Science of Nanoscale Systems and their Device Applications

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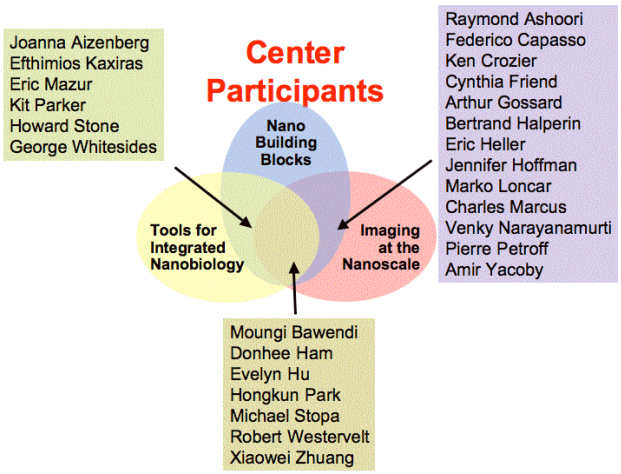
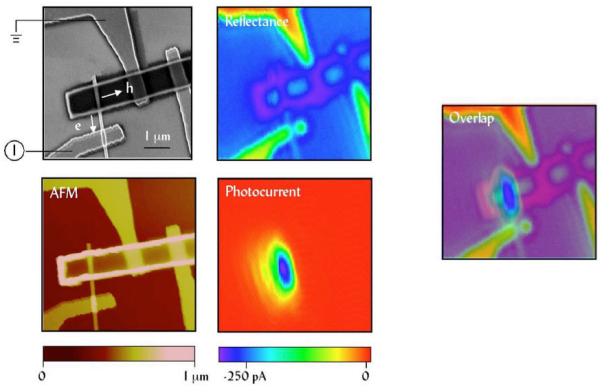
Our Nanoscale Science and Engineering Center develops tools to study nanoscale systems. We would like to control electrons and photons in nanostructures for nanoelectronic and nanophotonic devices. The Center plans to do this by synthesizing nanoscale building blocks and by developing new imaging techniques. We would also like to understand how biological systems function at the nanoscale by developing tools based on the Physical Sciences.



Three Clusters address these goals:

Cluster I: Tools for Integrated Nanobiology builds bridges between the Physical Sciences, Biology, and Medicine. The Physical Sciences offer powerful new tools for manipulating and testing biological cells and tissues, based on microfluidics, semiconductor technology and biological probes. In turn, Biology and Medicine offer an enormous range of engaging problems in functional biological systems, and the opportunity to think about "hybrid" systems that combine biological and non-biological components.

Cluster II: Nanoscale Building Blocks addresses the synthesis of new classes of nanostructures that exhibit size-dependent properties. An emphasis is placed on structures with unconventional shapes, as well as on zero- and one-dimensional nanoparticles and nanowires. Techniques are being developed to synthesize nanostructures from new materials, including oxide semiconductors and metal chalcogenides. These nanoscale building blocks provide new approaches for nanoelectronics and nanophotonics as well as sensors for biological systems.



SEM, AFM, Reflectance and Photocurrent Images (**Park**)

Cluster III: Imaging at the Nanoscale explores new ways to image the quantum behavior of electrons and photons in nanostructures using custom-made cooled scanning probe microscopes for capacitive probing of electrons and near-field scanning optical microscopes for subwavelength imaging with custom tips. Imaging is an essential tool for the development of nanoelectronics, nanophotonics, and qubits for quantum information processing. New types of semiconductor heterostructures are grown for this work using Molecular Beam Epitaxy.

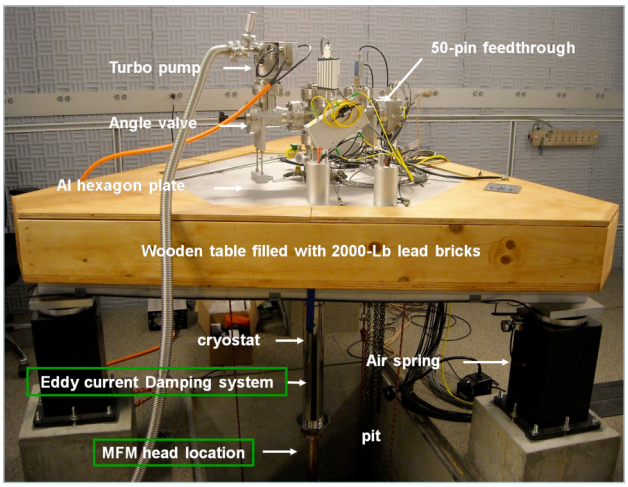


Figure: A high-vacuum, low temperature AFM

The **Center for Nanoscale Systems (CNS)** is a major investment by Harvard to create and maintain the facilities needed for research in this nanoscience and technology. A new building, the **Laboratory for Integrated Science and Engineering,** completed in fall 2007, houses **CNS** facilities for imaging, nanofabrication, and materials growth. Harvard and UC Santa Barbara provide facilities to outside users through the **National Nanotechnology Infrastructure Network (NNIN)**.

Connections with **Industry** are built by Harvard's **Office of Technology Development** and by the **Industrial Outreach Program** of the School of Engineering and Applied Sciences. Our Center is funded by the **Nanoelectronics Research Initiative** (**NRI**) of the **Semiconductor Reseaerch Corporation** to develop new oxide materials for future logic switches. Many Center participants collaborate with industry.

Our Center promotes **Education** in nanoscale science and engineering and develops **human resources** at the pre-college, undergraduate, graduate, and postdoctoral levels through a range of activities including REU and RET programs, a Harvard course *Applied Physics 298r — Interdisciplinary Chemistry, Engineering and Physics*, and workshops including annual *Industry Partnership Program* workshops and *Frontiers in Nanoscale Science and Technology* workshops held with our international collaborators.

Our Center aims to increase **Diversity** by recruiting a more diverse group of graduate students and postdocs, increasing the diversity of participating faculty, recruiting members of under-represented groups through our REU program, introducing public school students to science and engineering, and developing long-term partnerships with predominantly female and minority-serving institutions.

The **Museum of Science, Boston** informs the public about advances in nanoscience and technology in an entertaining and informative way. Larry Bell and Carol Lynn Alpert at the Museum help direct the **National Informal Science Education (NISE)** network in partnership with The Exploratorium in San Francisco and The Science Museum of Minnesota. The NISE network is designed to foster public awareness, engagement and understanding of nanoscale science, engineering and technology.

For further information, please see our website **http://nsec.harvard.edu**.

The **Laboratory for Integrated Science and Engineering** at Harvard houses **Center for Nanoscale Systems** shared facilities.