

# Nanoscale Science and Engineering Center

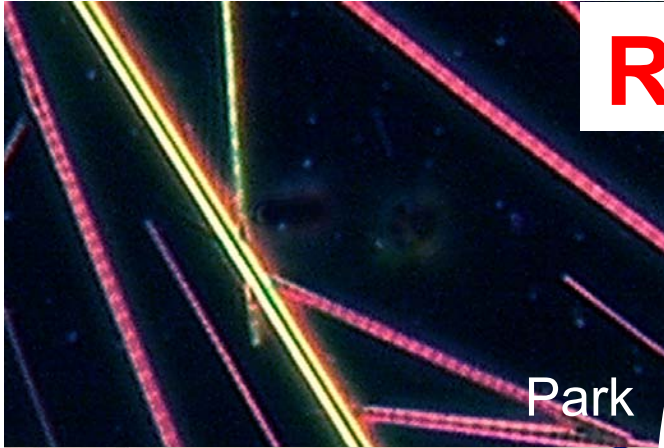
## **Science of Nanoscale Systems and their Device Applications**

**Harvard, MIT, UC Santa Barbara and Museum of Science Boston**  
**Sandia, Oak Ridge and Brookhaven National Labs**  
**TU Delft, Uni Basel, NEST, Lund Univ and Univ of Tokyo**



**R.M. Westervelt** Director, **R. Graham** Asst Director  
**N. Brave** Center Coordinator

# Research Areas



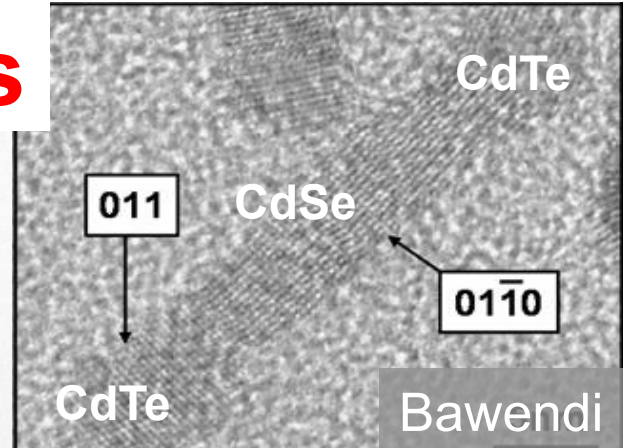
Park

**Nanoscale Building Blocks**

coordinators

**Bawendi**

**Park**



CdTe

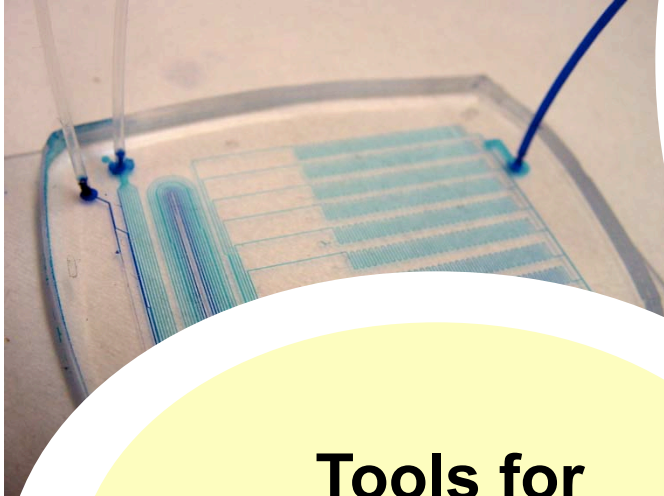
011

CdSe

0110

CdTe

Bawendi



**Tools for Integrated Nanobiology**

coordinator

**Whitesides**

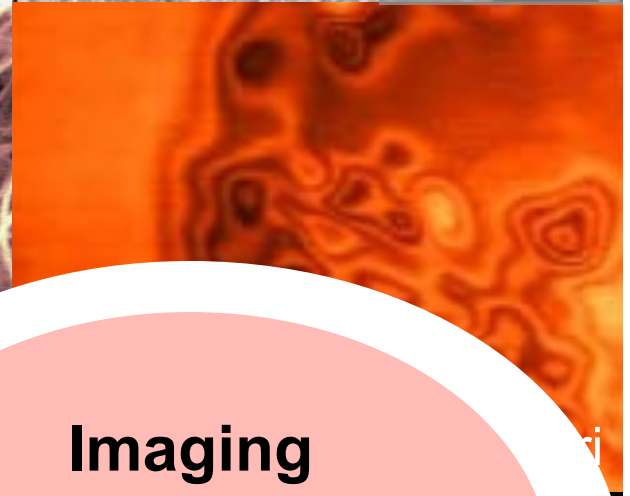
Whitesides

**Imaging at the Nanoscale**

coordinator

**Ashoori**

Heller



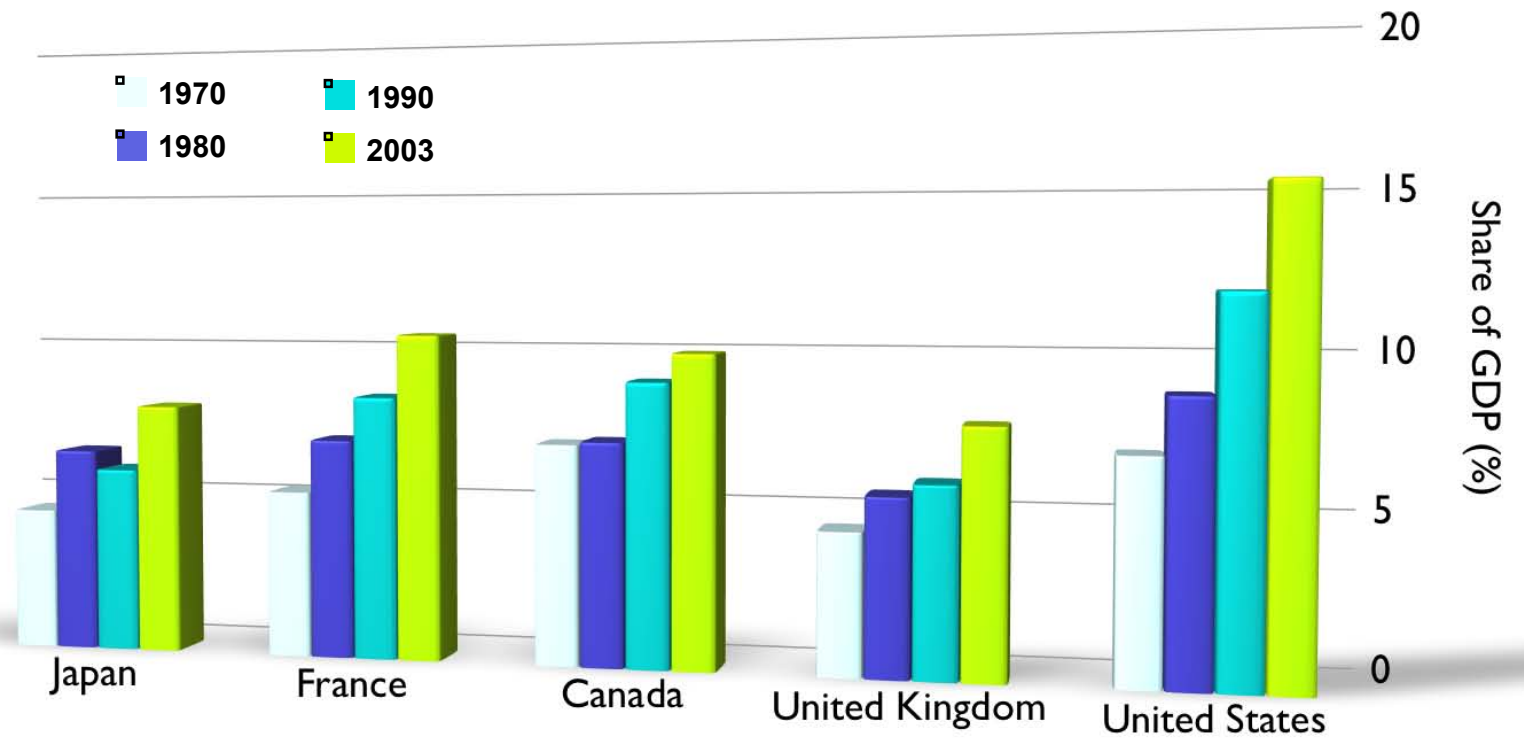
Heller

# Outline – The Future

- **Low Cost / High Tech Medicine**
  - Point of Care Diagnostics
  - DNA and Protein Analysis on Chip
- **Future Nanoelectronics**
  - Smaller, Faster, Lower Energy Circuits
  - New Medical Applications
- **Academic Research to Industry**
  - Startup Companies & New Jobs
  - Collaborations & Licenses to Industry
- **Infrastructure for Research**
  - Harvard's Center for Nanoscale Systems
  - NNIN – National Nanotechnology Infrastructure Network
- **Education to Engage the Public**
  - Museum of Science
  - NISE – Nanoscale Informal Science Education Network



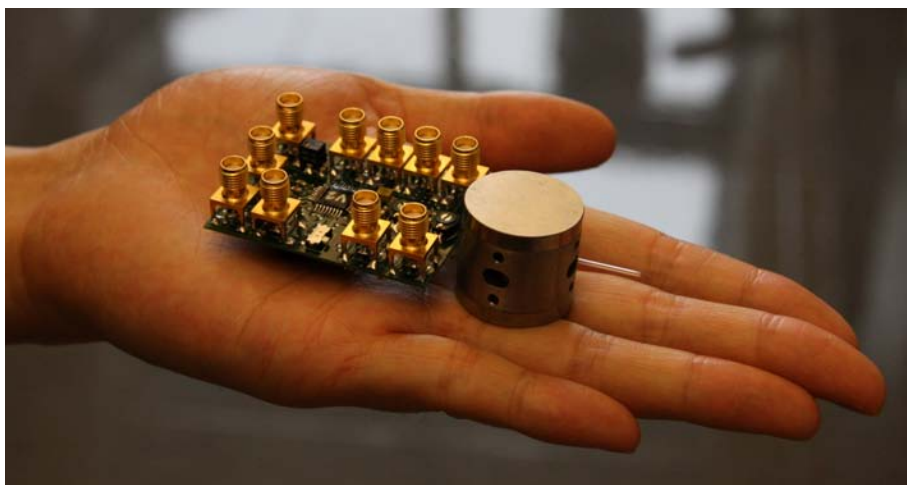
# Total Healthcare Costs



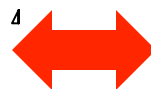
# Bringing Diagnostics to the People



# Handheld NMR Biosensor (Donhee Ham)



**Handheld 1-chip  
NMR relaxometer  
Weight ~ 1 lb  
Cost ~ \$100**



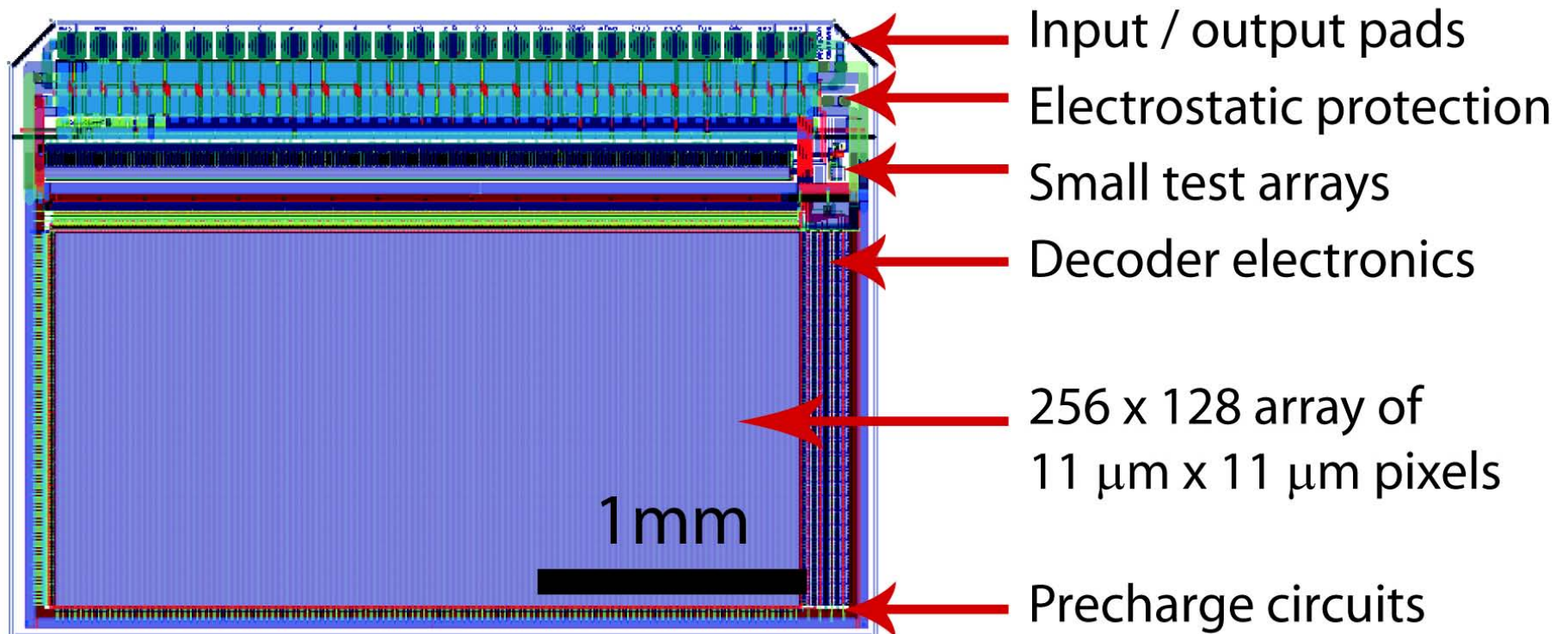
**Benchtop NMR  
Relaxometer  
Weight ~250 lb  
Cost ~ \$80,000**

**Same Molar Sensitivity**

**Portable, low-cost medical devices**

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# Programmable Microfluidics (Robert Westervelt)



**Integrated Circuit DEP “display” controls the motion of cells and droplets in a microfluidic chamber above**

**Tom Hunt, Dave Issadore, Keith Brown**

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# Biology & Chemistry on Chip

Containers

Transport

Release Contents

Mix Contents

Control Temperature

Control Individual Cells

Deform

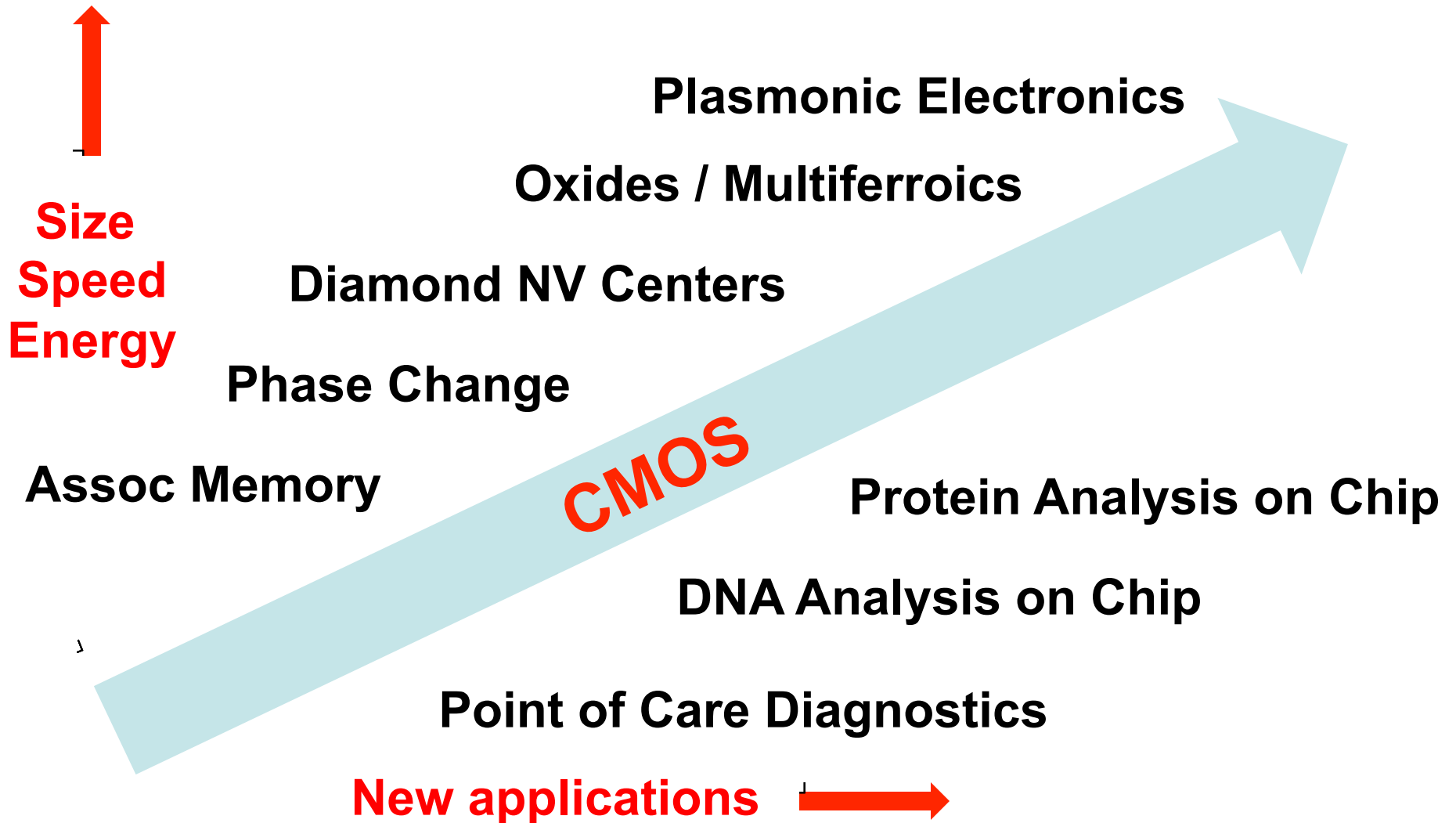




# Outline – The Future

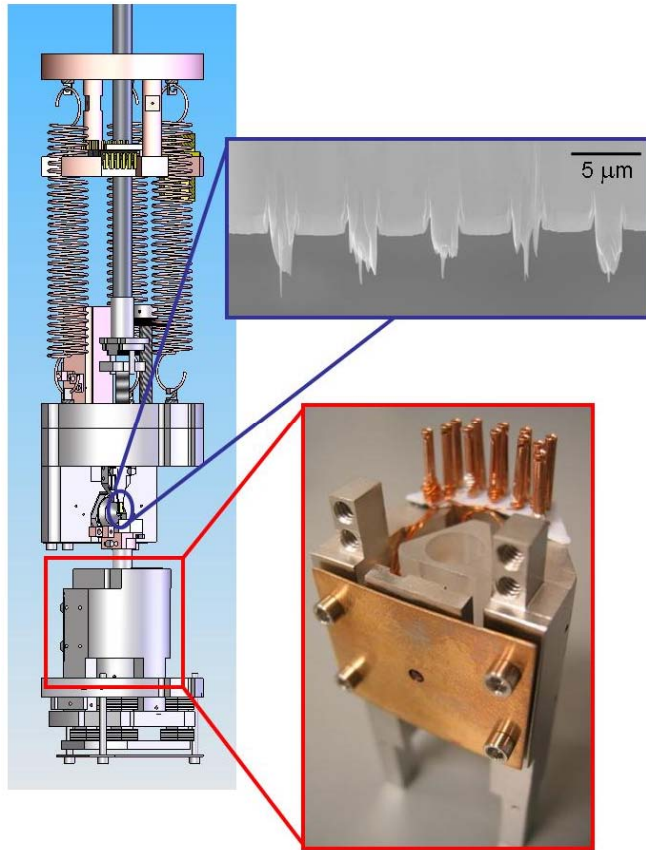
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# Nanoelectronics for the Future

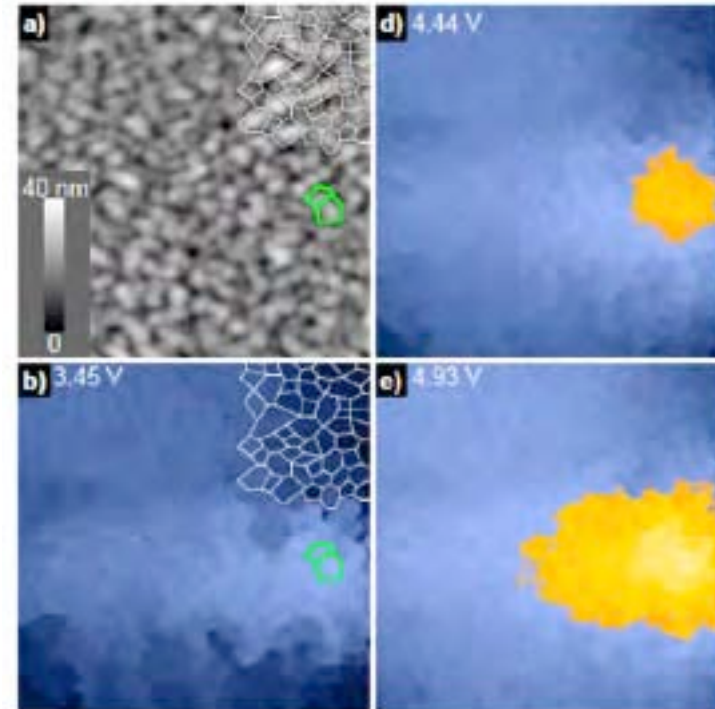


# Imaging the Metal-Insulator Transition in $\text{VO}_2$ thin films

(Shriram Ramanathan & Jenny Hoffman)



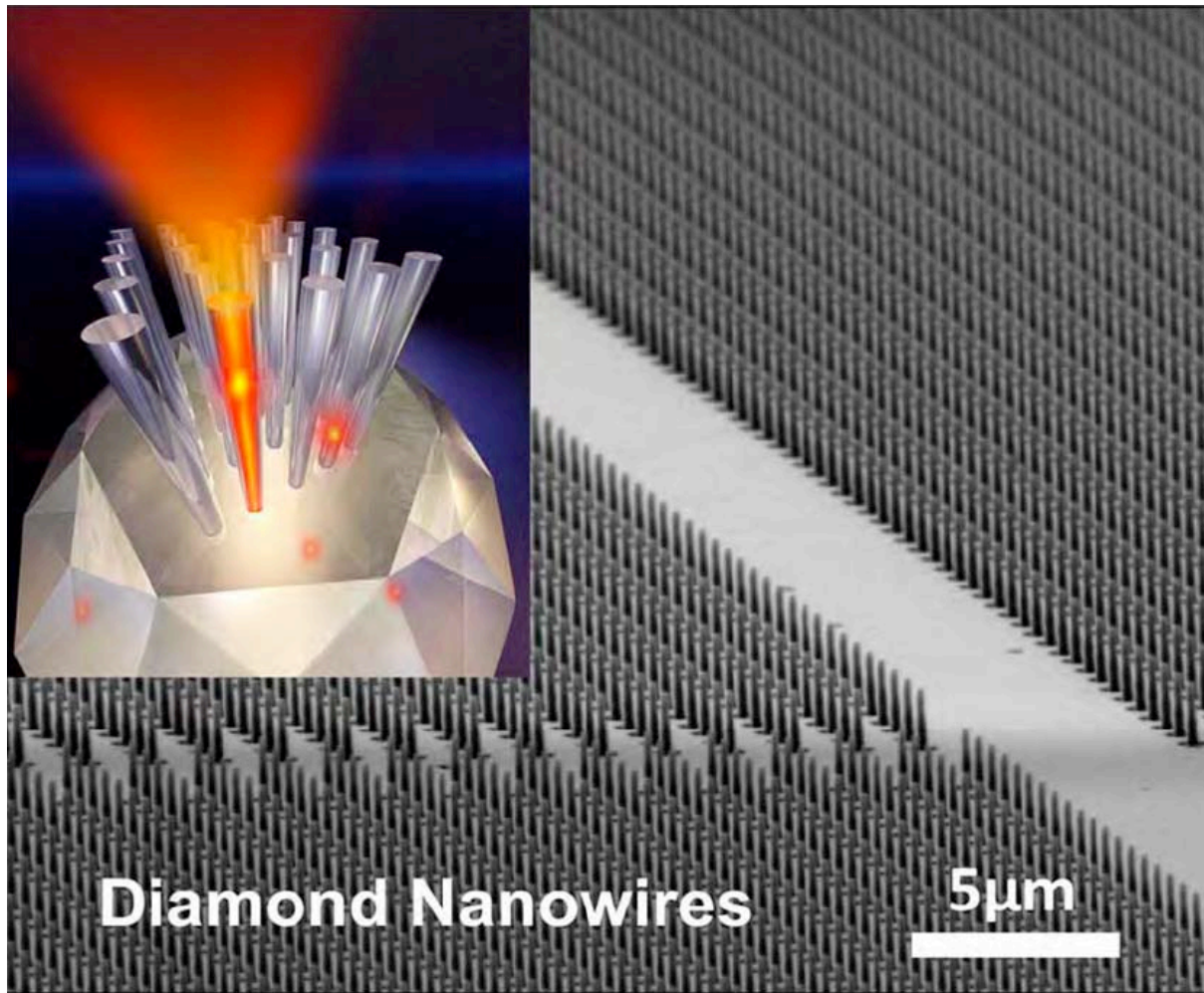
Custom made atomic force microscope (Hoffman).



Electric-field induced metal-insulator transition in a  $\text{VO}_2$  thin film imaged by a SPM (Hoffman and Ramanathan).



# Diamond Nanowire NV Centers (Marko Loncar)



**ultrasensitive magnetic field sensor**

**Mikhail Lukin**

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# Startups and Industrial Connections

## 23 Startups by NSEC Faculty (2001-2010)

*Arsenal Medical* (Bioactive Composites - Whitesides) to  
*SiEnergy Systems* (Oxide Fuel Cells - Ramanathan)

**440+** High Tech jobs created

## 30 Companies Licensed NSEC Researcher Intellectual Property (2001-2010)

**180+** Licenses on NSEC Researcher IP (2001-2010)

*Agilent Technologies* to *Vista Therapeutics*

**\$6.8M** total licensing fees (2001-2010)

## 43 Industrial Collaborations

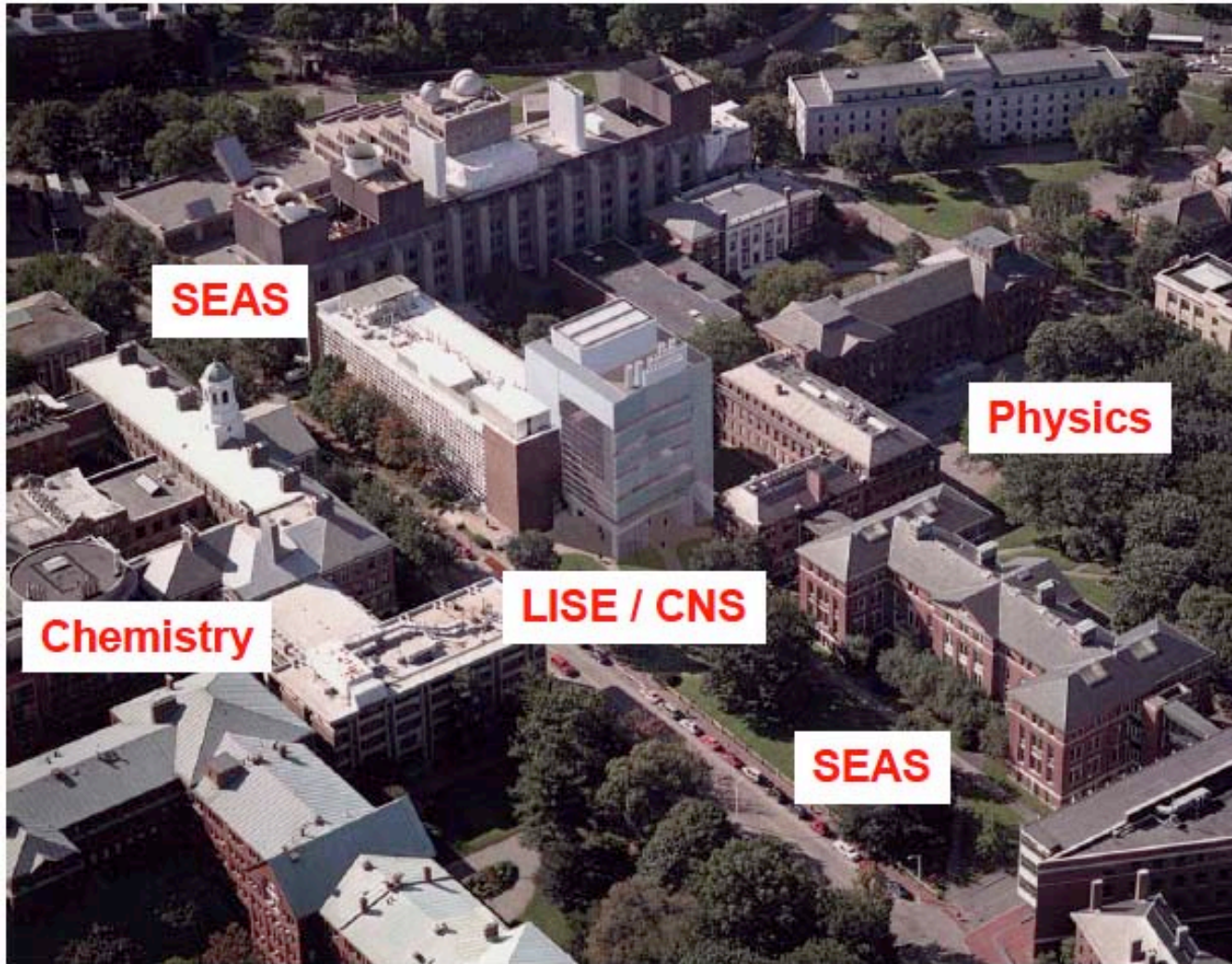
*Advanced Energy Consortium* to *Zena Technologies*

## 60 Connections with Industry & other Sectors

*Advanced Diamond Technologies* to *Zena Technologies*

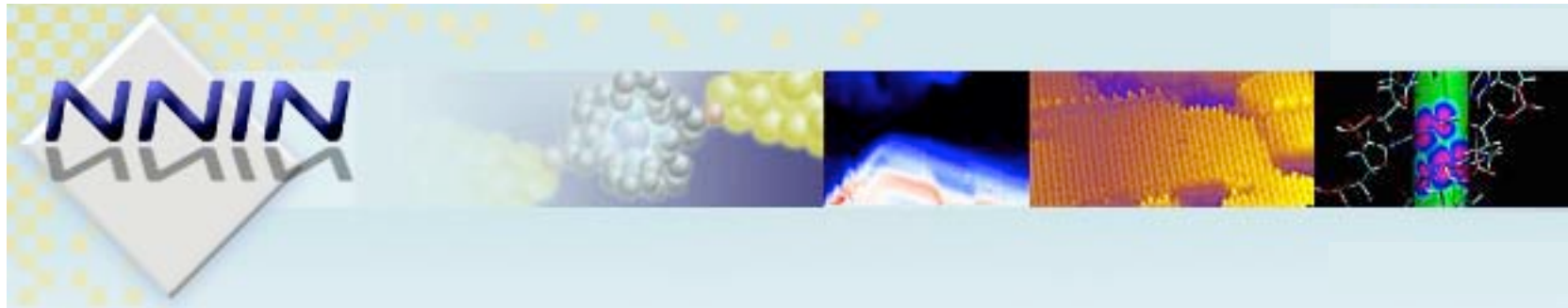


# LISE / CNS Nanofabrication, Electron Microscopy and Materials Synthesis Facilities at Harvard



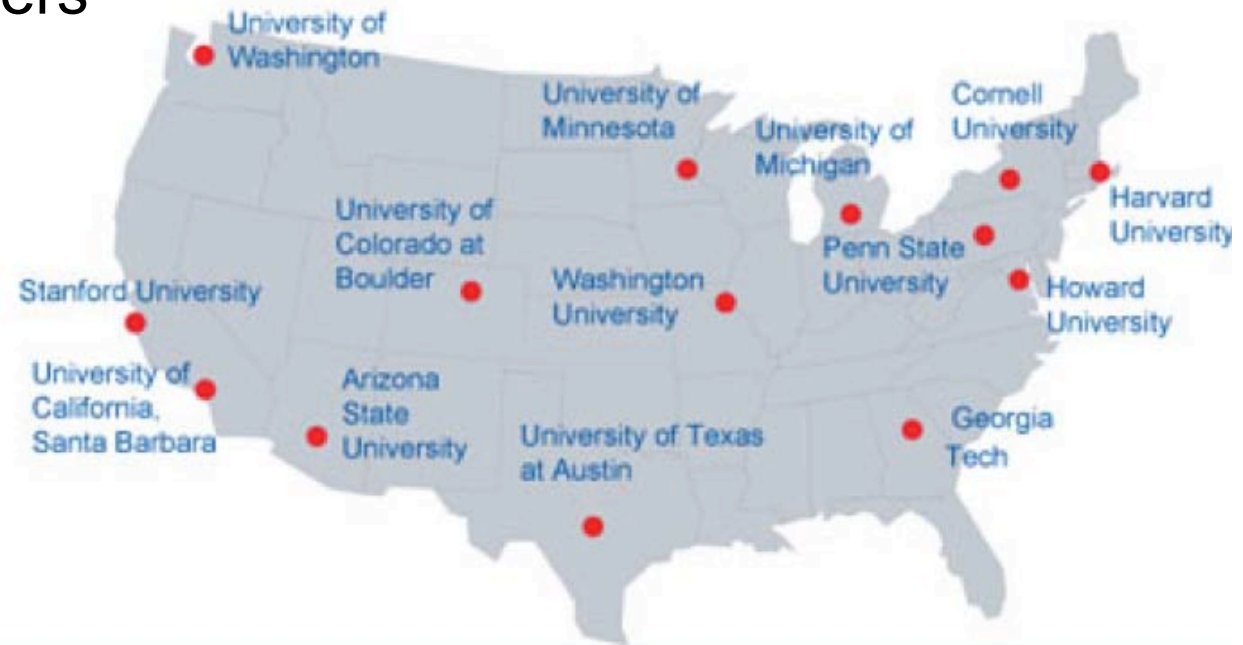
Laboratory for Integrated Science and Engineering (LISE) and Center for Nanoscale Systems (CNS) centered in between the School of Engineering and Applied Sciences (SEAS) laboratories, the Dept of Chemistry and Chemical Biology (Chemistry) and the Dept of Physics (Physics).

# National Nanotechnology Infrastructure Network



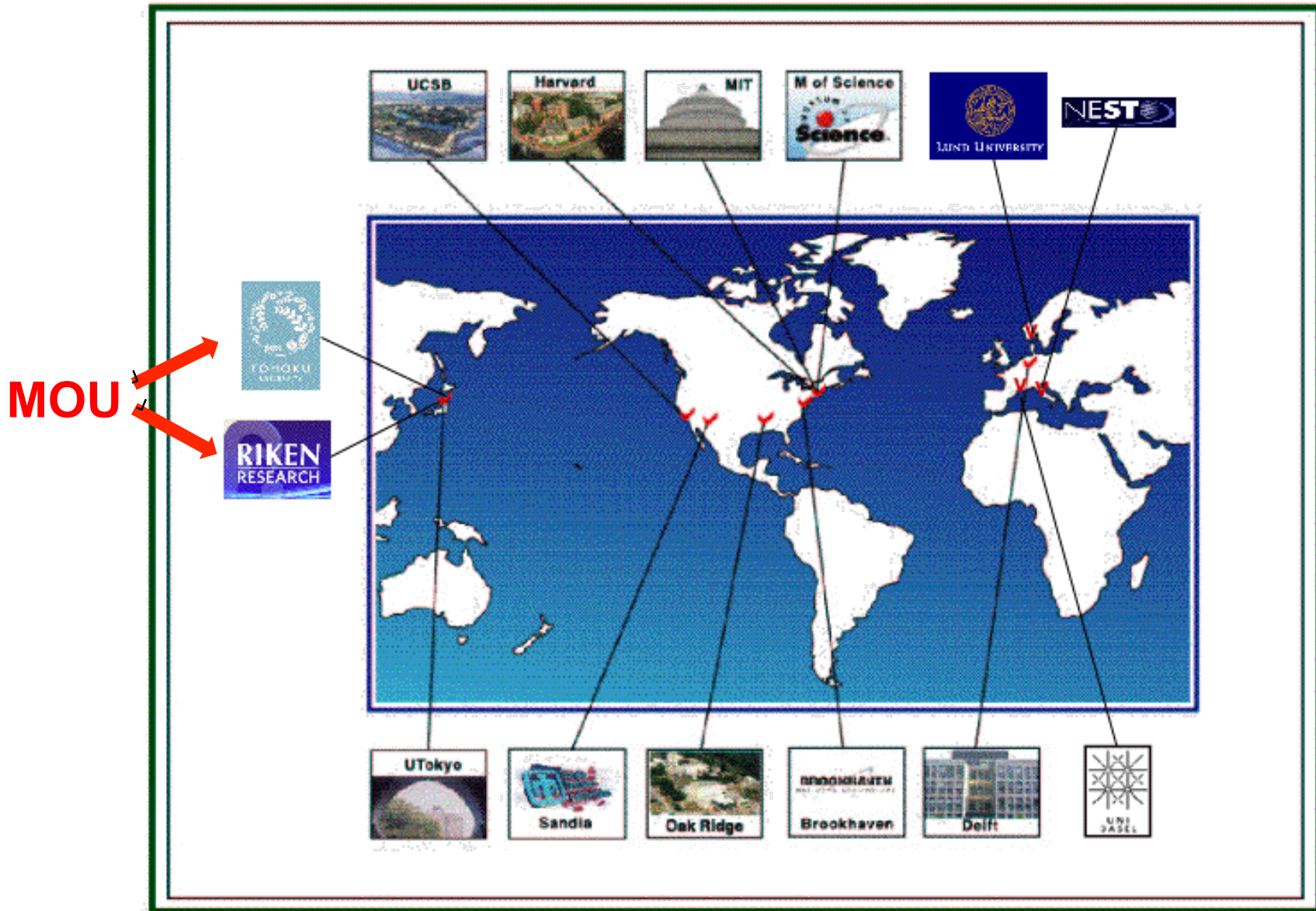
## Center for Nanoscale Systems (CNS) at Harvard

One of 14 members





# International Collaborations



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# Museum of Science, Boston / NISE Network



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# NSEC

## Science of Nanoscale Systems and their Device Applications

Overview Education Events Participants Highlights Research

### Robert Westervelt, PI & Director *and* Bertrand Halperin, Co-PI

Our Nanoscale Science and Engineering Center (NSEC) is a collaboration among Harvard University, the Massachusetts Institute of Technology, the University of California—Santa Barbara, and the Museum of Science—Boston with participation by Delft University of Technology (Netherlands), the University of Basel (Switzerland), the University of Tokyo (Japan), and the Brookhaven, Oak Ridge, and the Sandia National Laboratories.

The NSEC combines "top down" and "bottom up" approaches to construct novel electronic and magnetic devices with nanoscale sizes and understand their behavior, including quantum phenomena. Through a close integration of research, education, and public outreach, the Center encourages and promotes the training of a diverse group of people to be leaders in this new interdisciplinary field.



Harvard and UC Santa Barbara are two of an integrated partnership of thirteen user facilities, led by Cornell and Stanford, that provide opportunities for nanoscience and nanotechnology research.

*NSEC at Harvard is supported by the National Science Foundation.*

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- Industry & Outreach
- International Collaborators
- NanoTech Links
- Researchers



## Websites

[NSEC.Harvard.edu](http://NSEC.Harvard.edu)

[CNS.fas.Harvard.edu](http://CNS.fas.Harvard.edu)

[NNIN.org](http://NNIN.org)

[MOS.org/nano](http://MOS.org/nano)

[NISEnet.org](http://NISEnet.org)

**Thank You**

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