SAND2007-7614C

Creating the Next Generation of Innovators and Innovations Through Discovery Science and Engineering Innovation Institutes

Government ⇔ University ⇔ Industry

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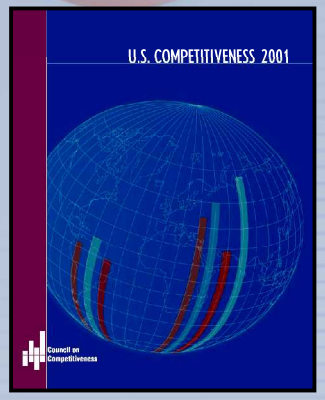
Sandia is a multiprogram laboratory operated by Sandia Corporation, a Lockheed Martin Company, for the United States Department of Energy's National Nuclear Security Administration under Contract DE-AC04-94AL85000.

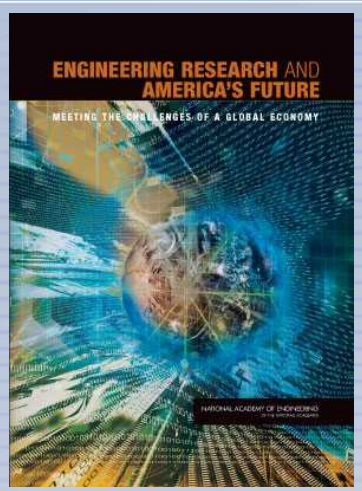
National Nuclear Security Administration

Sandia National Laboratories

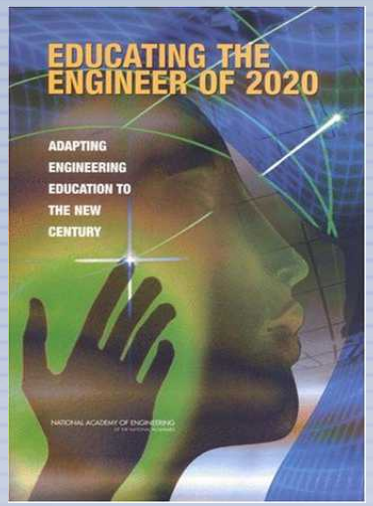
The future of America's Innovation Engine has been called into question



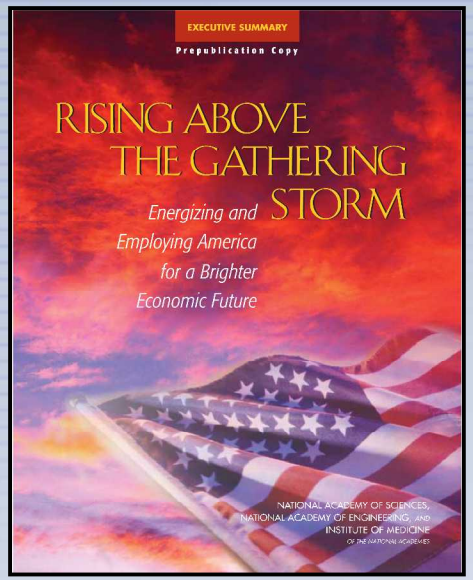
U.S. Competitiveness 2001: Strengths, Vulnerabilities and Long Term Priorities, *Council on Competitiveness*



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



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



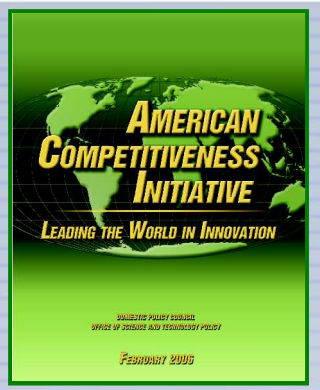
Rising Above The Gathering Storm, *National Academies*, 2006 (Augustine)

- Global competition for talent – need for highly qualified personnel.
- Significant reductions in U.S. industrial R&D.
- The rest of the world is closing the technology gap.
- Other countries using government-industry-university innovation hubs with significant success.

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

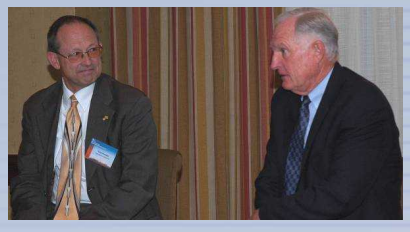
America COMPETES Act signed into law August, 9th, 2007

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

Sandia National Laboratories

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 Ridge NL
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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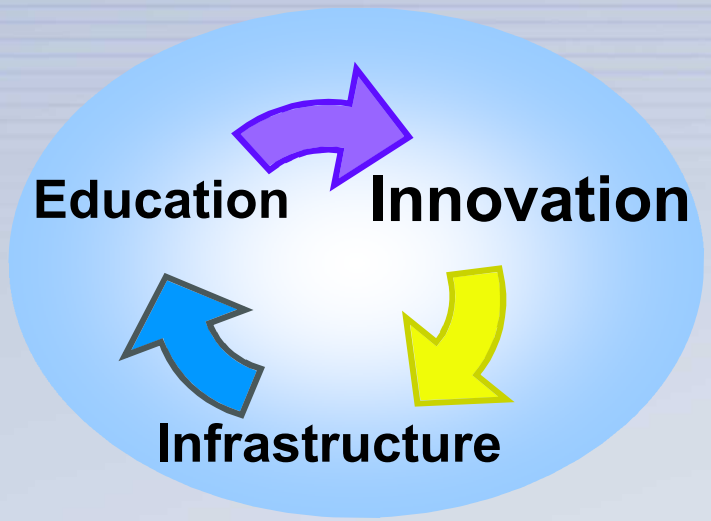
Discovery Science & Engineering Innovation Institutes: *A New Idea*

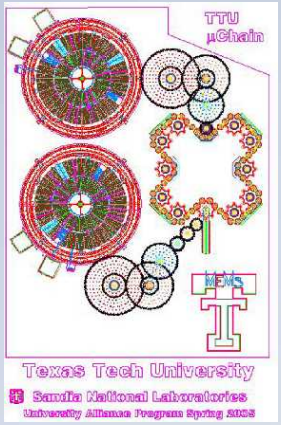
University

Government

Industry

Innovation Institutes – National Centers of Excellence





Future Innovators & Next-Generation Innovations

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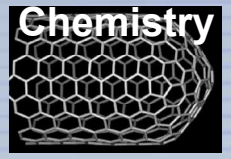
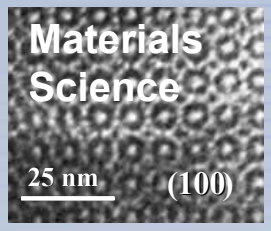
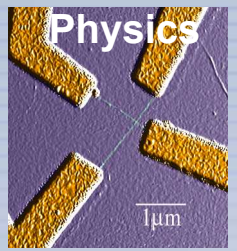
Prototyping the Innovation Institute Concept:
The National Institute for Nano-Engineering

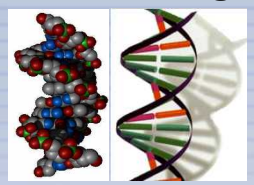
Nano-engineering will be a critical competitive hinge for the U.S.







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 *

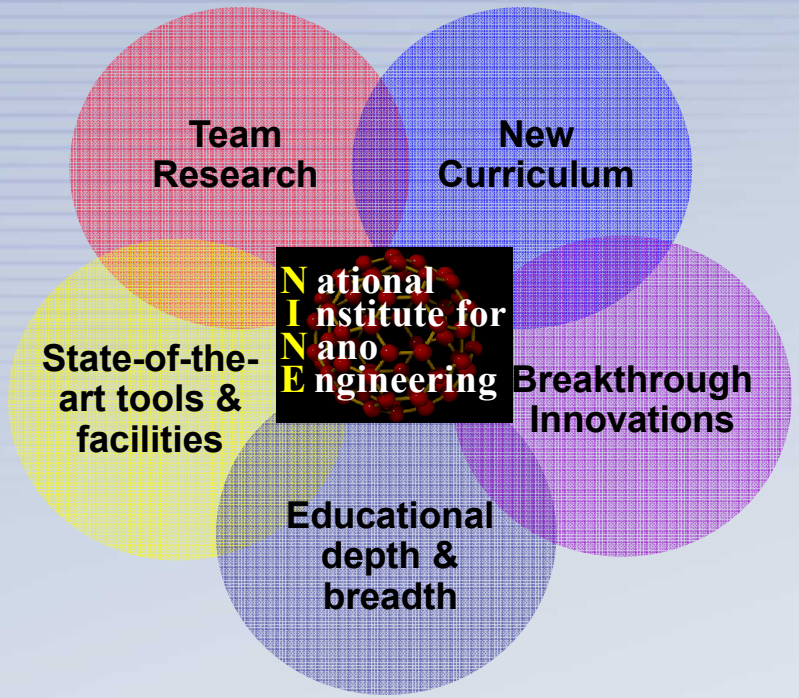
* PCAST report on Nanotechnology R&D, May 2005

Sandia National Laboratories

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**

NINE: A hub & spoke institute

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*

- Operating structure – Board, committees, etc.

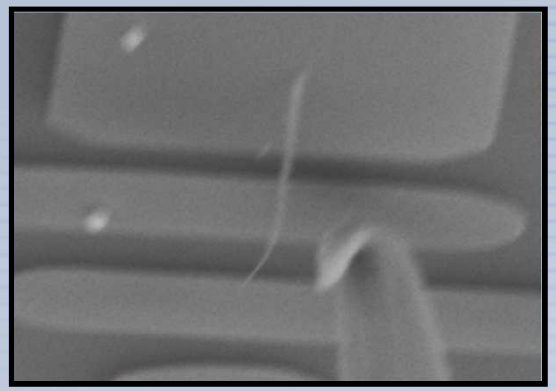
- Thirty-three students from most partner universities began the NINE program this summer

National Institute for Nano Engineering

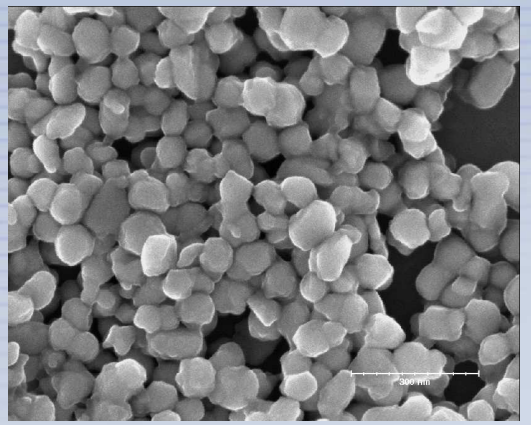
Sandia National Laboratories

The NINE research focus is consistent with Sandia's nanoscience strengths

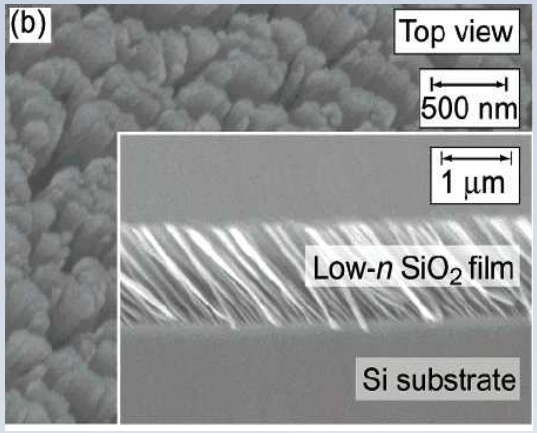
Nano-electronics & quantum computing



Nanomaterials processing & manufacturing



Nano-based Energy Technologies



NINE is a complementary part of our nano S&T program

Nano-electronics & quantum computing

National
Institute for
Nano
Engineering

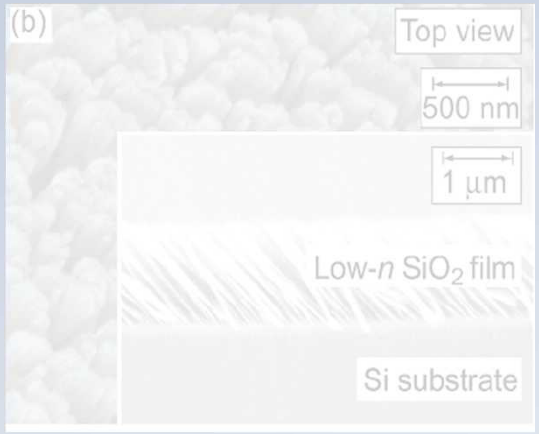
Education & innovation partnerships

Nanomaterials processing & manufacturing

CINT

Discovery science & user program

Nano-based Energy Technologies



MESA

Technology development & product realization

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

Nanocomposite Materials Design

Controlling nanoparticle synthesis and processing: functionalization, rheology, dispersion & patternability, robustness

NanoParticle Flow Consortium

P&G

BASF The Chemical Company

Medtronic Alleviating Pain · Restoring Health · Extending Life

CORNING

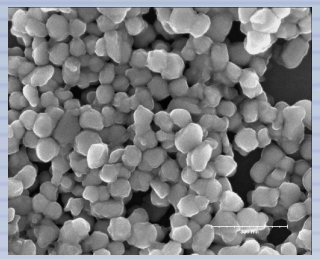
3M

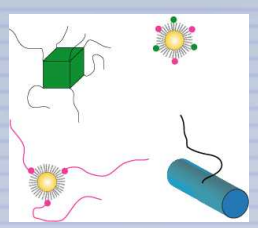
Boston Scientific Delivering what's next.™

DOW CORNING

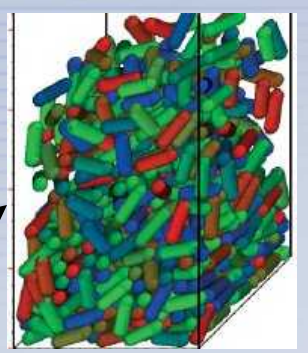
UNM

THE UNIVERSITY OF TEXAS AT AUSTIN

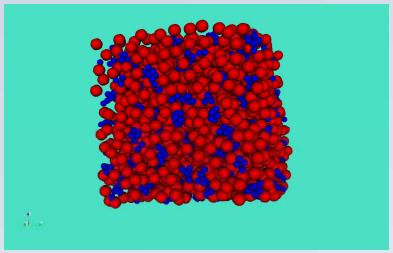




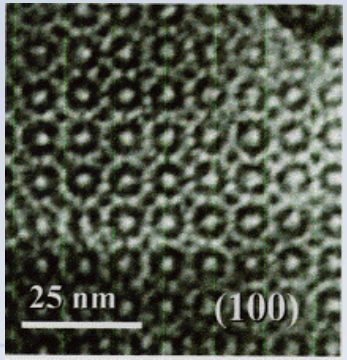
Multi-scale predictive Simulation - e.g. coating, casting…



Rheology



Dispersion stability



Surface self-assembly (membrane)

C.J. Brinker & R. Schunk

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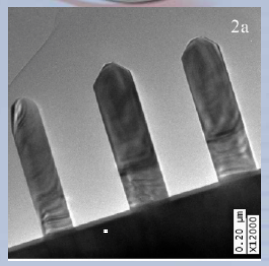
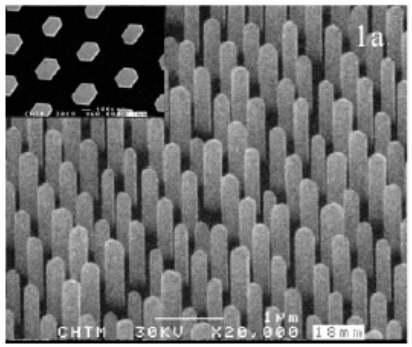
Next generation nano-electronics & photonics

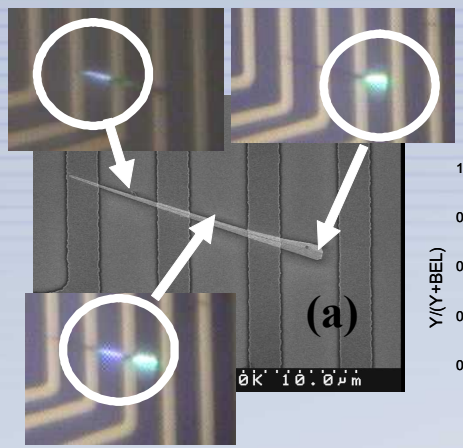
A. Talin

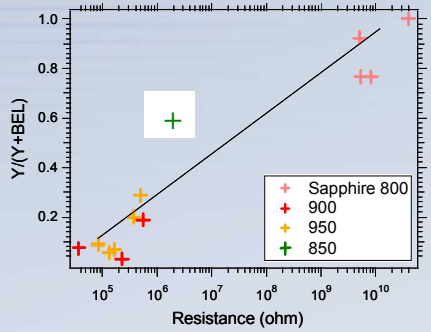


Dislocation-free ordered GaN arrays

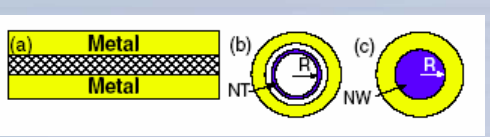


Ordered growth and integration

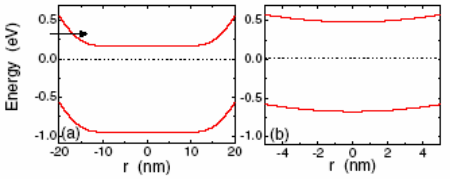


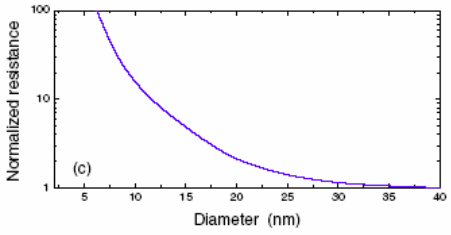


GaN and Ge NW devices for electrical/optical characterization



modeling contact resistance in nanotubes and nanowires





Leonard & Talin, PRL 97, 2006

State-of-the-art fabrication, test, and modeling of nanodevices

Nanoscale circuit simulation

hp invent

Yale

UNM

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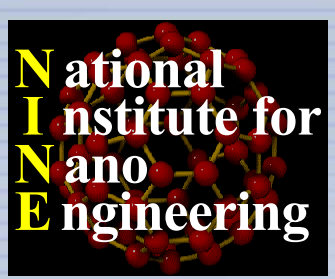
We have an aggressive schedule for NINE

2007



- Stand-up NINE
  - ✓ Technical collaborations kick-off
  - ✓ MOU signed by partners
  - ✓ Partner visits
  - ✓ NINE Education Summit
  - ✓Summer program involving partner students/faculty
  - ✓ Establish Executive Steering Committee
  - ✓ Develop IP agreement and business model
- Integrate NINE strategy with complementary SNL programs/capabilities
  - ✓ Access to MESA, high performance computing, CINT, etc. with NINE projects
  - ✓ Develop integrated vision for NINE with core SNL nano facilities and capabilities

2008

- Conduct technical theme area workshops with university and industry participation
- Submit DOE proposal to become a Discovery Science & Engineering Innovation Institute
- NINE Implementation including Nano curriculum, technical projects, facilities
  - ✓Initiate new projects, co-funded by DOE and NINE industry partners
  - ✓Implement facility plan
  - ✓Begin new nano education programs

Institutes will connect the entire talent pipeline through full-spectrum outreach

Integrating new & existing outreach efforts into a coherent program

Career

Graduate fellowships

Mentoring

Specialty classes

Excellence in science & engineering teaching

Science Bowl

Interns programs

Linking science & schools

National Institute for Nano Engineering

Sandia National Laboratories