Networking for Technological Education in Nanotechnology in the U.S.

Stephen J. Fonash
NSF NACK Center
Penn State University
December 9, 2009

NACK CENTER
Nanotechnology Applications & Career Knowledge
WWW.NANO4ME.ORG

NSF

Starting Points

- High-quality nanotechnology workforce development requires that students and educators at educational institutions of all types have ready access to the most advanced expertise and equipment
- It is simply not possible to maintain advanced nanotechnology expertise and facilities at every educational institution

NACK CENTER
Nanotechnology Applications & Career Knowledge
WWW.NANO4ME.ORG

Copyright 2009 The Pennsylvania State University

Starting Points

- Delivering high-quality nanotechnology workforce development will increasingly depend upon resource sharing, whereby students and educators at any institution have access to the advanced expertise and facilities located at the relatively few institutions that house them

NACK CENTER
Nanotechnology Applications & Career Knowledge
WWW.NANO4ME.ORG

Copyright 2009 The Pennsylvania State University

The Solution

- Create a network to share facilities and equipment dedicated to workforce development among institutions across the country

NACK CENTER
Nanotechnology Applications & Career Knowledge
WWW.NANO4ME.ORG

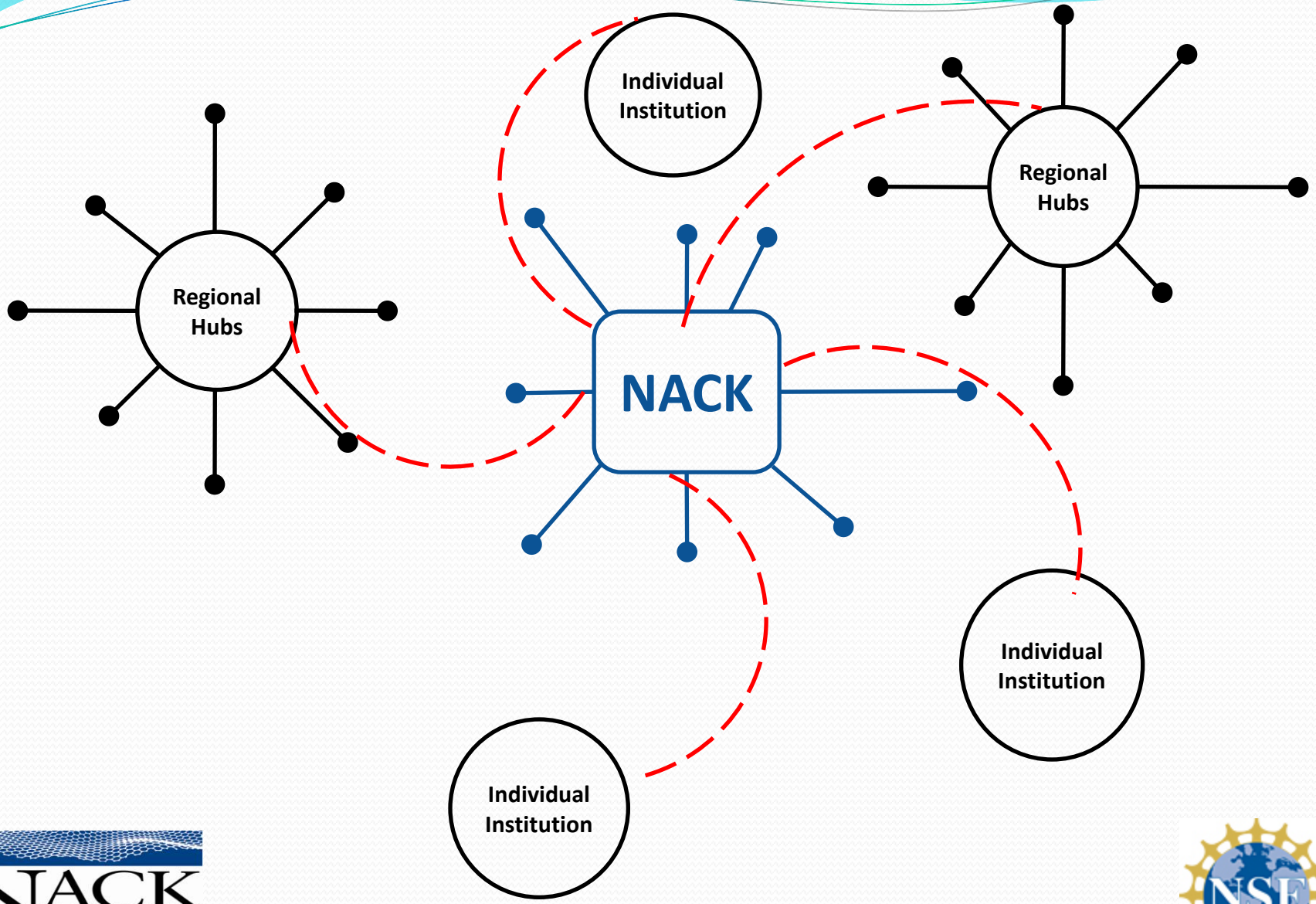
Copyright 2009 The Pennsylvania State University

The Network

- Community colleges
- Four-year, primarily teaching, institutions
- Research universities
- Penn State (NSF Nanotechnology Applications and Career Knowledge Center—NACK)

NACK CENTER
Nanotechnology Applications & Career Knowledge
WWW.NANO4ME.ORG

Copyright 2009 The Pennsylvania State University



NACK CENTER
Nanotechnology Applications & Career Knowledge
WWW.NANO4ME.ORG

Copyright 2009 The Pennsylvania State University

The Advantages of this Network

- Resource sharing (Equipment and staff needed to support equipment only at one –or several—places)
- Expensive equipment dedicated to education only needed at one—or several-- locations
- Student 2+2 +…. pathways
- Uniform awareness of, and attention to, health, safety, and environment issues

NACK CENTER
Nanotechnology Applications & Career Knowledge
WWW.NANO4ME.ORG

Copyright 2009 The Pennsylvania State University

The Mission of NACK is to enable Nanotechnology Education for

- Two-year Community and Technical Colleges
- Universities and Colleges which do not have the facilities for Nanotechnology Education
- Industry

NACK CENTER
Nanotechnology Applications & Career Knowledge
WWW.NANO4ME.ORG

Copyright 2009 The Pennsylvania State University

NACK Objectives

- Share the facilities, technical staff, and expertise of Penn State with college and university partners across the nation to bring state-of-the art, nanotechnology courses and degree programs to every section of the US.
- Empower students across the US with a broad approach to nanotechnology giving them the basis for a lifetime of adapting and learning.

NACK CENTER
Nanotechnology Applications & Career Knowledge
WWW.NANO4ME.ORG

Copyright 2009 The Pennsylvania State University

Key Principles

#1 Meaningful nanotechnology education must be an exposure to **synthesis/fabrication** techniques used to build and to **characterization** tools used to "see" at the nano-scale.

NACK CENTER
Nanotechnology Applications & Career Knowledge
WWW.NANO4ME.ORG

Copyright 2009 The Pennsylvania State University

Key Principles

#2 Meaningful nanotechnology education requires resource-sharing.

NACK CENTER
Nanotechnology Applications & Career Knowledge
WWW.NANO4ME.ORG

Copyright 2009 The Pennsylvania State University

Key Principles

#3 Give students a **broad, hands-on** nanotechnology education on which they can build for their professional lifetime. Do not train students for **an** industry.

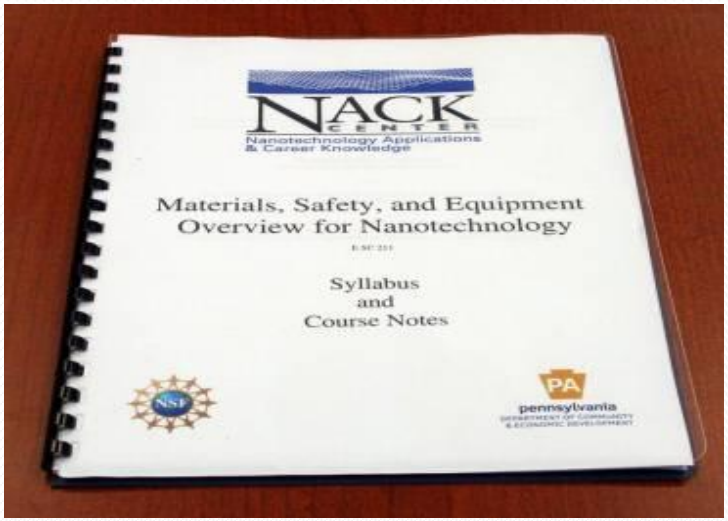
NACK CENTER
Nanotechnology Applications & Career Knowledge
WWW.NANO4ME.ORG

Copyright 2009 The Pennsylvania State University

Resource Sharing

Copyright 2009 The Pennsylvania State University

Created 6 nanotechnology courses—both lectures and labs. 18 credits for use by technical college and sophomore level BS degree students. (Notes/labs available at www.nano4me.org)



NACK CENTER
Nanotechnology Applications & Career Knowledge
WWW.NANO4ME.ORG

Copyright 2009 The Pennsylvania State University

Summary of Skills Taught in the NACK Suite of 6 Nanotechnology Courses

Safety and Environmental Awareness

- Basics of Chemical and Material Properties
- Health, Safety, and the Environment
- Chemical and Materials Handling

Micro- and Nanotechnology Foundation Skills

- Cleanroom Use, Design, and Maintenance
- Pumps, Flow Control Systems, Scrubbers, Sensors: Use and Maintenance
- Vacuum Systems: Use and Maintenance
- Plasma Generating Systems: Use and Maintenance
- Furnaces: Use and Maintenance
- Chemical Reaction Systems: Use and Maintenance
- Contamination Control
- Process Integration
- Introduction to Statistical Process Control
- Biocompatibility

Foundation Skills in Pattern Transfer

- Optical, e-beam, stamping, and imprinting lithography
- Block co-polymer techniques

Micro- and Nanotechnology Fabrication Skills

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

Micro- and Nanotechnology Characterization Skills

- 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

Micro- and 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

Resources

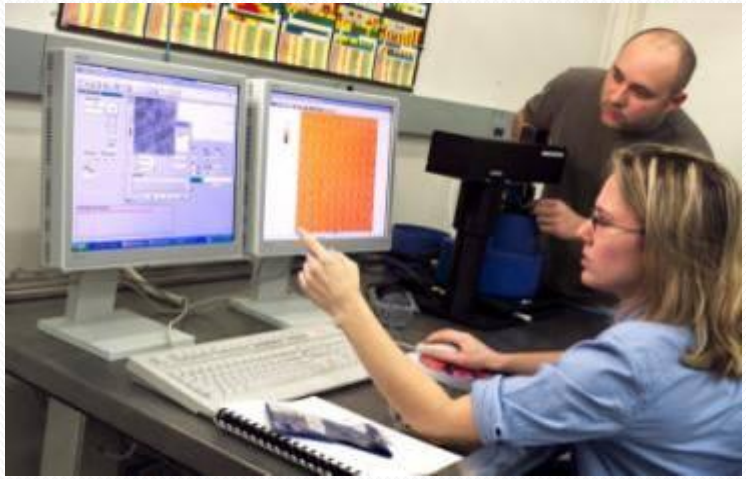
Six Nanotechnology Courses taught by NACK

- Students can come to NACK from their institution and take this “capstone suite” of 6 courses (one semester)
- Students can take these courses over the web
- Students can take these courses at their home institution or at a regional hub

NACK CENTER
Nanotechnology Applications & Career Knowledge
WWW.NANO4ME.ORG

Copyright 2009 The Pennsylvania State University

Web-access to equipment—students can run many tools from anywhere



Equipment at NACK…

…Operated in your classroom

Copyright 2009 The Pennsylvania State University

Some Examples

Scanning probe tools

Copyright 2009 The Pennsylvania State University

Some Examples

Field Emission Scanning Electron Microscope

Copyright 2009 The Pennsylvania State University

Conclusions

- Nanotechnology workforce development requires that students and educators at educational institutions of all kinds have ready access to the most advanced expertise and equipment.
- It is simply not possible to maintain advanced nanotechnology expertise and facilities at every educational institution.
- Delivering high-quality nanotechnology workforce education requires networking
- It requires resource sharing, whereby students and educators at any institution have access to the advanced expertise and facilities located at the relatively few institutions that house them.

NACK CENTER
Nanotechnology Applications & Career Knowledge
WWW.NANO4ME.ORG

Copyright 2009 The Pennsylvania State University

Assistance Available from NACK to Get Started

Should your Institution have a Nano Program?

NACK works with interested institution to determine--

1. Where are the jobs?

2. What we can do for you

3. Financially viable approach

NACK can assist in Program Preparation and Course Delivery

Preparing Faculty for a Nano program

Intro Workshop –Intro to Nano

Preparing Faculty to Teach the 6 NACK Courses

Training the Trainer Workshops

NACK can also assist with

-Student Recruitment

-Industry Support

For More Information, Visit

www.nano4me.org

NACK CENTER
Nanotechnology Applications & Career Knowledge
WWW.NANO4ME.ORG

Copyright 2009 The Pennsylvania State University