

Trends in Nano: Careers and Workforce Needs

Nanotechnology Applications & Career Knowledge

WWW.NANO4ME.ORG

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Hosted by MATEC NetWorks www.matecnetworks.org



Welcome to NACK's Webinar



Dr. Sheryl Hale

Director Innovative Programs, Research and Development Oklahoma Department of Career and Technology Education shale@okcareertech.org



Robert Ehrmann

Managing Director Nanotechnology Applications and Career Knowledge (NACK) Network <u>REhrmann@engr.psu.edu</u>

> Moderator: Michael Lesiecki











Session Outcomes

- Describe the partnership in PA that creates a pipeline of nanotechnology graduates into jobs
- Consider lessons learned from the Oklahoma Nanotechnology Education Initiative
- Identify the challenges associated with preparing students for careers



Nanotechnology Programs:

- A. We have an associates degree program
- B. We have integrated nanotechnology into courses in a number of programs
- C. We are contemplating starting a nanotechnology program
- D. We are not exactly sure what a nanotecnology program means at the two year or four year level



Starting a Nanotechnology Program:

- A. Convince the President it was OK
- B. Get Curriculum Committee approval first
- C. Get Industry's OK
- D. Get Industry's buy-in
- E. All of the above



Our Next Speaker



Robert Ehrmann *Managing Director*

Nanotechnology Applications and Career Knowledge (NACK) Network

Center for Nanotechnology Education and Utilization @ Penn State





 Home of the PA Nanofabrication Manufacturing Technology Partnership





NMT Partnership

National NSF Center for
Nanotechnology
Applications and Career
Knowledge (NACK) since
September 2008





What is the Pennsylvania NMT Partnership?

• A joint effort among Pennsylvania (PA) post-secondary institutions, industry, and the State

 Mission: develop a PA nanotechnology workforce and of incorporating nanotechnology into PA secondary education, post-secondary education, and industry

 The PA NMT Partnership is the recognized national leader in undergraduate nanotechnology workforce development.



Partnership Outcomes



Pennsylvania Degree Programs

• 30 Associate degree programs at 19 institutions

- 13 PA community colleges
- Penn College of Technology
- 2 PA Campuses of the Allegany College of Maryland
- California University
- Clarion University (Venango)
- Lock Haven University
- Millersville University

• 22 Baccalaureate degree programs at 12 institutions

- 8 State System Universities
- Penn College of Technology
- Gannon University
- Harrisburg University
- Juniata College

Diversity & Growth of Disciplines of PA Degree Programs in Nanotechnology





- Integral part of the 30 associate and 22 baccalaureate degree programs at partner institutions across PA
- Covers broad applications of micro- and nanotechnology
- Cost effective means of bringing nanotechnology training to every corner of Pennsylvania



Arizona Experience





Center for Integrated Nanotechnologies

Wired.com



More PA NMT Facts / Results

- 738 Capstone Semester graduates to-date (38 are attending this summer)
- 137 Companies have hired Capstone grads for microand nanotechnology jobs
- 1,314 Educators & Industry personnel have completed nanotechnology workshops





CNEU - NACK

CNEU - NACK

What Approach is Taken?

A General Approach to Nanotechnology / Nanofabrication with the **Objectives** of:

- 1. Providing a solid, broad information base that an individual can build upon; and,
- 2. Creating a versatile nanotechnology workforce that can move from industry to industry with the ebb and flow of international market forces.

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



The Suite of 6 Courses

E SC 211	Materials, Safety, and Equipment Overview for Nanotechnology
E SC 212	Basic Nanotechnology Processes
E SC 213	Materials in Nanotechnology
E SC 214	Patterning for Nanotechnology
E SC 215	Materials Modification for Nanotechnology Applications
E SC 216	Characterization, Testing of Nanotechnology Structures, and Materials

Summary of Skill Sets Taught in the 6 Nanotechnology 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-polymer 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



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 - Capacitance Measurements
 - Opto-electronic Device Measurements
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 - X-ray Diffraction

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Center Results

PA Companies who have hired Capstone Grads



Academic Partners
 Industry Advisory Board Members
 PA Companies who have hired NMT graduates

Institutions That Have Hired Capstone Semester Graduates for Micro- and Nanotechnology Jobs

II-VI Corporation Accellent Adhesives Research. Inc Advanced Acoustic Concepts Advanced Cooling Technologies Advanced Gas Technologies Advanced Powder Products Advantech AGAM Agere Alcoa Allied Electronics Alden Products AMAX Minerals Amedeo Amgen Inc. **Apogee Photonics** Arrow International Avail Technologies BioElectroSpec B. Braun **Boston Applied Technologies** BD (Becton, Dickinson) **BP** Solar Bridge Semiconductor Cabot Cabot Microelectronics Carbon NanoProbes Celgene-LifebankUSA Chemcut **Correae Sensors Cosmos Technologies** Crystalplex Cyoptics Dendreon **DRS Laurel Technologies** Dana Corporation Doucette Dow Chemical Drexel University Eastman Chemical Company East Penn Manufacturing Fx One Fairchild Semiconductor Fincor Automation

First Energy F.S. Elliott General Dynamics Robotic System **General Electric** GlaxoSmithKline Globalfoundries GTS Haraeus Noblelight Hale Products Hershey Medical Center Illuminex Infinera Inovative Micro Technology Intel Corporation IQE Johnson & Johnson Johnson Matthey Judson Technologies **Keystone Communications Keystone Engineering** Keystone Research & Pharmaceuticals Kongsberg Defense Kurt J. Lesker Kyowa America LCM Technologies Lehighton Electronics Lockheed Martin Lucent Technologies Lutron Electronics Maxima Technologies Max Levy Autograph Meadow Burke Products Membrane Assavs Merck Mintera Corporation NanoHorizons Natural Nano, Inc. North American Hoganas North Carolina State University Northrup Grumman, Inc Optellios **Optinel Systems** P2i Penn State CNEU Penn Sate Dubois

Penn State Applied Research Lab Penn State Electro-Optics Center Pfister Energy Philips Medical Systems Philips Respironics Plextronics **Probes Unlimited** Proconex PPG PPL QorTek Restek Rhetech Rohm and Haas **Ross Technologies RJ** Lee Schroeder Industries Scientific Systems Seagate Technologies Siemens Co. SI International Slack Pek Solar Innovations Solarity Spectrum Technologies Strainrite Strategic Polymers Structure Probes Inc. **Svnthes** Telecardia Textron Lycoming Thermo Electric PA Transene Tyco Electronics **US Air Force** Uniroval Optoelectronics University of Florida University of North Carolina - Charlotte University of Pittsburgh Vectron International Velox Semiconductor Western Digital Westfalia Technologies Westmoreland Mech. Testing & Research Xactix

5-13-13 107/137

Institutions That Have Hired Capstone Semester Graduates for Micro- and Nanotechnology Jobs

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First Energy F.S. Elliott General Dynamics Robotic System Haraeus Noblelight Hershey Medical Center Illuminex Infinera Intel Corporation inson & Johnson ohnson Matthey Judson Technologies Keystone Communications Keystone Engineering Keystone Research & Pharmaceutical Kongsberg Defense Kurt J. Lesker Kyowa America ent Technologies Lutron Electronics Maxima Technologies Max Levy Autograph Meadow Burke Products Membrane Assays Merck Mintera Corporation NanoHorizons Natural Nano, Inc North American Hoganas North Carolina State University Northrup Grumman, Inc Optinel Systems

Penn State Applied Research Lab Penn State Electro-Optics Center

> Johnson & Johnson Johnson Matthey Judson Technologies Keystone Communications Keystone Engineering Keystone Research & Pharmaceuticals Kongsberg Defense Kurt J. Lesker Kyowa America LCM Technologies Lehighton Electronics Lockheed Martin Lucent Technologies Lutron Electronics

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Strainrite Strategic Polymers Structure Probes Inc. Synthes Telecardia Textron Lycoming Thermo Electric PA Transene US Air Force Uniroyal Optoelectronics University of Florida University of North Carolina - Charlotte University of Pittsburgh Vectron International Western Digital Westfalia Technologies Westmoreland Mech. Testing & Research Xactix



Our Next Speaker



Sheryl Hale Director

Innovative Programs, Research and Development Oklahoma Department of Career and Technology Education



A Bumpy Ride with Buckyballs!







Evolution

- Oklahoma's Beginning Infrastructure
- ONEI Goals
- ONEI Outcomes
- Bumps Along the Way
- Political Realities







Beginning

- Spirit of Collaboration
 - Oklahoma State University Institute of Technology
 - Oklahoma Career and Technology Education
- Penn State Visit (2005)
- ATE Project Award (2007)







State Vision

Oklahoma companies are world leaders in creating new and improved products through applications of nanotechnology.











- The real winners in nanotechnology will be the companies who adopt nano processes to improve their existing and emerging products.
- In 2006, the Oklahoma legislature decided to leapfrog over other states and help Oklahoma companies gain this competitive advantage by creating the Oklahoma Nanotechnology Sharing Incentive Act.









 The Oklahoma Nanotechnology Sharing Incentive Act established the Oklahoma Nanotechnology Applications Project, which allocated nearly \$2 million annually to promote and provide incentives for companies to use applications of nanotechnology to create new or improved commercial products.









- Since 2006 Oklahoma has grown from four to more than 65 companies involved in nanotechnology.
- Approximately half of these companies are emerging new companies and other half are established companies using nanotechnology discoveries to improve existing products.









Oklahoma was recognized as one of the top three states in commercializing new or improved products through nanotechnology applications.







ONEI Goal

To develop a technician workforce that will advance industries' use of microtechnology and nanotechnology.







Workforce

- High School
- Associate/Bachelors
 Degree
- Masters/Doctoral Degree

- Production Operator
- Inspector
- Production Supervisor
- Engineer
- Research Assistant
- Research Scientist
- Chief Technical Officer
- R & D Engineer











- Develop Resources to Support Career and Technology Education Integration
- Develop Applied Associate Nanotechnology Degree – Nano-Scientific Instrumentation
- Provide Faculty Development
- Create Educational Pathways









- Applied Associate Degree
- High School and Middle School Resources
- Nanotechnology Summer Camps
 - Increased Student Interest
 - Increased Faculty Interest/ Enthusiasm
- Educational Program Integration (Initial)











Associate in Applied Science Nano Scientific Instrumentation 75 Credit Hours





Recruitment

- Created Dual Major
 - Instrumentation and Nano-Scientific
 Instrumentation
- Introduction to Nanotechnology
 - Approved as a Science Credit
- Technology Center/High School Visits
 - Girls in Engineering, Encounters of the Orange Kind, etc.



careertech



Summer Camps

To introduce high school students to the science and application of nanotechnology.







97 percent of students participating in the summer camps indicated that the camps increased their interest in science, technology, engineering and math!









- Safe Way to Introduce Faculty to Nanotechnology
- Created Nanotechnology Enthusiast
- Link Skills/Concepts into Other Disciplines









http://www.okcareertech.org/about/initiatives /oklahoma-nanotechnology-educationinitiative







Bumps

- Key Personnel
 - Attrition
 - Passion
- Assembly
 - Top Down Versus Bottom Up
 - When you build it . . . they don't always come.









- Content Expertise
 - Industry
 - Faculty
 - Fit and Alignment
- Curriculum Crowding

 Standards, Common Core
 - What Do You Leave Out?









- Science, Technology, Engineering and Math
 - Connection and Application
 - Emerging Technology
- Nanotechnology Industry or Enabling Technology?







Building Blocks

- Awareness to Awakening
- Oklahoma's Application
- Fundamental Tools
- Student and Faculty Enthusiasm
- Industry Commitment
- State Infrastructure
- Continuing Evolution









ΤΗΕ ΟΚΙΑΗΟΜΑ NANOTECHNOLOGY EDUCATION INITIATIVE

Special Recognition

Michael Taylor Department of Engineering Oklahoma State University Institute of Technology

Steve Holley

Principal Investigator Oklahoma State University Institute of Technology **EENTERS**







Thank You













www.dctc.edu









Our Next Speaker



Robert Ehrmann *Managing Director*

Nanotechnology Applications and Career Knowledge (NACK) Network



If you look in the want-ads from last Sunday and searched for nanotechnology in the jobs section, how many would you find? (make a guess)

- A. None
- B. 1-3
- C. 4-10
- D. 11-20
- E. More than 20

Job Titles for Nanotechnology Graduates

Biological Laboratory Tech.

Biofuels Tech.

Chemical Laboratory Tech.

Cleanroom Tech.

Deposition Tech.

Device Tech.

Equipment Maintenance Tech.

Engineering Tech. Etch Tech.

Failure Analysis Tech.

Laboratory Tech.

Lithography Tech. Materials Science Lab Tech. Medical Devices Tech. Microfabrication Tech. Nanobiotech Researcher Nanoelectronics Expert

Nanofabrication Tech. Nanotechnologist Process Tech. **Production Scientist**

Quality Control Tech. Research Assistant

SEM Operator SPM Operator Scientist Specialist Solid State Tech.

Test Tech. Thin Films Tech. Vacuum Tech.



Source - NACK Alumni Committee

NACK Alumni Network

Mission: To help graduates of associate degree programs enhance their professional opportunities, inform them of educational opportunities, and connect them with networking groups.

- 1. Provides online networking opportunities
- 2. Access career resources
- Connects interested alumni and students in mentoring relationships
- 4. Keeps alumni informed of current nanotechnology events and activities
- 5. Shares alumni success stories





Companies Who Have Hired Graduates

Listing of companies arranged by industry sector that have hired program graduates of nanotech programs across the nation:

Leah Riley, PhD "My two employees with nanotechnology backgrounds are vital to the development of new products at EnerG2. Both employees clearly have a strong background in hands-on learning and research. They are comfortable with new techniques and knowledgeable about a broad range of nano-characterization methods and data interpretation. Their most valuable asset, however, is their positive and novel contributions to Product Development gained from their education in nanotechnology. Both employees speak very highly of the [North Seattle Community College nanotechnology in their positive and here the strength of the technology.	Director of Research and Development, EnerG2 Inc. Provided by Seattle's Hub for Industry– driven Nanotechnology Education (SHINE.) ATE Project,	Featured Companies RJC EnerG2 Inc. Silicon Designs Intertox Hysitron
nanotechnology] program and I would look to hire other graduates with the same background."	DUE 1204279	Hystron

Who Hired Graduates7

Search Companies by Category

Select a Category:	-	
Select a Category:		
BIOLOGICAL/ BIOTECH/ MEDICAL/ PHARMACEUTICALS		
CHEMICAL/ MATERIALS		
ENVIRONMENTAL/ ENERGY		
ELECTRONICS/ COMMUNICATIONS/ OPTICS		
COMPONENTS/ DEVICES/ INDUSTRIAL PROCESSING/ EQUIPMENT		
students succeed.		

Tiles

Nanoscience Associate Job Titles

The Industry Advisory Committees at colleges offering Nanoscience Technology associate degrees have discussed the challenge of promoting the new program when there are few positions titled nanoscience technician. Colleges have found that graduates can expect to find employment using their nanoscience skills in positions such as: Click here to view job titles.



Companies Who Have Hired Graduates

An example company listing in one industry sector:

W	Who Hired Graduates?			
Se	arch Companies by Category			
I	BIOLOGICAL/ BIOTECH/ MEDICAL/ PHARMACEUTICALS			
I	Accellent			
l	Amedeo			
I	Amgen Inc.			
I	Arrow International	I		
I	B. Braun	I		
I	BD (Becton, Dickinson, and Company)	I		
I	BioElectroSpec	I		
	Bioforce Nanosciences			
L	Boston Applied Technologies			



Nano Graduates To-Date

1,000+

... and growing!

As of May 2013, capstone graduates at Penn State & AAS degree graduates throughout the U.S.

Survey of PA NMT Capstone Graduates (Completed March, 2011)

Some Survey Findings:

- When they completed the nanotechnology 6 course suite, 59% were enrolled
- In a 2-year associates degree program and 41% in a baccalaureate program.
- At the time of the survey, **69% are employed** <u>in a nano field</u> & 65% said the capstone influenced their career pathway
- <u>95%</u> are currently either working or in a degree program full-time



Survey of NACK Capstone Graduates (Completed March, 2011)

Some Survey Findings (continued):

- 48% entered the workforce or changed jobs in 2010 (Impressive in a very poor job market)
- 34% are still enrolled in a degree program, primarily BS or MS (40% of these are also working full time)
- AS graduates had an average salary of \$37,000. BS (or higher) had an average salary of \$56,000.

What does PA industry say about PA NMT Grads?

Plextronics, Inc. (Pittsburgh, PA):

- ... grads make up 10% of growing Plextronics team
- These employees bring skills and hands-on experience to Plextronics that the company would have been otherwise unable to find.
- …PA NMT … provides a solid technical foundation that enables employees to grow into any number of career paths.
- ... program graduates now hold positions from entry level technicians to management.



Plextronics



Robert J. Kumpf, Ph.D.

Challenges of Identifying Careers and Jobs



Operate commercial-scale production equipment to produce, test, or modify materials, devices, or systems of molecular or macromolecular composition. Work under the supervision of engineering staff.

This title represents an occupation for which data collection is currently underway.

|--|

Tasks | Tools & Technology | Work Values | Wages & Employment | Job Openings

Government Forecasts

For Outreach / Program Justification Sources: Jim Kadke (NNCO) and Mihail Roco (NSF)



Why Teach Nano?



"It has been estimated that the worldwide market value of products incorporating nanotechnology will:

- increase by 100X over the two decades
- from about \$30 billion in 2000 to about \$3 trillion in 2020
- ...from 0.8% of GDP to 5% of GDP..."



Mihail Roco, May 2011 Chemical Engineering Progress

NNI Vision

A future in which the ability to understand and control matter at the nanoscale leads to *a revolution in technology and industry that benefits society*









- An NSF study said 6 million nanotechnology workers will be needed worldwide by 2020, with 2 million of those in the U.S.
- There are more than 70 nano-specific degree programs in higher education institutions across the U.S.
- Many of these jobs can be filled by workers with **2-year degrees**
- There are currently at least 2 dozen associates degree programs in the U.S. with **new programs launching every semester**





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Contact Information

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Webinar Recordings

To access this recording, slides and handout visit:

nano4me.org/webinars.php



2013 Events Calendar

2013-2014 Webinar Series: Starting in September!

- Aug. 12-15:Course Resource Workshop II:WorkshopPatterning, Characterization & Applications
- Sept. 16-19:Course Resource Workshop I:WorkshopSafety, Processing & Materials

Visit <u>www.nano4me.org/webinars</u> for more details about these and other upcoming events.



Thank you for attending the NACK Network webinar

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