universities that work with high school teachers, the Stanford program trains teachers who work with younger students. “By the time [students] reach high school, a lot of them have already turned off [to science],” Moler said.

The center is interdisciplinary, with faculty from many departments represented. Hongjie Dai from the Chemistry Department, for example, has developed a wafer-scale process for fabricating carbon nanotubes on the end of silicon atomic force microscope (AFM) tips, which among other advantages allows for much higher spatial resolution in imaging. He will collaborate with other CPN researchers to adapt this technique for a variety of measurements. Kyeongjae Cho and Adrian Lew, multi-scale modeling experts from the Mechanical Engineering Department, will help other investigators understand the interactions between the tip and their samples and design tips optimized for specific applications. Calvin Quate (Applied Physics), co-developer of the AFM with IBM's Gerd Binnig and Christoph Gerber, will consult with students and faculty

on issues related to the conception, design and fabrication of cantilevers. Other key Stanford participants include Malcolm Beasley (Applied Physics), Mark Brongersma (Materials Science and Engineering), Aharon Kapitulnik (Applied Physics and Physics) and Hari Manoharan (Physics).

Participants from IBM's Almaden Research Center in San Jose, Calif., include Don Eigler, a pioneer of low-temperature scanning tunneling microscopy, spectroscopy and atom manipulation who will participate in CPN's middle-school educational outreach; Barbara Jones, a theoretical and computational physicist who as CPN's “roving theoretician” will study quantum spins and help various groups interpret their data; and Dan Rugar, a manager of nanoscale studies who is developing a magnetic resonance force microscope to detect individual electron and nuclear spins. Researcher John Kirtley of IBM's T. J. Watson Research Center in Yorktown Heights, N.Y., will work to develop special sensors to study the nanoscale properties of magnetic and superconducting structures.

Source: Stanford University