National Innovation Institutes: The National Institute for Nano-Engineering

SAND2008-0609P

A new model for developing the Future Innovators and Innovations in Science & Engineering through a Unique Partnership

Government ⇔ University ⇔ Industry

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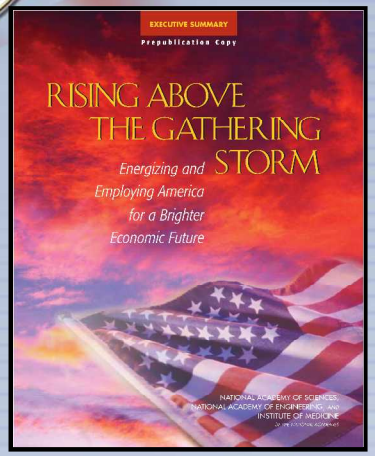
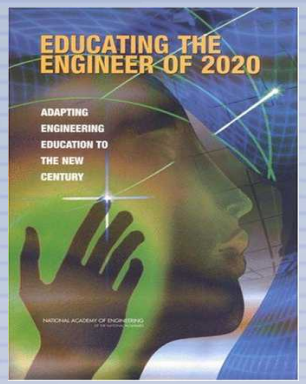
Sandia National Laboratories

The future of America's Innovation Engine has been called into question

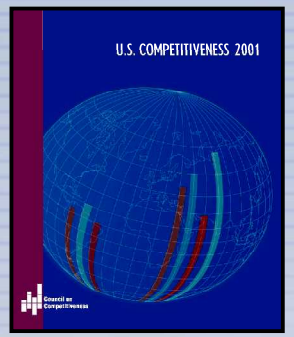


Rising Above The Gathering Storm, *National Academies*, 2006 (Augustine)

Engineering Research and America's Future, *National Academies*, 2005 (Duderstadt)



Educating the Engineer of 2020, *National Academies*, 2005 (Clough)



U.S. Competitiveness 2001: Strengths, Vulnerabilities and Long Term Priorities, *Council on Competitiveness*

Bell Laboratories

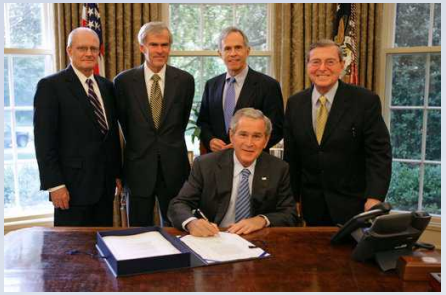
GE

IBM

DUPONT
The miracles of science

- Global competition for talent, markets
- Significant reductions in U.S. industrial R&D.
- The world is closing the technology gap.
- Government – industry - university partnerships used in other countries with success.

America COMPETES Act



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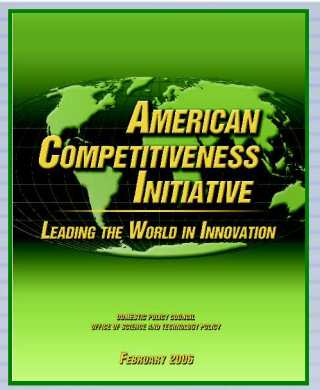
The nation is developing an aggressive plan

"In partnership with the private sector, State and local governments, and colleges and universities, the American Competitiveness Initiative will promote new levels of educational achievement and economic productivity."

GEORGE W. BUSH, STATE OF THE UNION ADDRESS, 2/2/2006



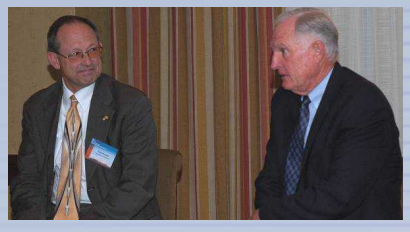
National Science Foundation
WHERE DISCOVERIES BEGIN

America COMPETES Act signed into law August, 9th, 2007

- ✓ Discovery Science & Engineering Innovation Institutes included as a provision for DOE.

All the R&D sectors recognize a few key challenges

Accelerating Engineering Innovation Summit, Sandia National Labs
Albuquerque, May 31st - June 2nd, 2006



Participants

Corning	Harvard	Harvey-Mudd
Exxon-Mobil	U Florida	RPI
Goodyear	U Michigan	MIT
Hewlett Packard	U Wisconsin	Notre Dame
IBM	U Illinois	Yale
Intel	UC Davis	U New Mexico
Lockheed Martin	UC Santa Barbara	U Texas Austin
Microsoft	Rose-Hulman	Oak RidgeNL
Monsanto	Los Alamos NL	DOE

A few key issues were identified

1) **Partnerships will be the key to future breakthroughs.**
   - **Engineers need to know how to partner effectively.**
   - **Partnering among U.S. institutions must be simpler.**
2) **Engineers need broader experience.**
   - **Multi-disciplinary education is important, but the challenges are great.**
3) **A concerted effort is needed to attract, inspire & retain top US students.**
   - **Bright minds want important problems and capabilities to solve them.**

The DOE is in a position to 'change the game'

Unique national facilities

~ 25,000 DOE scientists & engineers

Mission Drivers

- Meeting national security needs
- Reducing energy consumption & fossil fuel reliance
- Improving our critical infrastructure
- Sustaining the environment
- Economic security

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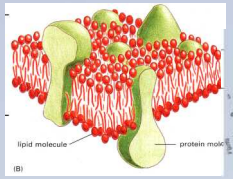
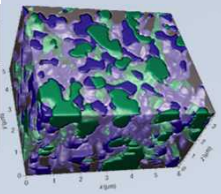
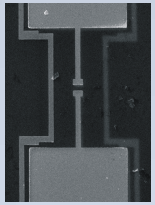
Discovery Science & Engineering Innovation Institutes: *A New Approach*

Young diverse talent







Compelling research for national needs

Discovery Innovation Institutes:

Government – Academia - Industry

Transformed education

Mentoring

State-of-the-art facilities

Broad collaborations

OUTCOMES

- Future science & engineering leaders
- New breakthroughs
- Expanded partnerships through outreach
- Enhanced lab vitality

"Cooperation is a value multiplier." - Greg Leeming, Intel Corporation.

Building from the best aspects of successful models

International Innovation Institutes

KIST Korea Institute of Science and Technology

BECOME ONE OF THE MOST WANTED ENGINEERS IN THE UNIVERSE

EUROPEAN INSTITUTE of TECHNOLOGY -EIT-

DOE User Facilities

NSF Centers

Research Consortiums

SRC Semiconductor Research Corp.

'Our members state that SRC students are worth ~$100k more when hired because of the broadening experience we provide'. **Steve Hillenius, SRC**

Internships, fellowships, K-12 outreach

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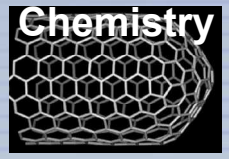
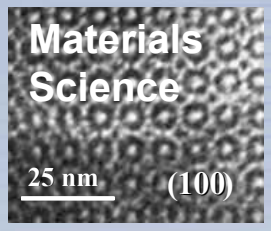
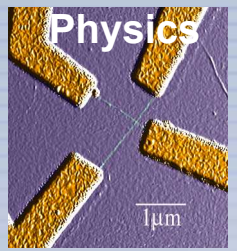
Prototyping the Innovation Institute Concept: *National Institute for Nano-Engineering*

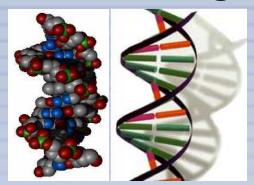
Nano-engineering will be a critical competitive hinge for the U.S.







Theory & Modeling



- New electronics
- Sensors
- Catalysts
- High-performance materials
- Energy storage
- Optics
-

NINE Mission: Help develop the next generation of engineering leaders needed to drive future innovations in micro- and nano-technology

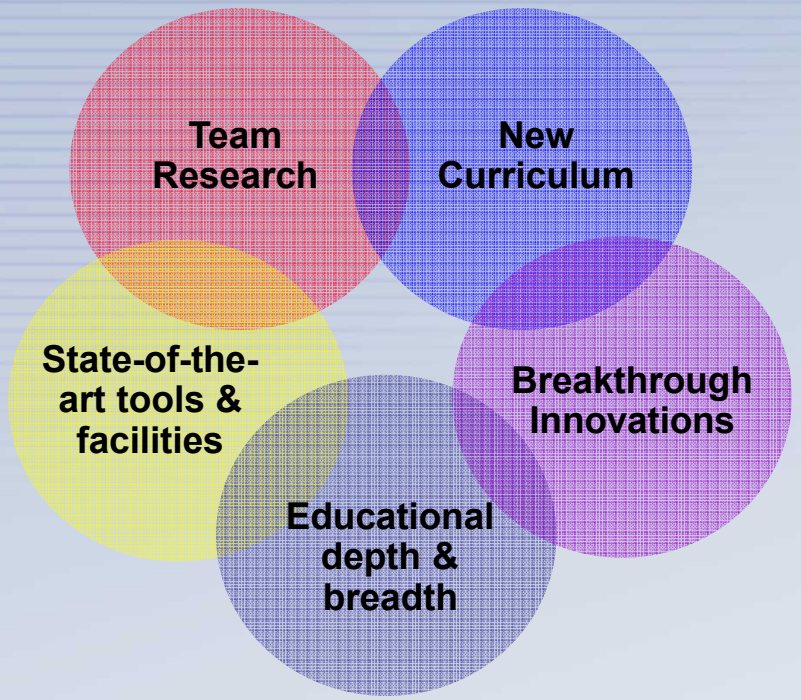
Nano-Engineering is a critical U.S. topic for education/ workforce preparation, innovation and technology transfer *

* PCAST report on Nanotechnology R&D, May 2005

We are developing NINE now!

NINE Goals

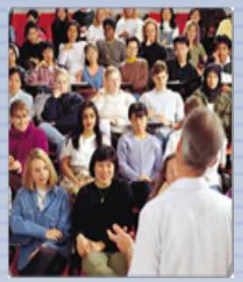
- Transform engineering education in this new, interdisciplinary field
- Develop a generation of nano-engineers skilled in working across multiple disciplines and institutions using the latest engineering tools and facilities
  - ✓ Graduate focus, undergraduate involvement, K-12 outreach
- Pilot government-academic-industry education & innovation hubs
  - ✓ Build off previous experience and successful models (e.g., SRC, Sematech)
- Capitalize on DOE investments to address problems of national importance



NINE began initial operation this summer

NINE educational environment: complementing universities & coupling to industry

- **Broad, experiential learning**
  - ✓ Multi-disciplinary research team
  - ✓ Involvement in the full product cycle
  - ✓ Significant problems
- **Experience with state-of-art S&E tools**
  - ✓ MEMS and μ-fabrication
  - ✓ high-performance computing
  - ✓ nano-engineering integration tools
- **Innovation Lecture Series**
  - ✓ Entrepreneurism, IP, business
- **Access to partner university courses**
  - ✓ Graduate & undergraduate
- **Jointly developed target area courses**



The NINE partnership process is progressing

- Memorandum of Understanding signed by our core partners
  - ✓ University: UNM, RPI, Yale, Harvard, Harvey Mudd, Wisconsin, Illinois, Florida, Texas, UCSB, Notre Dame, Rice
  - ✓ Industry: Intel, Goodyear Tire & Rubber, HP, IBM, P&G, Lockheed Martin, ExxonMobil, Corning
- IP agreements being developed to enable partners to fully engage in technical conversations and projects.
  - ✓ IP agreement will emphasize open partnership model – *educational focus, 'pre-competitive' research*
- Students
  - ✓ Graduate student fellowships – NINE certificate w/ degree
  - ✓ Undergraduate internships – NINE certificate w/degree
- Partner meetings
- Operating structure – Board, committees, etc.

NINE seed projects have been started in selected nano-engineering theme areas

~$7.5M seed funding

- **Nanoelectronics and Quantum Information Processing**
  - ✓ Nano-electronics and photonics for the 21st Century
  - ✓ Atom Chip Device Engineering for Cold Atom Quantum Information Science and Technology
  - ✓ Self-assembly to direct manipulation of nanostructures on length scales from atoms to microns
- **Nanomaterials Processing & Manufacturing**
  - ✓ Nanocomposite Materials Design: Scientific Understanding and Control of Rheology, Assembly & Functionality
  - ✓ Phase Imprint Lithography for Large Area 3D Nanostructures
  - ✓ Nano-Engineering by Optically Directed Self Assembly
  - ✓ Stress-Induced Chemical Detection Using Flexible Nanoporous Metal Organic Frameworks
  - ✓ Electrostatic Microvalves Utilizing Conductive Nanoparticles for Improved Speed, Lower Power, and Higher Force Actuation
  - ✓ Interfacial Property Control of Elastomeric Nanocomposites
- **Nano-based Energy Technologies**
  - ✓ Nanoengineering for Solid State Lighting
  - ✓ Developing a Thermal Microscopy Platform for In-Situ Thermal/Thermoelectric Structure-Property Studies of Individual Nanotubes and Nanowires
  - ✓ CO2 Reduction Using Biomimetic Photocatalytic Nanodevices
  - ✓ Improving Electronic Structure Calculations to predict Nanocatalyst Functions
  - ✓ Optimized Nanoporous Materials
  - ✓ Fundamentals of Synthetic Conversion of CO_2 to Simple Hydrocarbon Fuels

NINE builds on Sandia's strong nano/micro science & technology program

NATIONAL INSTITUTE FOR NANO ENGINEERING

"Sandia's facilities are unique in combination and provide the ability to produce prototype nano-micro technology systems involving multiple facilities and capabilities, a difficult opportunity for universities to provide their students." – **David Duquette, RPI and Kevin Jones, Univ.of Florida.**

Education & innovation partnerships

Center for Integrated Nanotechnologies

Discovery science & user program

Microsystems & Engineering Sciences Applications

Technology development & product realization

Office of Basic Energy Sciences

National Nuclear Security Administration

Sandia National Laboratories

NINE - A breakout strategy for the future

Mission Innovation

University Education:

- ***Undergraduates – fundamentals, opportunities***
- ***Graduate students – breadth of experience, connections, ..***
- ***New and revised curriculum***
- ***New collaborations and joint programs***

K-12 Education:

- ***Teachers – STEM credentials, teaching materials***
- ***Students – Outreach***

Engaged Industrial Partners

Committed Set of Early Career Scientists and Engineers

This model can be scaled nationally at other labs with other focus areas

NINE – A status update

- America COMPETES Act signed – Discovery Science & Engineering Innovation Institutes included as a provision for DOE.
  - ✓ Administration opposition expressed – associated with link to economic development
- NINE partnership group established (MOU) – Press Release coming out.
  - ✓ University: UNM, RPI, Yale, Harvard, Harvey Mudd, Wisconsin, Illinois, Florida, Texas, UCSB, Notre Dame, Rice
  - ✓ Industry: Intel, Goodyear Tire & Rubber, HP, IBM, P&G, Lockheed Martin, ExxonMobil, Corning
- Projects underway in three theme areas with partners ($7.5M).
  - ✓ Nanoelectronics and quantum information processing
  - ✓ Nanomaterials processing & manufacturing
  - ✓ Nano-based energy technologies
- Three dozen students from most partner universities began the NINE program this summer.
- Constituency building – Congress, DOE leadership, R&D community.