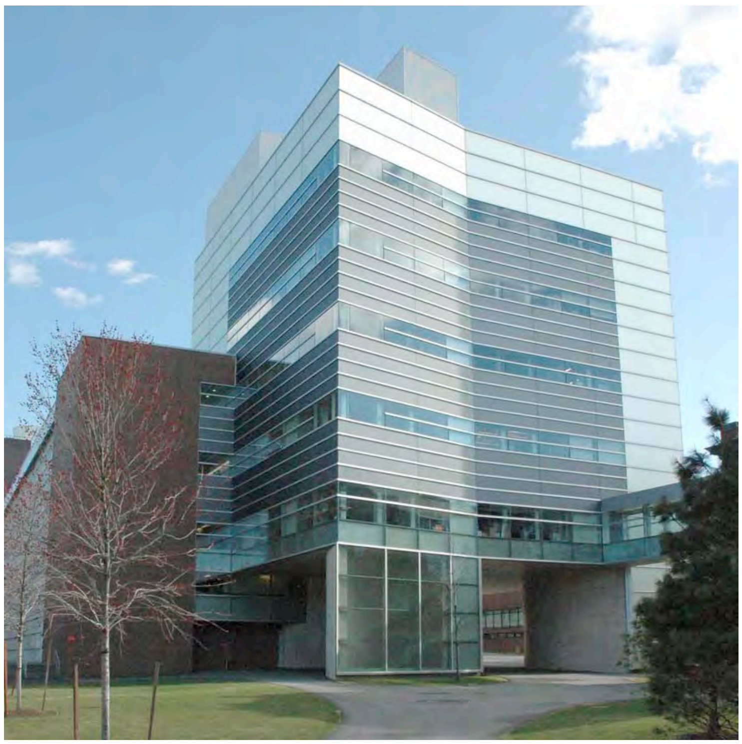
Laboratory for Integrated Science and Engineering
&
Center for Nanoscale Systems

Harvard University



Goals

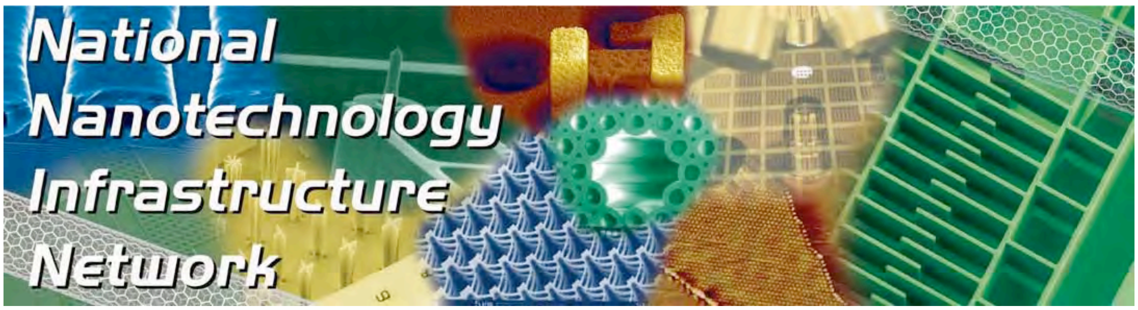
To provide world-class, centralized facilities and technical support for Harvard faculty research groups as well as the larger community of external users from academia and industry.

To foster leading-edge, multi-disciplinary research and education in the area of imaging and nanoscale systems, bridging the disciplines of chemistry, physics, engineering, materials science, geology, biology, and medicine.

To create an environment for collaborative research by providing shared research facilities and meeting places conducive to productive scientific interactions.

National Nanostructure Infrastructure Network (NNIN)

Harvard University and University of California at Santa Barbara



Harvard and UC Santa Barbara are two of an integrated partnership of fourteen user facilities led by Cornell and Stanford that provide opportunities for nanoscience and nanotechnology research. At Harvard, the NNIN provides expertise in computation and in soft lithography and assembly through the Center for Nanoscale Systems. At UCSB, the NNIN provides expertise in optics and electronic materials. The NNIN was funded by the NSF in January 2004.

NanoDays 2008: March 29 – April 5
Museum of Science, Boston

Harvard NSEC-associated researchers and graduate students gave talks and demonstrations during the first annual NanoDays event at the Museum of Science. Hundreds of families got to explore the nano world and to see *The Amazing Nano Brothers Juggling Show.*

NanoDays 2008 at MOS: Don Eigler shows youngsters how to move an atom in California through the IBM "Atom-o-Scope" web interface for a scanning probe microscope. Don's talk at MOS was filmed and is included in the *Talking Nano* DVD set. "After watching this DVD, one comes away feeling that one has "seen" the nanoworld," wrote Sir Harry Kroto in his review in *Materials Today.*

The Amazing Nano Brothers Juggling Show features performers Dan Foley and Joel Harris. In this scene, the rings and clubs represent the zeros and ones of computer code. 9500 museum visitors saw the show in 2008. It has received more comment card raves than any other program in the Museum repertoire. A typical comment: "Very entertaining AND educational!"

DragonflyTV Nano
Museum of Science, Boston

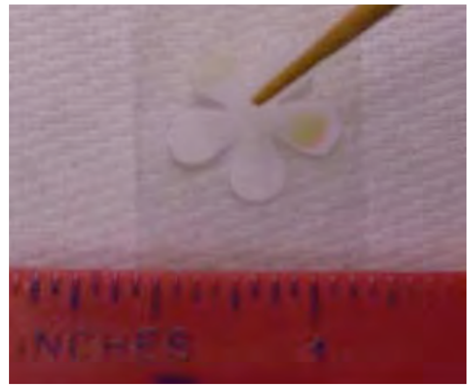
Dragonfly TV Nano teen actors Jasmine and Ebony Hollis suit up for a clean room visit at Harvard's LISE laboratories.

Dragonfly TV Nano teen actors Jasmine and Ebony Hollis speak with Dave Isadore at Harvard in a scene from the episode on size and scale.

In the spring of 2008, Twin-Cities Public Television filmed scenes at Harvard's NSEC laboratories and at the Museum of Science for two episodes of the PBS kid's series *Dragonfly TV Nano*. The filming was arranged through a partnership between TPT and MOS. Each *Dragonfly TV* episode is viewed by over a million people.

Miniaturizing Assays:
Adapting Paper Diagnostics for the K-12 Classroom

Graduate student Andres Martinez talks with teachers Tray Sleeper and Rebekah Ravgiala about the science and engineering behind paper diagnostics.



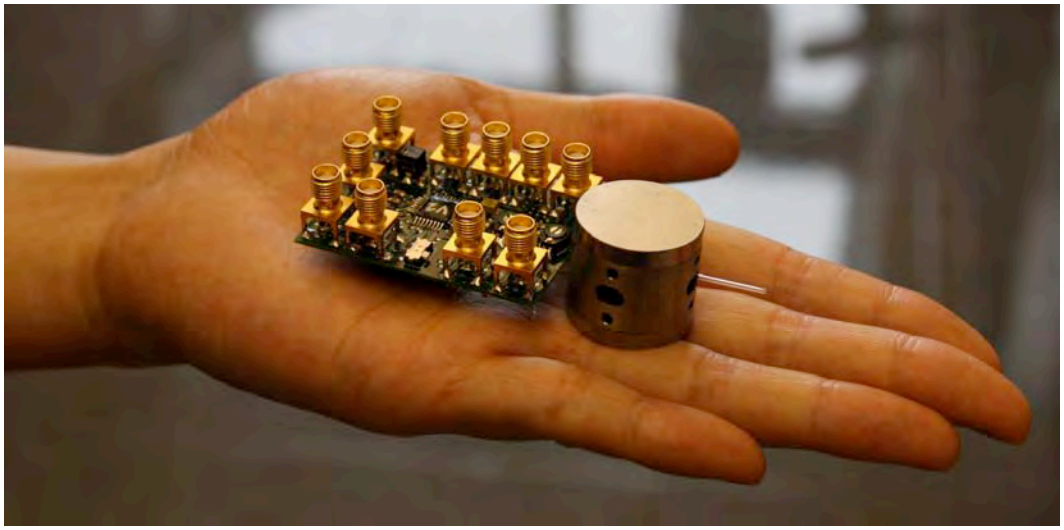
Paper diagnostics prototype for the K-12 classroom made with chromatography paper and a craft punch. Reagents for standard assays for pH and protein are dotted on each "petal" and sample is loaded in the center with a toothpick. Capillary action causes the sample to travel to all petals; a color change indicates pH and protein.

Research Experiences for Teachers participants worked with researchers in the George Whitesides laboratory to translate current research on paper diagnostics for the K-12 classroom. Current classroom assays for protein, pH, and carbohydrates are time- and resource-intensive; adapting these assays to paper platforms can save classroom and preparation time. Teachers have prepared lesson plans on the social implications of paper diagnostics, a scientific inquiry "who-done-it," and the reagent and cost savings of using paper diagnostics.

CMOS NMR RF Biomolecular Sensor

Donhee Ham

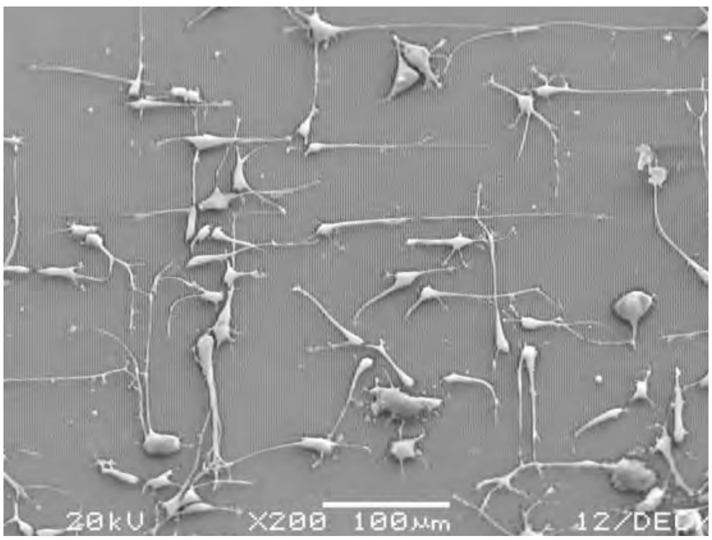
3rd Prototype



Our CMOS NMR RF biosensor work uses silicon RF chips not for wireless applications, but for biosensing aimed at disease detection. The RF chip controls and monitors proton dynamics in water via NMR. Target bioobjects (cancer marker proteins) alter the proton dynamics, the basis for our biosensing. The highly sensitive RF chip enabled us to construct an entire NMR system in a 0.1kg platform (unpublished, 3rd prototype), which is 1200 times lighter, yet 150 times more mass sensitive than a state-of-the-art commercial system. Our system is a circuit designer's approach to pursue low-cost disease detection in a hand-held platform.

Controlling Cellular Morphology and Assembly Using Engineered Nanostructured Substrates

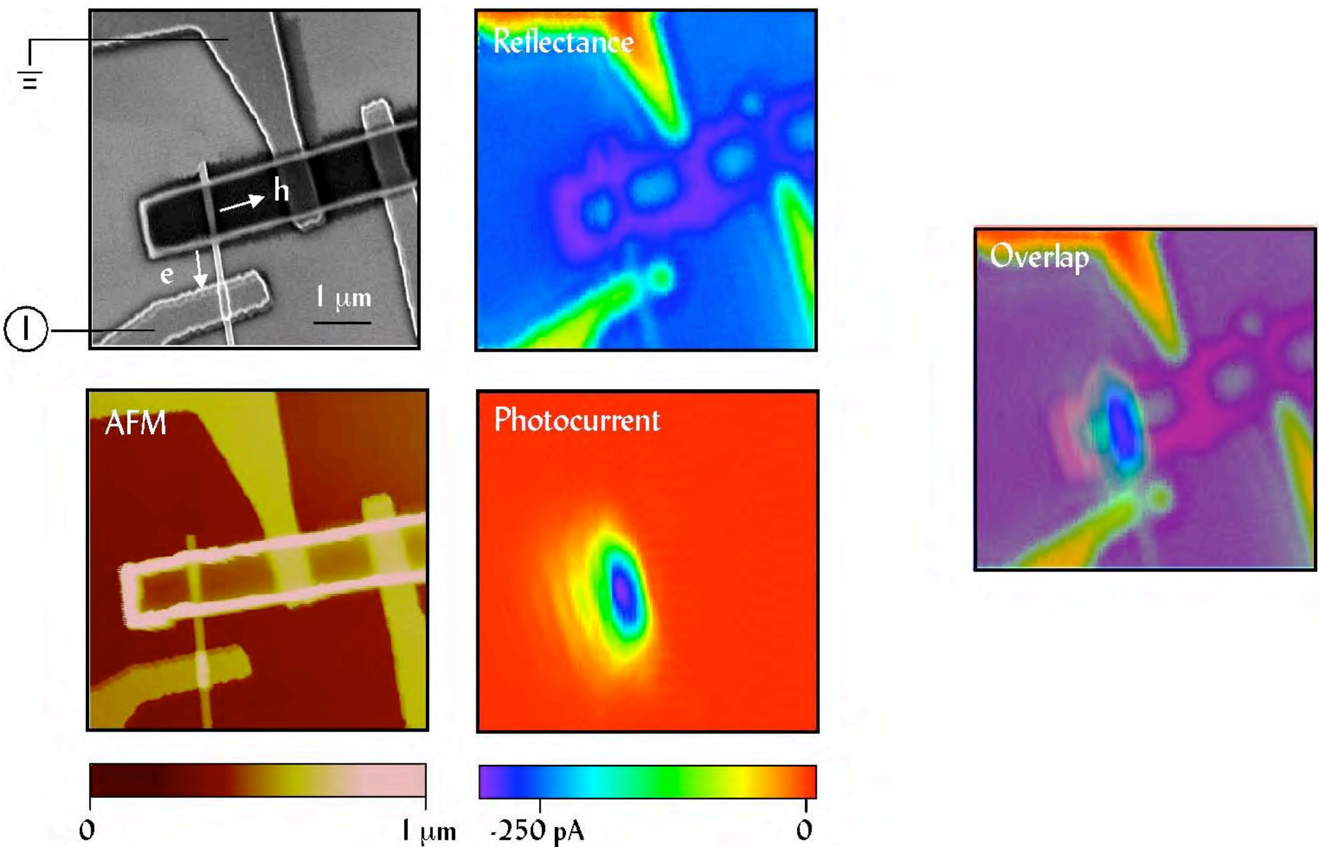
Joanna Aizenberg



Nanopost arrays with tailored size, spatial distribution, and chemistry were fabricated to control stem cell differentiation. Such nanostructures seem to induce distinct morphological characteristics in stem cells that resemble neuronal architectures. Further studies are underway to utilize the nanopost arrays in a reciprocal system that illicits cellular responses via topographical, chemical, and mechanical actuation. This approach can be used as a platform to probe cell-matrix interactions by mapping cell-matrix forces, as well as to direct cell behavior, for example, to form complex cellular networks in neural chips, enhance phenotype purity in stem cell lineage specification or illicit tissue-specific cell behavior for other regenerative medicine and tissue engineering applications.

SEM, AFM, Reflectance, and Photocurrent Images of a Single CdS-NW-P3HT Heterojunction

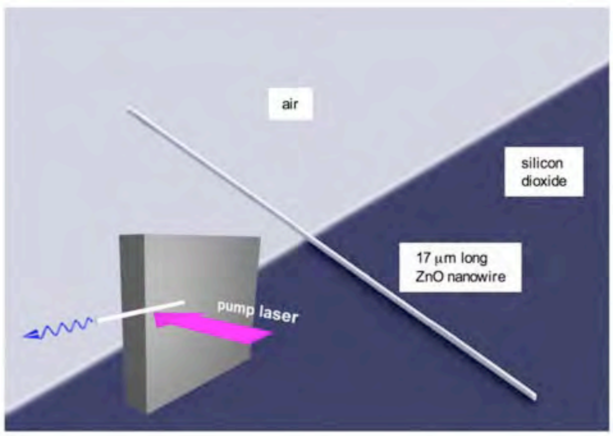
Hongkun Park



SEM (*upper left*), AFM (*lower left*), reflectance (*upper right*), and photocurrent (*lower right*) images of a single CdS-NW-P3HT heterojunction. These images clearly indicate that the photovotalic action of CdS-NW-P3HT solar cell occurs entirely at the junction between the CdS NW and the P3HT polymer strip.The analysis of the photocurrent data as a function of laser wavelength provides information on the charge separation efficiency as a function of photon energy.

Semiconductor Nanowire Lasers

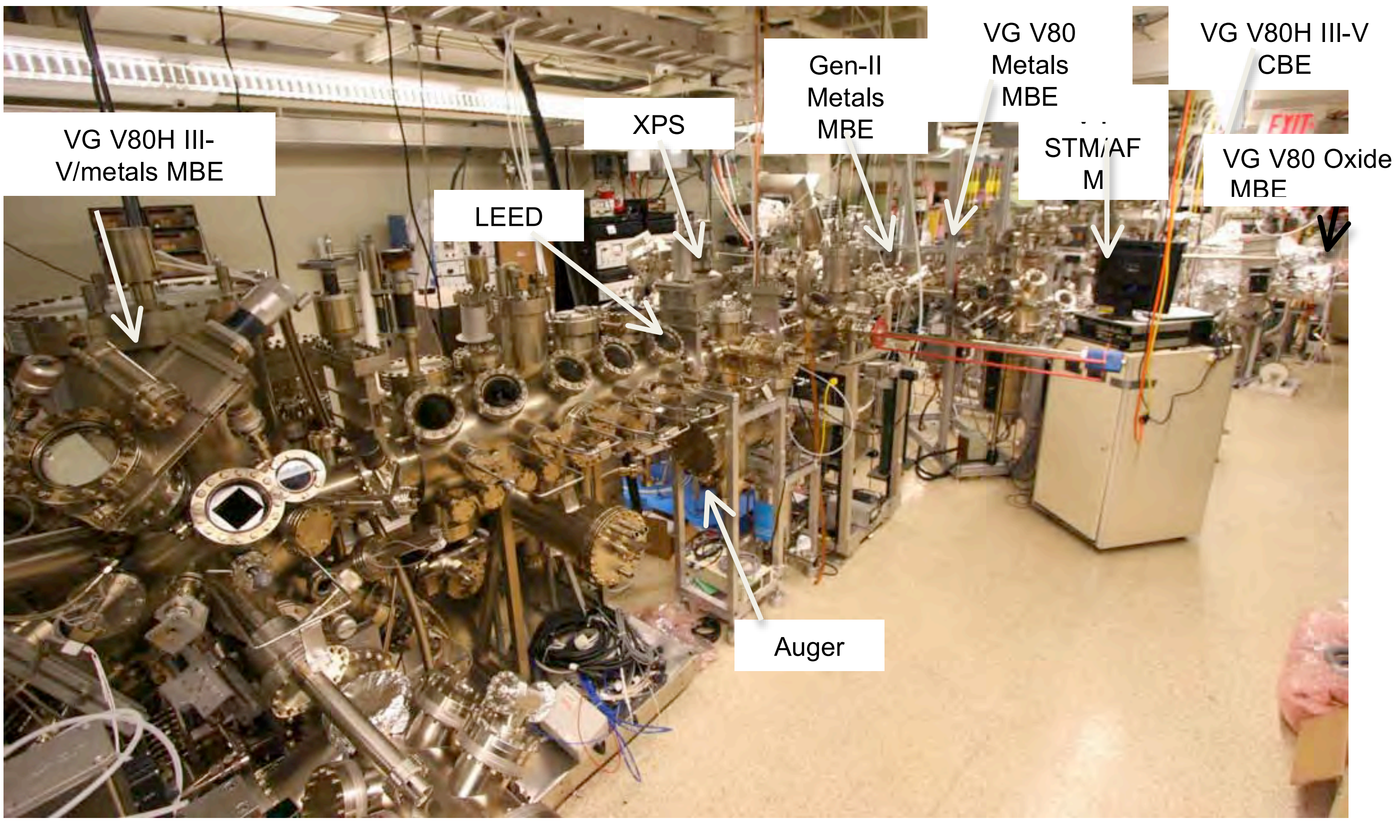
Federico Capasso



We have measured, for the first time, the output power of a single semiconductor Zinc Oxide nanowire laser emitting in the ultraviolet. The figure shows the experimental configuration: A nanowire, partially suspended in air, is excited uniformly along its entire length and the emission is collected from one end, at 90° from the excitation beam, using a silicon detector. This measurement provides a useful benchmark for the development of semiconductor nanowires as components of future integrated photonic circuits. Furthermore, our unique geometry can be used for the detailed characterization of the near-field and far-field emission of nanowire lasers, which is instrumental for a full understanding of nanowire lasers as well as for their optimization.

New in-situ Growth and Characterization System at UCSB

Chris Palmstrom and Arthur Gossard



High Resolution Force Microscope

Jennifer Hoffman

Magnetic imaging at the sub-nanometer scale is challenging. We are con-structing a new cryogenic force microscope employing a vertical cantilever and a novel AC magnetometry technique with planned magnetic force resolution of sub-picoNewton and spatial resolution of sub-nanometers. Our force microscope will be applied to exploit the technological potential of superconductors, multi-ferroics, and magnetic nanoparticles. The collage shows a photo of the fully assembled microscope system, measured noise spectra, and the result of an active Q control through a capacitive coupling.