

# NIST Update

**Dr. James M. Turner**  
**Deputy Director**

VCAT Meeting  
June 10th, 2008

**NIST**  
**National Institute of  
Standards and Technology**  
U.S. Department of Commerce



## Outline

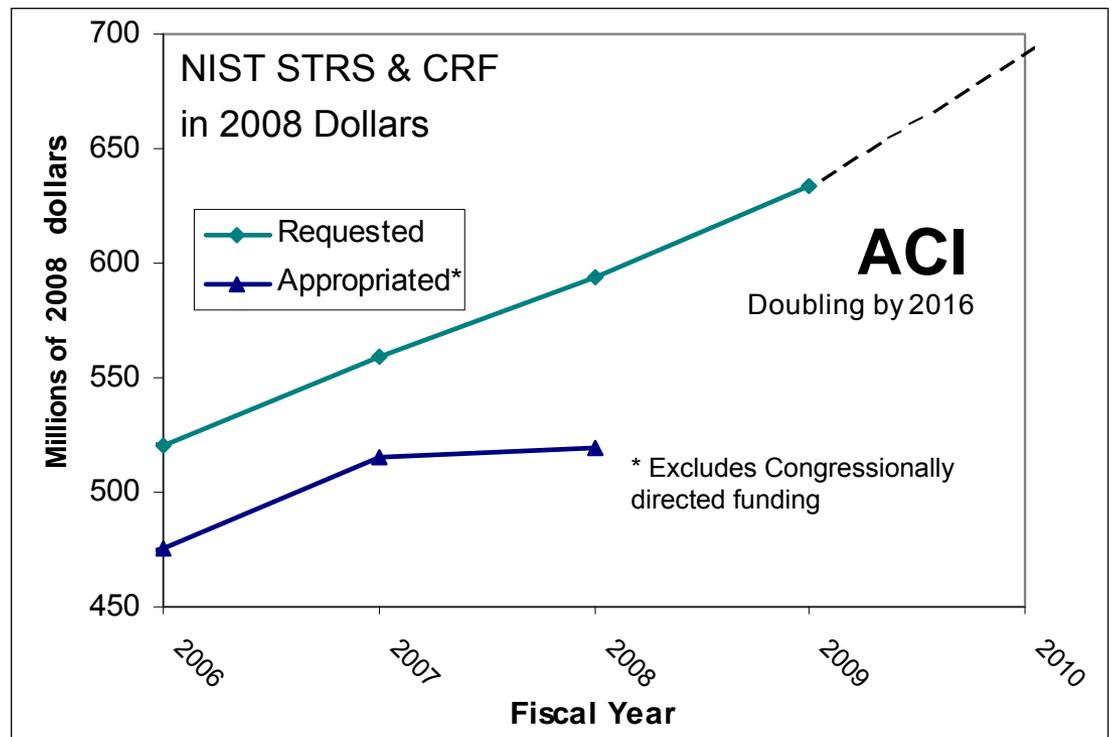
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### ➤ **Background to NIST FY09 Budget**

- NIST Recognition – External and Internal
- Technical Highlights
- Outreach and Partnership Activities

## ACI , America COMPETES – NIST has a major role

- NIST core research and facilities funding is critical to U.S. innovation,
- Both ACI and the America COMPETES Act call for substantially increased funding of NIST core research and facilities
- Increases provided in FY 2007 allowed projects to start in nanotech, neutron research, quantum science; need to sustain momentum
- FY 2008, NIST Laboratory funding cut in real dollars
  - \$13.5 million short of the amount needed to cover salary increases and other anticipated costs
  - Can't fund planned projects involving an additional 300 experts in hot R&D areas needed to jump start innovation efforts; can't fill more than 70 vacancies
- Need to get back on the ACI doubling track



# The FY08 Budget: Falling from the Doubling Track

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## Examples of the FY08 budget impact:

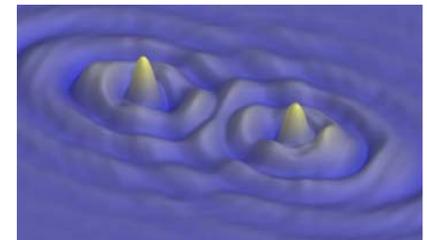
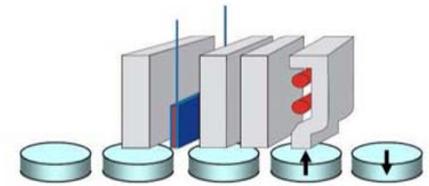
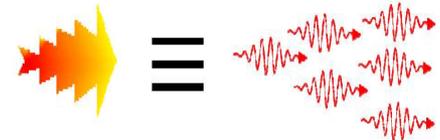
- **Nanotechnology:** Dramatically slows development of sorely needed characterization and measurement methods and standards **(NOT FUNDED)**
  - Reduces industrial ability to safely exploit nanotech's economic potential safely
  - Limits the development of next-generation, nanotechnology-based cancer therapies
  - Risks loss of consumer confidence in nanotech products
- **Quantum computing:** Postpones by at least a year progress in transformational research vital to the nation's competitiveness. **(NOT FUNDED)**
  - Delays development and implementation of absolutely secure solutions for financial and national security communications
- **Climate change:** Curtails improvement of the accuracy and credibility of climate change predictions relied upon by policy makers assessing the advantages and consequences of options for mitigating climate change. **(NOT FUNDED)**
  - Sets back calibrations of satellite sensors needed to quantify measures of solar irradiance and terrestrial temperatures
- **Earthquake, flood, and wildfire-resistant structures:** Opportunities to reduce \$52 billion in annual natural disaster-related losses will be missed. **(NOT FUNDED)**
  - Slows progress in developing model building codes, standards and tools for evaluating seismic strength as well as wind- and wildfire-resistance of buildings and communities

**These new initiative areas build upon, but do not replace, NIST's existing and essential core research programs to tackle some of the toughest problems facing the Nation today.**

# FY 2008 Innovations in Measurement Science (IMS) projects

The IMS program funds innovative, high priority research within NIST to expand or develop expertise to support emerging national metrology needs.

- **Redefining Optical Power Traceability: Bridging the Gap from Single Photons to Tera-photons**  
To radically change the traceability of optical power and energy (EEEL, PL, ITL)
- **Magnetic Nanostructures for Post-CMOS Nanoelectronics**  
To develop alternative device architectures to overcome “beyond CMOS” limiting dimensions and frequencies (MSEL, ITL, EEEL)
- **High Frequency Nanoscale Spintronics: Metrology for Beyond CMOS**  
To develop metrology of the magnetic effects at the nanoscale where defects dominate device behavior (EEEL, ITL)
- **NIST Standard Stars**  
To develop absolute stellar calibration SI traceable standards for astronomy, satellite, and defense programs (PL)



# Getting Back on the Doubling Track—FY 2009 Request for NIST

(in millions of dollars)

	FY 2007 <u>Enacted</u>	FY 2008 <u>Enacted</u>	FY 2009 <u>Request</u>
Scientific & Technical Research & Services (without directed grants)	\$434.4	\$439.6*	\$535.0
Construction of Research Facilities (without directed projects & construction grants)	\$ <u>58.7</u>	\$ <u>79.2</u> **	\$ <u>99.0</u>
	\$493.1	\$518.8	\$634.0
<div style="border: 1px solid black; padding: 5px; display: inline-block;">           NIST Core      Δ (08-09) = <b>+\$115.2 (+22%)</b> </div>			
Industrial Technology Services	\$183.8	\$154.8	\$ 4.0
	(MEP+ATP)	(MEP+TIP)	(MEP)
<b>Total NIST</b>	<b>\$676.9</b>	<b>\$673.6</b>	<b>\$638.0</b>

\* Does not include \$0.9 million for a congressionally directed project

\*\* Does not include \$81.3 million for congressionally directed projects and competitive construction grants

## Budget Request for MEP and Technology Innovation Program

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### President's FY 2009 budget proposes an end to federal funding of the Hollings Manufacturing Extension Partnership Program and the Technology Innovation Program (TIP)

- Very difficult decisions based on the need to fund higher priorities during tough budget times
- FY 2009 request provides \$4M for federal MEP shutdown costs
- No TIP funding requested for FY 2009
- TIP phase-out costs would be funded from carryover funds from FY 2008

# FY 2009 President's Budget Request Increases for NIST

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*New initiatives are in italics*

## Addressing urgent environment, safety, and security needs (+\$26.2 million)

- ***Nanotechnology: Environment, Health & Safety Infrastructure***
- Climate Change Science: Measurements and Standards
- National Earthquake Hazards Reduction Program
- Disaster Resilient Structures and Communities
- Biometrics: Identifying Friend or Foe

## Boosting U.S. science/engineering capacity and capability (+\$63.7 million)

- NIST Center for Neutron Research (NCNR) Capacity and Capability
- Boulder Building 1 Extension: 21st Century Tools
- JILA Building Expansion: Pushing the Scientific Frontier
- Safety, Capacity, Maintenance and Major Repairs

## Investing in strategic and rapidly advancing technologies (+\$42.8 million)

- ***Bioscience Measurements & Standards***
- Quantum Information Science
- Nanotechnology: Discovery to Manufacture
- Innovations in Measurement Science
- ***Comprehensive National Cyber Security Initiative: Leap Ahead Technologies***
- ***Optical Communications and Computing***
- Enabling the Use of Hydrogen as a Fuel
- Manufacturing Innovation through Supply Chain Integration

## Nanotechnology: Environment, Health & Safety (+\$12M)

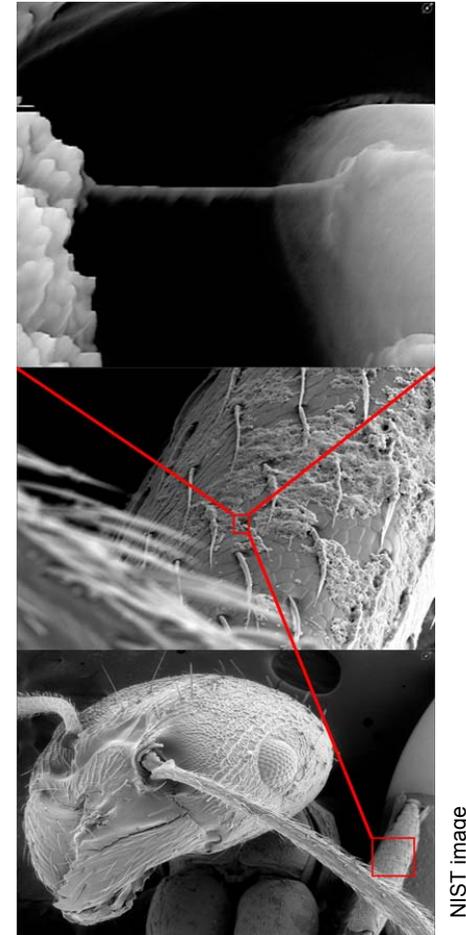
### Environmental, health & safety of nanotechnology—Very little known

- Hundreds of products already contain nanoscale components
- Regulatory agencies lack basic scientific information to assess and address risks
- Industry concerned about liability

### Funding increase will allow:

- Development of accurate measurement and detection methods
- Industry to exploit the tremendous economic potential of nanotech safely
- Consumers to retain confidence in nanotech products

“NIST is ideally positioned to lead the development of characterization methods and standards, building on extensive expertise and experience in this area [of nano-EHS].” –  
*Woodrow Wilson International Center (2006)*



NIST image

A carbon nanotube is shown on the hair of an ant's leg

## Bioscience Measurement and Standards (+\$10M)

### Inaccurate bioscience measurements increase the cost and lower the quality of healthcare

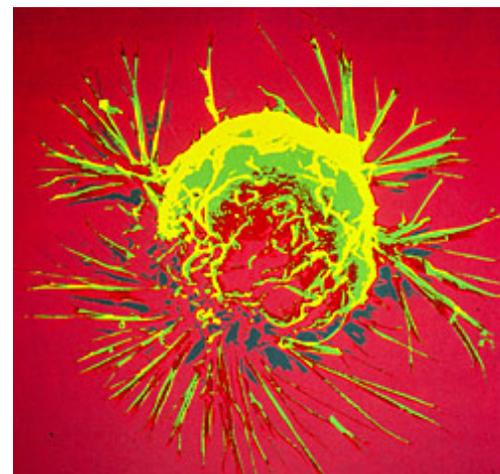
- Requires retesting, possible misdiagnosis
- Costly drug design, \$1 billion per drug, 8-10 years, 8 % reach market

### Biopharmaceutical economics study found:

- Better measurements should reduce R&D costs for approved drugs by 25-45 %
- Reduce manufacturing costs by 23 %

### NIST bioscience initiative will help

- Reduce errors, reduce costs, and enable innovative medical technologies
- Pave the way to personalized medicine
- Widen use of bioinformatics and modeling tools
- Enable “systems biology”—quantitative approach to disease analysis and drug design



Source: National Cancer Institute

False color image of breast cancer cell. Breast cancer alone can be linked to mutations in over 100 different genes – with no two tumors sharing the same pattern of mutations. This diversity makes treatment and management of cancer extremely difficult.

Inaccurate bioscience measurements sometimes make it hard to tell when treatments are healing or causing harm.

## Comprehensive Cyber Security Initiative (+\$5M)

### U.S. economy reliant on interconnected networks

- Face ever-increasing threats
- Improving network security must be a national priority

### NIST a recognized world leader in cyber security

### Initiative funding will thwart attacks by

- Development of new cryptographic keys
- Improved interoperability and authentication of users
- Standardization of computer security settings

### Results will include

- Lower economic impact from ID theft
- Increased productivity in cyber security



© Shutterstock

Better cryptographic "keys" will lead to improved security on computer networks.

This NIST request is part of the Administration's Comprehensive National Cyber Security Initiative

## Optical Communications and Computing (+\$5.8M)

### High-speed communication drives the economy

#### Downloads much faster in other countries

- Japan, Korea, Finland—10 to 30 times faster than in U.S.
- U.S. geography/industrial structure require different technology to reach these speeds

#### U.S. optical networks choked with data traffic, not well synched

- Need better measurements
- Ways to redirect traffic around bottlenecks

#### Next generation computers may use light instead of electronics

- Need ways to measure performance, allow interconnection of devices

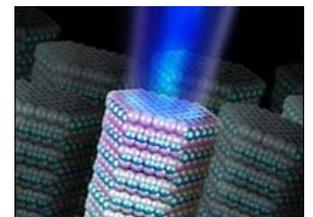
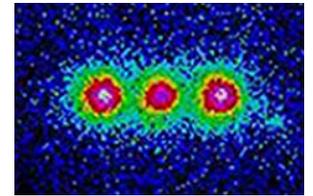
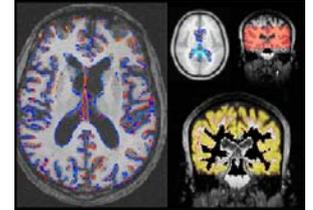


Better tools for measuring light can lead to faster computers and improved communications networks.

## FY 2010 Initiative Topical Areas

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- Advanced Biomedical Measurements for Accelerating Innovation in Healthcare
- Ensuring U.S. Competitiveness in a Quantum World
- Enabling Security Through New Energy Technologies
- Measurement Science for a Sustainable Future
- Future U.S. Manufacturing: High Value, Knowledge Intensive Production



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- **NIST Recognition – External and Internal**
- Technical Highlights
- Outreach and Partnership Activities

## Staff Recognition

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# 2007 ARTHUR S. FLEMMING AWARDS RECOGNIZING OUTSTANDING FEDERAL GOVERNMENT SERVICE



**John Butler, chemist**

His contributions to the field of DNA measurement science for human identification, particularly for investigations of mass disasters (both natural and intentional) and missing persons.



**Eric Shirley, physicist**

For fundamental theoretical advances in solid-state physics to enable accurate prediction of optical properties of materials and in optical diffraction.



**Taner Yildirim, physicist**

For developing new approaches to understanding, identifying and exploiting key properties in superconductive and hydrogen storage materials.

### Other Major Awards



**James Bergquist, 2008 Arthur L. Schawlow Prize in Laser Science**

His contributions to laser science and tests of fundamental physical principles in application to ultra-stable lasers to test fundamentals of quantum mechanics.

**Debbie Jin, 2008 Benjamin Franklin Medal in Physics**

For her pioneering investigations of the quantum properties of an ultracold gas of fermionic atoms, atoms that cannot occupy the same quantum state, and in particular for the creation of the first quantized gas of fermionic atoms.



**John Kitching, MIT's 10 Emerging Technologies of 2008**

For developing a chip-scale atomic magnetometer with others in PL and EEEL.

# Staff Recognition

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## Society Fellows



**Kent Irwin,  
APS Fellow**



**Alan Migdall  
APS Fellow**



**Stephen Long  
Royal Society of Chemistry  
Fellow**



**Paul Lett  
AAAS Fellow**



**Ted Heilweil  
OSA Fellow**



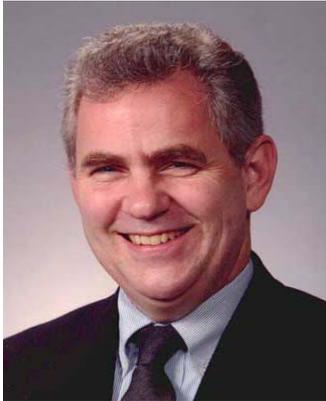
**Thom Germer  
SPIE Fellow**



**Richard Silver  
SPIE Fellow**

# Administration Changes...

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Chemical Science and  
Technology Laboratory  
Deputy Director

Richard Cavanagh



Baldrige National Quality  
Program  
Deputy Director

Jeffrey Lucas



Building and Fire Research  
Laboratory  
Deputy Director

William Grosshandler



Center for Nanoscale  
Science and Technology  
Deputy Director

Lloyd Whitman

# NIST Fellows and Senior Research Scientists (as of June 2, 2008)

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## **Building and Fire Research Laboratory:**

Richard G. Gann (Senior Research Scientist)  
Emil Simiu

## **Center for Nanoscale Science and Technology**

Joseph A. Stroscio

## **Center for Neutron Research**

Jeffrey W. Lynn  
Charles F. Majkrzak  
Tawfik Raby (Senior Research Scientist)

## **Chemical Science and Technology Laboratory:**

John M. Butler **new in 2008**  
M. Miral Dizdar  
Michael R. Moldover  
Raymond D. Mountain  
Dale E. Newbury  
Stephen S. Stein  
Wing Tsang

## **Electronics and Electrical Engineering Laboratory:**

Herbert S. Bennett  
Kent D. Irwin  
Edwin R. Williams  
Information Technology Laboratory:  
Emanuel H. Knill  
Geoffrey McFadden  
Kevin L. Mills (Senior Research Scientist)

## **Information Technology Laboratory:**

Emanuel H. Knill  
Geoffrey McFadden  
Kevin L. Mills (Senior Research Scientist)

## **Materials Science and Engineering Laboratory:**

William J. Boettinger  
William F. Egelhoff  
Brian R. Lawn  
Sheldon Wiederhorn  
Wen-li Wu

## **Physics Laboratory:**

Eric A. Cornell  
Deborah Jin  
Judah Levine  
Paul Julienne  
David J. Nesbitt  
William D. Phillips  
David J. Wineland  
Jun Ye

## Outline

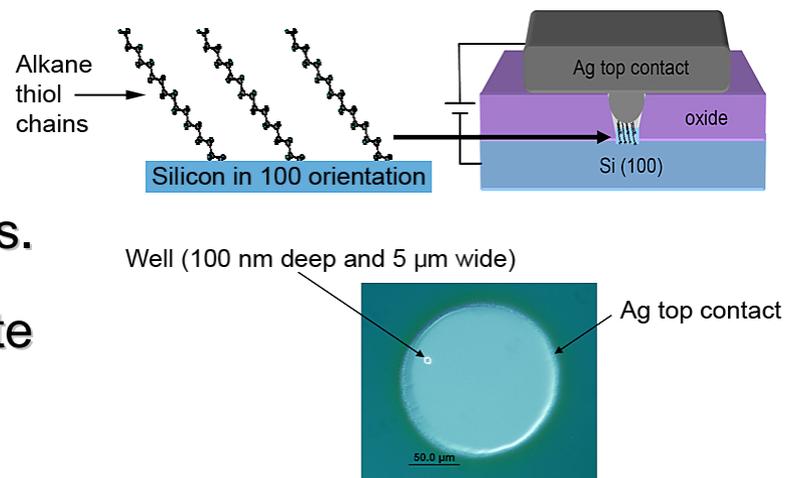
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## Technical Highlights ... *Rapidly Developing Technologies*

### Bridging Conventional and Molecular Electronics

- NIST researchers demonstrated that a single layer of molecules can be assembled on the same sort of substrate used in conventional microelectronic chips.
- The ability to use a silicon crystal substrate that is compatible with the industry-standard CMOS (complementary metal oxide semiconductor) manufacturing technology paves the way for hybrid CMOS-molecular device circuitry—the necessary precursor to a “beyond CMOS” totally molecular technology—to be fabricated in the near future.

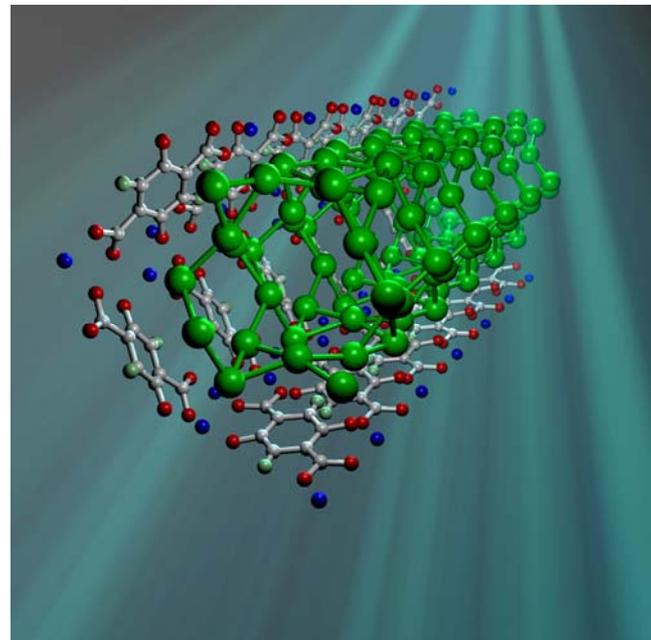


Side and top views of the NIST molecular resistor. Above are schematics showing a cross-section of the full device and a close-up view of the molecular monolayer attached to the CMOS-compatible silicon substrate. Below is a photomicrograph looking down on an assembled resistor indicating the location of the well.

## Technical Highlights ... *Rapidly Developing Technologies*

### New Hydrogen Storage Materials

- NIST researchers have demonstrated that a novel class of materials could enable a practical hydrogen fuel tank
- MOF-74 is a porous crystalline powder that resembles a series of tightly packed straws comprised of mostly carbon atoms with columns of zinc ions running down the inside walls.
- Neutron scattering and gas adsorption techniques were used to determine that at 77 K (-196 C), MOF-74 can adsorb more hydrogen than any unpressurized framework structure studied to date—packing the molecules in more densely than they would be if frozen in a block.
- This is a first step toward achieving greater energy densities at higher, and thus less costly, temperatures.

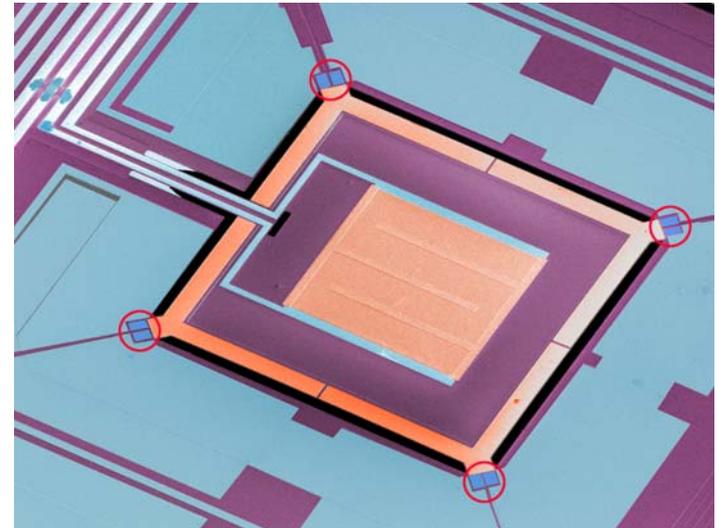


MOF-74 resembles a series of tightly packed straws comprised mostly of carbon atoms (white balls) with columns of zinc ions (blue balls) running down the walls. Heavy hydrogen molecules (green balls) adsorbed in MOF-74 pack into the tubes more densely than they would in solid form.

## Technical Highlights ... *Rapidly Developing Technologies*

### NIST Micro Sensor and Micro Fridge

- Researchers at NIST have combined two tiny but powerful NIST inventions on a single microchip, a cryogenic sensor and a micro refrigerator.
- This combination offers new applications:
  - in cheaper, simpler semiconductor defect analysis using X-rays (A small company is already commercializing an earlier version of this technology)
  - for use in astronomical telescopes which are increasingly using arrays of these chips to take pictures of the early universe at millimeter wavelengths - the NIST chips would lower the temperature and increase the speed at which these images could be made

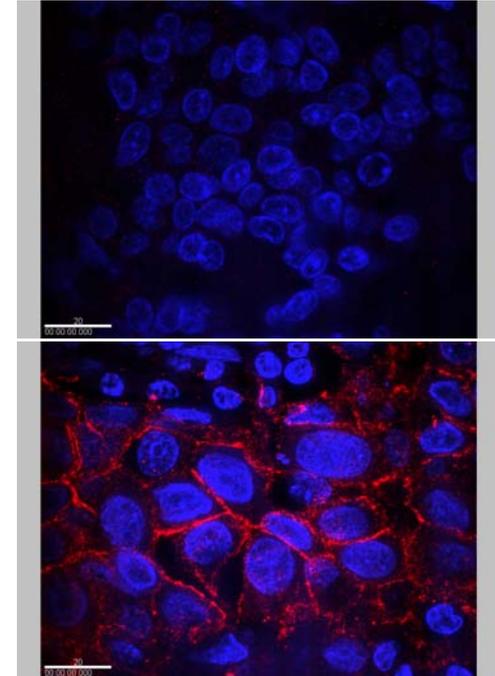


Colorized micrograph of a NIST chip combining four micro-refrigerators (circled in red) with a superconducting sensor (large orange square in the middle). The self-cooling chip could be used for applications ranging from detailed X-ray analysis of semiconductors to detection of microwave signals in deep space.

## Technical Highlights ... *Rapidly Developing Technologies*

### New Method for Detecting HER2 Breast Cancer

- Researchers at NIST, NCI, and SAIC have shown how to improve the detection of an aggressive form of breast cancer.
- The cancer biomarker HER2 is over expressed in 20-25% of breast cancers. New detection of this biomarker by tagging a target antibody with quantum dots (tiny, intense and tunable sources of colorful light) allows for more sensitive and reliable detection than the existing diagnostic tests.
- Improved reliability of the diagnostic test prevents some women from receiving a somewhat risky and expensive treatment that won't fight the type of cancer they have.
- NIST is funding the development of a standard reference material to support HER2 testing.



Immunohistochemical detection of HER2 cancer biomarker with IgY antibody and quantum dots is demonstrated in these samples of breast cancer cells from a patient with over production (bottom). Cell nuclei are stained blue, quantum dots responding to the HER2 protein light up in bright red at the cell membranes. Treatment with trastuzumab could only be effective for the latter patient.

## Technical Highlights ... *Responding to National Needs*

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### NIST Evaluates Firefighting Tactics In NYC High-Rise Test

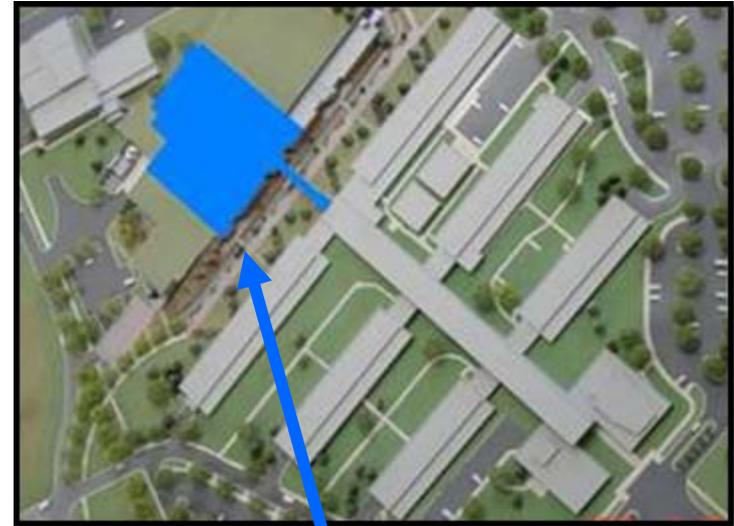
- NIST researchers turned an abandoned New York City (NYC) brick high-rise into a seven-story fire laboratory to develop an understanding of the wind-driven fires and measure the impact of firefighting tactics.
- Research findings from the Governors Island experiments are expected to help improve fire service guidelines for combating high-rise fires, enhance firefighter safety, and improving fire ground operations and use of equipment.
- NIST expects to issue a report on the high-rise experiments by November 2008.



Firefighters watch as a fan, simulating wind, changes airflow and smoke conditions during experiments in a seven-story high-rise abandoned apartment building on New York City's Governors Island. The NIST tests examined firefighting techniques such as the use of positive pressure ventilation fans, wind control devices and hose streams to control or suppress heat and smoke from wind driven fires.

# ACI Initiated Construction: B1/E Update

- Awarded design-build contract
  - ~225,000 GSF (Gross Square Feet); 48,000 NASF (Net Assignable Square Feet) of instrument lab and clean room quality space
- Phased funding and construction
  - \$10.1M reprogrammed for design update, PCAS (Post Construction Award Services), labor
  - Phase 1: \$28.0M in FY08 (lab side only; warm lit shell suitable for office space)  
**Planned award and Notice to Proceed scheduled for September 2008**
  - Phase 2: \$38.1M in FY09 (office side and finish to lab quality space)
- MRAD (Mountain Region Acquisition Division) providing contract support
  - Project re-discovery and initiation completed August 2007
- Awarded task order for design update late September 2007
- **Design update completed as scheduled in April 2008**
- **Construction documents sent out for cost proposals with bids due in mid-June.**
- **Other Boulder Construction: Central Utility Plant scheduled to be complete in June 2008.**



**Extension**

# ACI Initiated Construction: NCNR Update

## Current status...

### Construction:

- Awarded construction management contract;
- Awarded design-build contract;
- Notice-to-proceed expected June 2, 2008;
- Construction start expected October 1, 2008;

### Instruments:

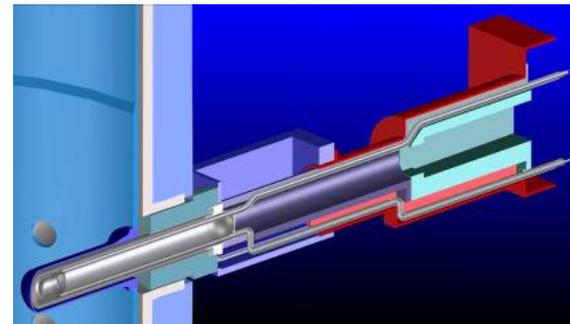
- Instrument suite selected with community input;
- Instrument conceptual designs approved;
- Design baselines under review;

### Guides:

- Developed guide system analysis & design;
- Awarded guide contract;
- Procurement of guides is underway (50%);
- Design of guide vacuum casings/shielding underway;

### Cold source:

- Completed design & analysis;
- Completed regulatory review;
- Built and tested scaled mock up;
- Detailed design & fabrication underway;



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## Smart Grid Activities at NIST

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### The Energy Independence and Security Act of 2007

mandates NIST to “coordinate the development of a framework that includes protocols and model standards for information management to achieve interoperability of smart grid devices and systems”



### Work Plan:

- Establish Smart Grid interoperability stakeholders group
- Make assessment of standards needs
- Participate in DOE Smart Grid Implementation Workshop, June 2008
- Host NIST Workshop on Smart Grid, November 2008
- Report on assessment of Smart Grid standards and recommendations for further standards development, December 2008
- Continue coordination of interoperability framework through working groups

# NIST - Nanoelectronics Research Institute (NRI) Partnership

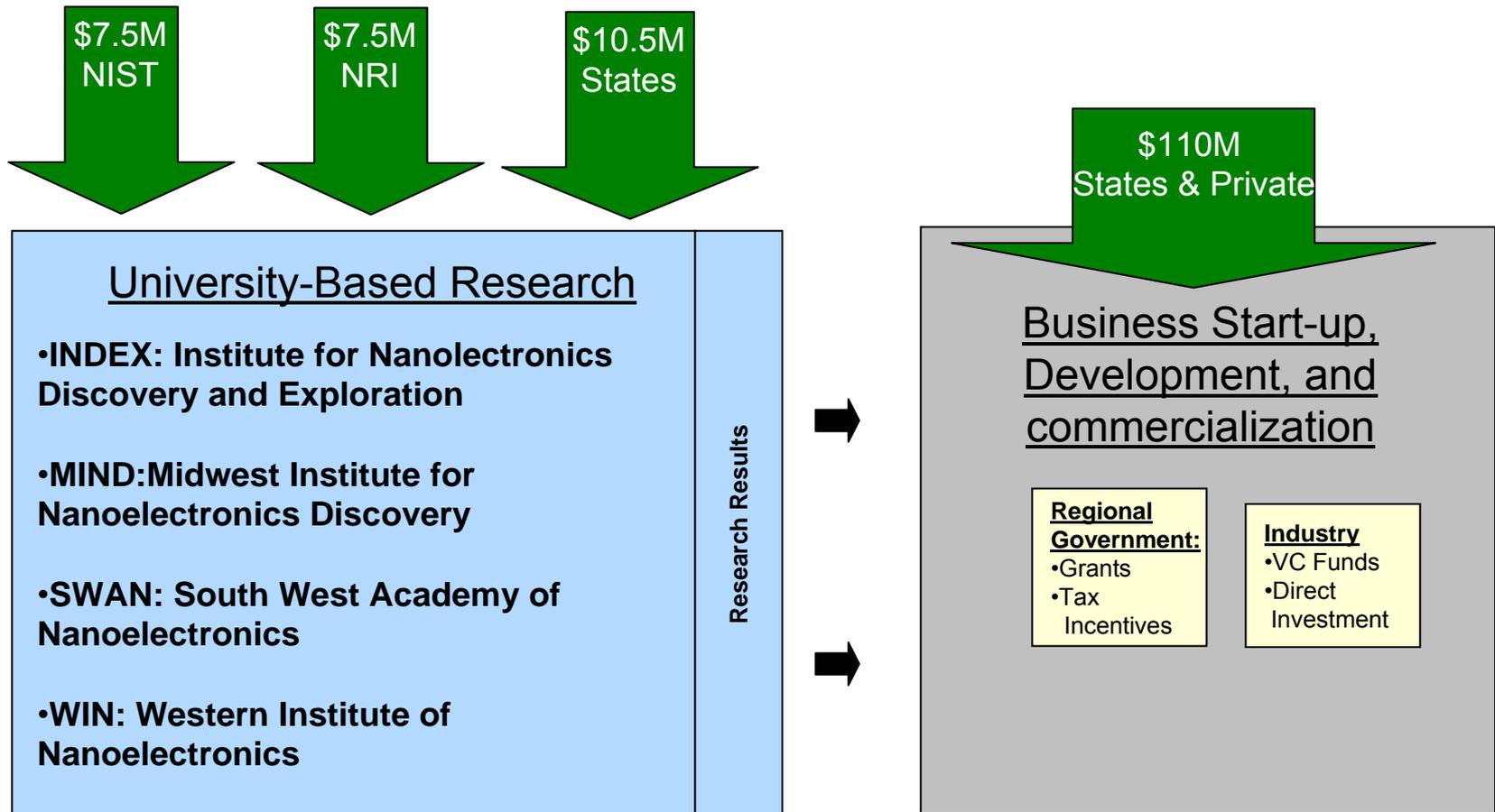
NRI Members: AMD, Freescale, IBM, Intel, Micron, TI



## Oversight and Strategic Planning

International Technology Roadmap for Semiconductors

*POST-CMOS: NRI Defined 13 Research Vectors of primary importance for finding the next switch*





### MIND

Midwest Institute For  
Nanoelectronics  
Discovery

★ Notre Dame  
Illinois-UC  
Michigan

Purdue  
Penn State  
UT-Dallas



★ SUNY-Albany GIT  
Purdue RPI  
Caltech MIT  
Yale UVA

Harvard  
Columbia  
NCSU



Western  
Institute of  
Nanoelectronics

★ UC Los Angeles  
UC Berkeley  
UC Irvine  
UC Santa Barbara  
Stanford  
U Denver  
Portland State  
U Iowa



SWAN  
Southwest Academy of Nanoelectronics

★ UT-Austin  
UT-Dallas  
U. Maryland

Rice  
ASU  
NCSU

Texas A&M  
Notre Dame  
Illinois UC

Columbia  
Harvard  
Purdue  
UVA  
Yale  
UC Santa Barbara  
Stanford  
U. Mass  
U. Arkansas  
U. Oklahoma  
Notre Dame  
U. Nebraska/Lincoln  
U. Maryland  
Cornell  
UT Austin  
Caltech



**35 Universities in 20 States**

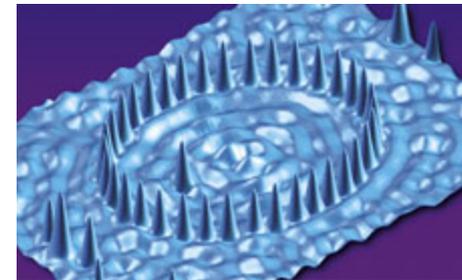
# College for Nanoscale Science and Engineering (CNSE) of the University at Albany-State University of New York

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**New MOU signed in April 2008**

**Partnership provides:**

- a framework for both organizations to share research, equipment, staff and other key resources
- for the development of future efforts in science and technology for measuring materials at the nanometer scale as well as creating new standards for nanomanufacturing



**Nanometer measurements are critical to the development of smaller and faster computer chips that offer higher performance and reduced power consumption for use in a wide range of industries, from health care, energy and telecommunications to military, aerospace and transportation**

## ***2007 Malcolm Baldrige National Quality Award Recipients***

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**April 23, 2008: President George W. Bush greets the recipients of the 2007 Malcolm Baldrige National Quality Award in the Oval Office.**



**The 2007 Baldrige Award recipients —listed with their category—are:**

**PRO-TEC Coating Co., Leipsic, Ohio (Small Business)**

**Mercy Health System, Janesville, Wisconsin (Health Care)**

**Sharp HealthCare, San Diego, California (Health Care)**

**City of Coral Springs, Coral Springs, Florida (Nonprofit)**

**U.S. Army Armament Research, Development and Engineering Center (ARDEC), Picatinny Arsenal, New Jersey (Nonprofit)**