

NSF National ATE Center for Nanotechnology Applications and Career Knowledge (NACK)



at

the Penn State



Center for Nanotechnology Education and
Utilization (CNEU)

Historical Summary

- PSU Center for Nanotechnology Education and Utilization (**CNEU**) established in **1998**. Dedicated to research, development, and education across all aspects of micro- and nanotechnology
- With PA state support **PA Nanofabrication Manufacturing Technology (PA NMT) Partnership** for nanotechnology workforce development established at CNEU in **1999**
- **NSF ATE Regional Center** for nanotechnology workforce development at CNEU from **2001 to 2008**
- Industry-led since inception
- Broad applications of nanotechnology
- National role since **2005**
- NSF ATE National Nanotechnology Applications and Career Knowledge Center (**NACK**) created in **2008** at CNEU



NACK's Mission



1. Build partnerships in nanotechnology education among Research Universities, 2-year Community and Technical Colleges, and 4-year Colleges/Universities through:
 - Resource sharing (courses, programs, laboratory facilities, staff)
 - Creating education pathways through these institutions for student development
2. Develop the means to enable a broad nanotechnology education in synthesis, fabrication, characterization, and applications at 2-year Community and Technical Colleges in **every region of the US**
3. Educate students for careers in a spectrum of industries by advocating a knowledge base which can be used in many types of applications and companies
4. Insure that this broad nanotechnology education is one which students can build upon throughout their professional careers

Mission Task 1

Building Partnerships among Research Universities, Community and Technical Colleges, and 4-year Colleges/Universities through resource sharing takes several forms in the NACK approach.

- In geographical regions where commuting and/or room and board support are available the research university can share its faculty, staff, and equipment by teaching nanotechnology courses for the partnership. Some examples following this NACK model include **NACK's own PA NMT Partnership in PA (33 partners and functioning since 1999)**, the University of Minnesota with Dakota County Technical College and NanoLink, the University of Puerto Rico (UPR) Humacao and the UPR system, and SUNY Albany and Hudson Valley Community College
- In geographical regions where commuting is not possible and student room and board support is lacking, students can come to a research university, for example, for long weekends of extensive hands-on experiences in nanotechnology synthesis, fabrication, and characterization.

Teaching Cleanroom: Hands-On Experience

- The 6 Nanotechnology Courses in Pennsylvania are taught using the teaching cleanroom and PSU NNIN facilities at University Park
- The Students spend 3 hours per day in lecture and 3 hours per day doing labs
- The goal is hands-on total immersion in nanofabrication and characterization



Mission Task 2

Developing the means to enable a broad nanotechnology education in synthesis, fabrication, characterization, and applications at 2-year Community and Technical Colleges in **every region of the US** has resulted in

- The creation of a suite of six 4th semester level nanotechnology courses that can be used anywhere. Done with extensive industry input
- Creation of power point presentations for every lecture of the NACK suite of 6 nanotechnology courses (Available for free downloading at www.nan4me.org)
- Creation of videoed lectures for the whole suite of 6 nanotechnology courses (Available for free downloading at www.nano4me.org)
- Creation of web access to nanotechnology characterization tools. This NACK resource means even the most geographically isolated institutions can still bring the ability to visualize the nano-world into their students' own hands with web operation of characterization tools

Suite of Six Nanotechnology Courses



The Courses

Summary of Skills Necessary to Take the Courses

E SC 211 Material, Safety and Equipment
Overview for Nanotechnology

- Basic properties of matter: atoms, molecules, gases, liquids, solids

E SC 212 Basic Nanotechnology Processes

- Basic concepts of chemistry

E SC 213 Materials in Nanotechnology

- Basic concepts of electro-magnetic phenomena

E SC 214 Patterning for Nanotechnology

E SC 215 Materials Modification for
Nanotechnology Applications

- Basic concepts of electrostatics

E SC 216 Characterization, Testing of
Nanotechnology Structures
and Materials

- Interaction of energy and matter

- Physics of light

- Introduction to biology (Optional)

Skill set developed in the 6 courses



Basic Nanotechnology EHS Awareness

- Basics of Chemical and Material Properties—Role of Scale
- Chemical and Materials Handling, Storage, and Disposal
- Nanotechnology Health, Safety, and Environmental issues

Nanotechnology Equipment and Processing Foundation Skills

- Chemical Hoods and Glove Boxes: Use and Maintenance
- Cleanrooms: Use and Maintenance
- Pumps, Flow Control Systems, Scrubbers, Sensors: Use and Maintenance
- Vacuum Systems: Use and Maintenance
- Plasma Generating Systems: Use and Maintenance
- Furnaces, Ovens, and Rapid Thermal Annealing Equipment: Use and Maintenance
- Chemical Facilities and Maintenance
- Contamination Control
- Process Integration
- Introduction to Statistical Process Control

Nanotechnology Patterning

- Optical, e-beam, and Ion Beam Lithography
- Stamping and Imprinting Lithography
- Chemical techniques; e.g., Block co-polymers and SAMs

Nanotechnology Fabrication

- Top-down Fabrication
 - Reactive Ion, Sputter, and Wet Etching
 - Chemical Vapor and Physical Vapor Deposition Systems
 - Ion Beam, Plasma, and Chemical Materials Modification
 - Nanoparticles: Etching and Grinding Approaches
- Bottom-up Fabrication
 - Chemical, Physical, and Biological Self-Assembly
 - Nanoparticles: Colloidal Chemistry
 - Nanoparticles: Plasma Approaches
 - Nanoparticles: Chemical Vapor Deposition Approaches

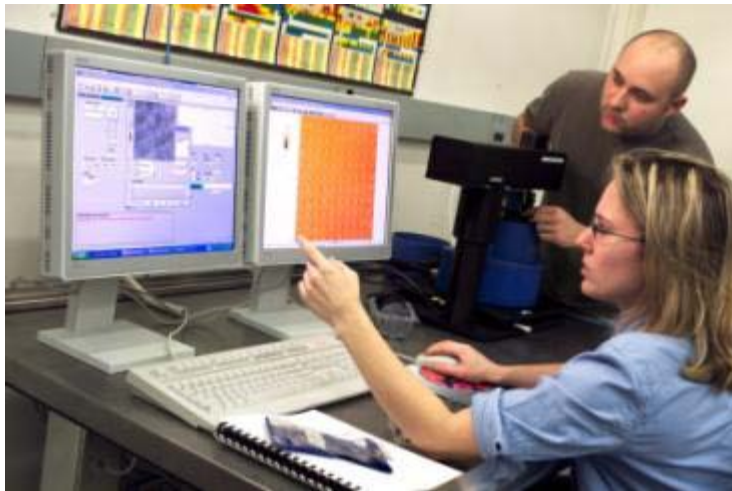
Nanotechnology Characterization

- Optical Microscopy
- Scanning Probe Microscopy
 - Atomic Force Microscopy
- Electron Microscopy
 - Scanning Electron Microscopy (SEM and FE-SEM)
 - Transmission Electron Microscopy (TEM and FE-TEM)
- Chemical Characterization
 - X-ray (EDS)
 - Secondary Ion Mass Spectroscopy
 - Auger Electron Spectroscopy
 - Fourier Transform Infrared Spectroscopy
- Electrical Characterization
 - Current-Voltage Measurements
 - Capacitance Measurements
 - Opto-electronic Device Measurements
- Physical Characterization
 - Spectrophotometer
 - Profilometer
 - X-ray Diffraction

Nanotechnology Professional Skills

- Team Building
- Problem Solving
- Project Organization and Planning
- Research Skills
- Assessing Cost of Ownership
- Presentation Skills
- Technical Reporting and Documentation
- Handling and Generating Intellectual Property

Remote Access & Control of Nano Equipment



From our lab...

...to any classroom



- Established web access procedures for SPM and FESEM utilization
- Established low-cost methodology for web access and control

Mission Task 3

Educate students for careers in a spectrum of industries by advocating a knowledge base which can be used in many types of applications and companies

- Have worked with our industry board to develop a skill set taught in the 6 courses that is applicable to a wide range of industries

National Industry Advisory Board



- Alcatel-Lucent
- Boeing
- Corning
- Cyoptics
- Dupont
- General Electric
- Imerys
- Johnson & Johnson
- Lockheed Martin
- 3M
- National Council for Advanced Manufacturing
- National Coalition for Advanced Technology Centers
- Northrup Grumman
- Plextronics
- PPG
- Semiconductor Research Corporation
- Strategic Polymers
- Stryker
- Tyco Electronics

Some Job Titles Held by Nanotechnology 2-Year Degree Graduates



Biological Laboratory
Tech.

Laboratory Tech.

Production Scientist

Biofuels Tech.

Lithography Tech.

Quality Control Tech.

Chemical Laboratory
Tech.

Materials Science Lab
Tech.

Research Assistant

Cleanroom Tech.

Medical Devices Tech.

SEM Operator

Deposition Tech.

Microfabrication Tech.

SPM Operator

Device Tech.

Nanobiotech
Researcher

Scientist Specialist

Equipment Maintenance
Tech.

Nanoelectronics Expert

Solid State Tech.

Engineering Tech.

Nanofabrication Tech.

Test Tech.

Etch Tech.

Nanotechnologist

Thin Films Tech.

Failure Analysis Tech.

Process Tech.

Vacuum Tech.

Mission Task 4

Insure a broad nanotechnology education which students can build upon throughout their professional careers

- By stressing that nanotechnology is 21st Century Materials Science and Engineering



NACK Support Activities

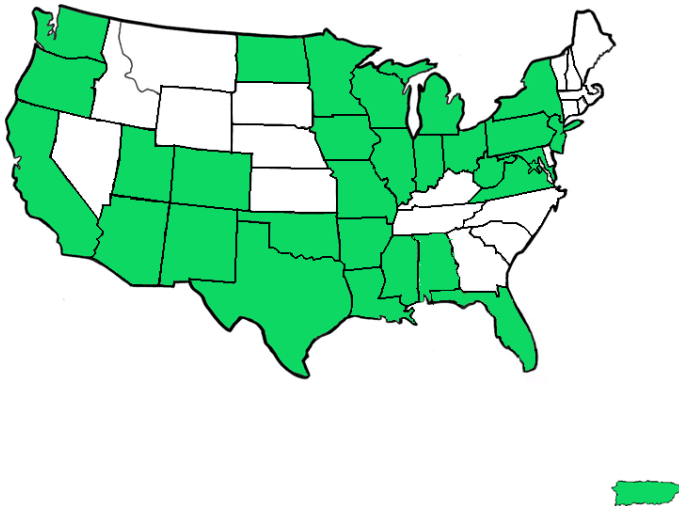


Faculty Development: Educator Workshops

Statistics

Attendees to Date

- 939 Educators
- 30 States, DC, and Puerto Rico



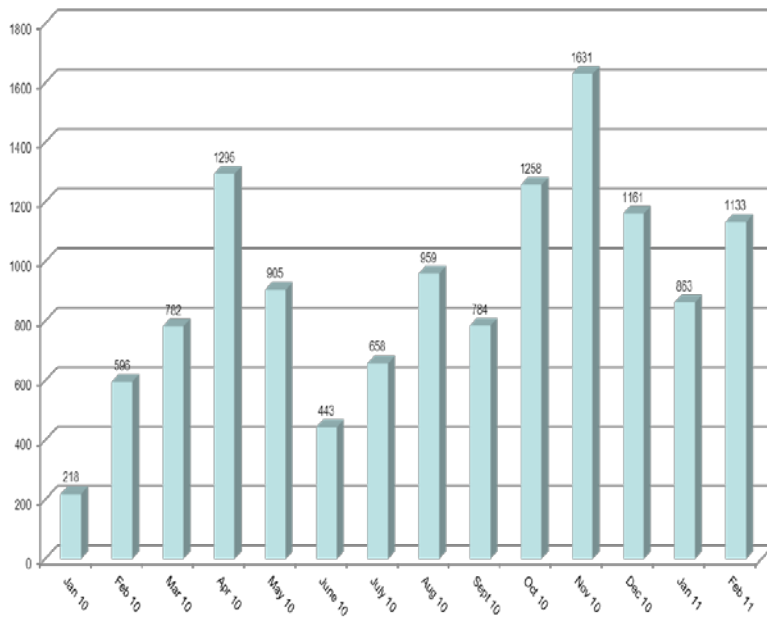
Attendance Options :

- Attending a workshop at NACK
- Host an on-site/off-site workshop
- Utilizing NACK workshop material and/or remote lecture and/or remote equipment access at local workshops

The Portal to NACK Resources

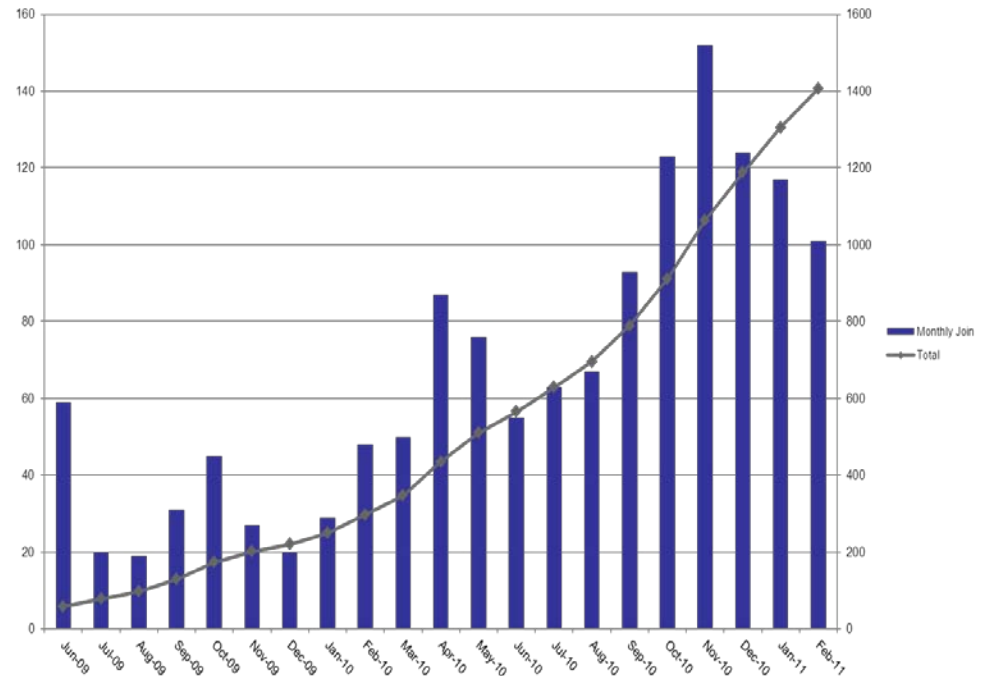


Nano4me Resource Downloads



Registered Nano4me Users

Total to Date = 1406



NACK Webinars



- ✓ Live monthly webinars
- ✓ Hosted by MATEC NetWorks
- ✓ Designed to engage and inform

Some samples of webinar topics are:

- Recruiting Under-Represented Minorities
- Introduction to Nanotechnology
- Tech Intersection: Understanding the Bio and Nano link
- Ways of Introducing Nano Into Your Program
- How is Nanotechnology Changing the Electronics Industry?
- Building a Nanotechnology Workforce
- Nanotechnology and Materials
- How Safe is Nanotechnology in Our Lives?

Visit <http://www.nano4me.org/educators.html#contenttop> for a complete listing of upcoming and archived webinars

Alumni Network Development

- To help graduates of associate degree programs enhance their professional opportunities, inform them of educational opportunities, and connect them with networking groups
 - ✓ Provides online networking opportunities
 - ✓ Access career resources
 - ✓ Connects interested alumni and students in mentoring relationships
 - ✓ Keeps alumni informed of current nanotechnology events and activities
 - ✓ Shares alumni success stories



Nanotech Academies



Secondary School Curriculum Enhancement



- Series of thought-provoking nanotechnology presentations
 - in-depth material for students and workers of all knowledge levels

- Designed to be used in workshops, courses, and overview lectures
 - introduce nanotechnology and its applications

- Can be integrated into **secondary** and **post-secondary** curriculum as well as for nanotechnology outreach



Modules

Downloadable at
www.nano4me.org

Conclusions



- Partnerships involving a research university and 2-year degree and 4-year degree institutions which utilize resource-sharing are very effective in delivering nanotechnology education
- The resource-sharing approach developed at the NACK Center is very useful for forming these partnerships. It relies on utilizing the teaching facilities, web capabilities, characterization tools, and faculty nanotechnology expertise at one (or perhaps several) advantageously, geographically positioned location
- NACK efforts are designed to insure that students emerging from US programs have an industry-established nanotechnology skill set in synthesis, fabrication, characterization, and applications, and a broad nanotechnology educational foundation on which students can build upon throughout their professional careers

Conclusions (cntd.)



- The resources provided by the NACK Center and shared with workforce training institutions include:
 - Lecture and laboratory experiment sets for six complete courses
 - Web available lectures (power-point and video formats) for the six courses to aid workforce training institutions to offer these courses
 - Educators workshops on how to teach these six courses
 - Assistance to faculty for learning more about and using these web accessible tools
 - Modules for use in recruiting, introductory courses in nanotechnology, or general public education
 - Web resources; e. g., webinars, alumni network, discussion boards, etc.
- The NACK resources outlined above are available to institutions across the US through funding made available by the US National Science Foundation.



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Bringing Nanotechnology to Education & Industry!

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