

InterNano

Resources for Nanomanufacturing

a project of  National
Nanomanufacturing
Network



Scalable Nanomanufacturing Technologies

*An Academic-Industry Workshop on Technologies for U.S.-Asia
Collaborations*

*Breakthrough Theatre
Matrix Building, Biopolis
February 25-26, 2016*

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InterNano

National Nanomanufacturing Network and InterNano

Establish a network of experts and stakeholders to identify challenges, solutions, and approaches for a nanomanufacturing roadmap

A catalyst for nanomanufacturing R & D advancement in the US via:

- Cooperative activities (workshops, conference, initiatives)
- An information clearinghouse (InterNano)

To support, and help launch, communities of practice in nanomanufacturing in both real and cyber space

Mark Tuominen - Director of NNN

Jeff Morse - Managing Director of NNN

Robert Stevens – Web Development



InterNano



Center for Hierarchical Manufacturing UMass Amherst

NSF Nanoscale Science
and Engineering Center
2006-2016

James Watkins-Director, Mark Tuominen-Co-Director

Snapshot:

- An NSF Nanoscale Science and Engineering Center
 - Funded through NSF's Division of Civil, Mechanical and Manufacturing Innovation
- \$4 million/year in NSF Support
 - The CHM is funded by NSF through 2016
- 39 Faculty in 8 disciplines at 6 Institutions (27 Faculty at UMass)
 - UMass Amherst (Lead Institute), Michigan, MIT, Rice, Indiana, Mt. Holyoke, Puerto Rico, Springfield Technical Community College

National Nanomanufacturing Network

- In addition to its own research program, the Center for Hierarchical Manufacturing manages the National Nanomanufacturing Network, providing the nanomanufacturing R&D community with technical information, workshops, and technology roadmaps.



www.umass.edu/chm

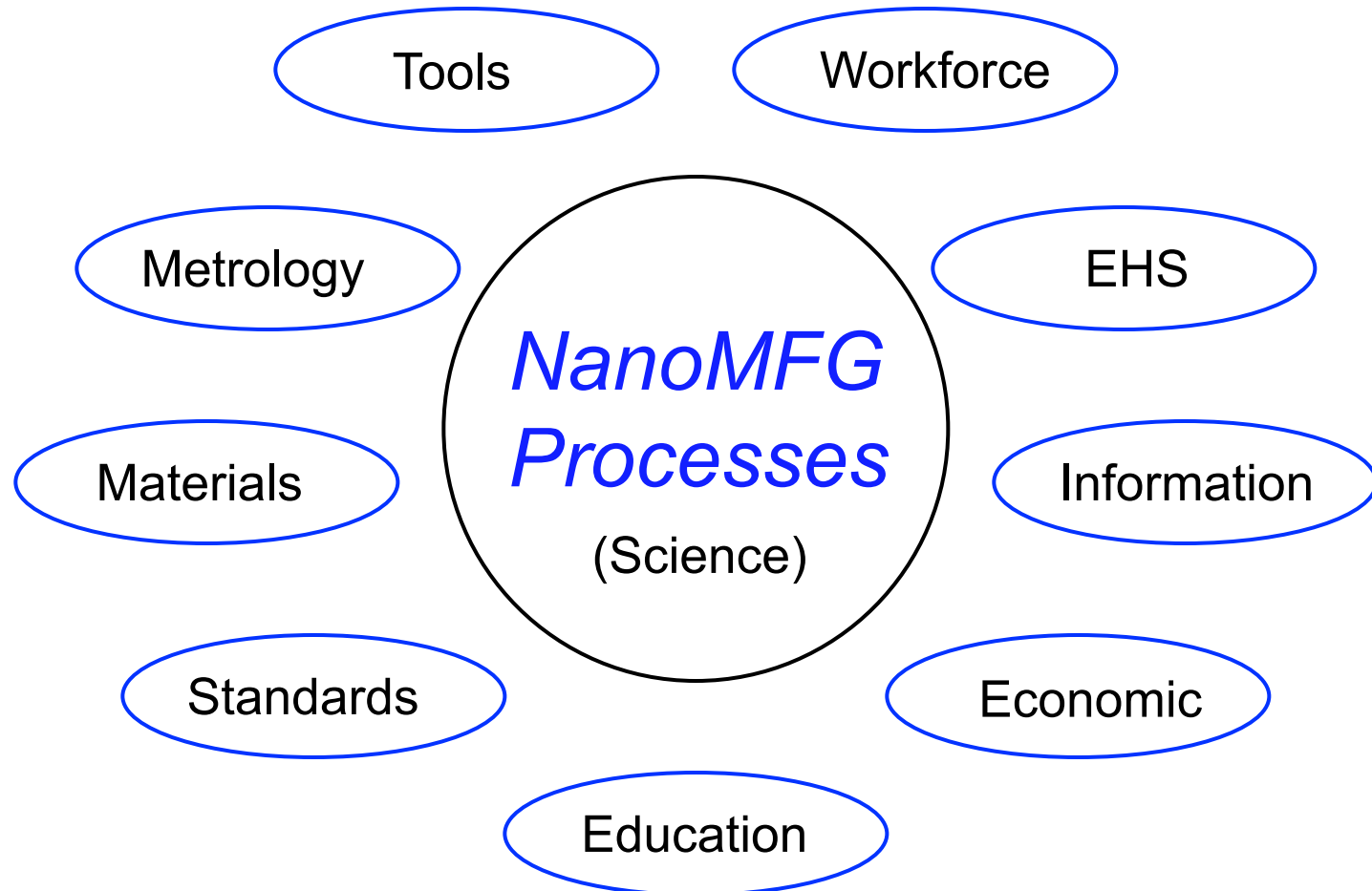
www.r2rnano.org



www.internano.org

InterNano

NNN Working With Stakeholders to Establish a Sustainable Nanomanufacturing Ecosystem



Information • Tools • Know-how • Roadmaps

Example NNN Outreach Activities



• NNN Workshops and Conferences

- First NNN Nanomanufacturing Summit (May 2009)
- Workshop on "Research Challenges for Nanomanufacturing Systems" (Feb. 2008)
- E-Workshop on "Deterministic Doping" for ITRS Roadmap (Nov. 2008) (SRC/NNN)
- Significant coordinating or participating roles in many other nanomanufacturing events and meetings
- US-EU Workshop on Nanofabrication Technologies for Scaled Roll-to-Roll and Print Manufacturing (Oct 23-24, 2013 Barcelona)
- Nanoinformatics 2013 (October 15, 2013, Philadelphia, PA)
- Nanomanufacturing Summit 2013 (October 15-17, 2013, Philadelphia, PA)
- Participated in organizing/planning activities for Air Force/Research Lab funded NanoBioManufacturing Consortium
- NIST-NNN Workshop on Nanofabrication Technologies for Roll-to-Roll Processing (September 27-28, 2011, Boston, MA)
- Promoting regional/state initiative strategies in several nanomanufacturing areas
- Lead ISO TC 229 standards project on "Terminology and Definitions for Nanomanufacturing Processes"



ISO Terminology Standard Published

TECHNICAL
SPECIFICATION

ISO/TS
80004-8

First edition

Nanotechnologies — Vocabulary —

Part 8:
Nanomanufacturing processes

*Nanotechnologies — Vocabulaire —
Partie 8: Processus de nanofabrication*

- 156 terms and definitions:
focusing on various types of
nanomanufacturing processes
- Sections:
 - General terms
 - Directed assembly
 - Self assembly
 - Synthesis
 - Fabrication
- Tuominen project leader
- 31 participant countries

Nanoinformatics

2013

“Informatics for Nanomanufacturing”

NNN Workshop: October 15, 2014; Univ. of Pennsylvania

Workshop Topics

- Informatics to speed development time and lower cost
- What has been developed already and how mature is it?
- Help to identify what data, analysis, and testing has been done
- Some data can be public, others will necessarily be private
- Manufacturing requires satisfying multiple requirements
- Basic research experiments and Design-of-Experiment data
- First principles modeling and statistical modeling

Nanomanufacturing Summit 2013

& 12th Annual NanoBusiness Conference

October 15-17, 2013 - University of Pennsylvania - Philadelphia



- Co-organized with NanoBCA, UPenn
- 2-days, Plenary, Topical Tracks
- Primary attendees from Industry
- Topical sessions on Regional, State, and Local Nanotechnology Initiatives
- Review of Nanotechnology Resources, Process Database
- Discussion of NNI Strategic Initiatives



October 15-17, 2013
Univ. of Pennsylvania
Philadelphia

Register Now!



Jim Phillips
 CEO
 NanoMech



Scott Livingston
 Chairman & CEO
 Livingston Securities



Ram Trichur
 Carbon Electronics Business
 Development Manager
 Brewer Science



Dr. Rutledge Ellis-Behnke
 Dept of Brain & Cognitive
 Sciences
 Massachusetts Institute of
 Technology



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 Managing Director
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Joe Piché
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 Eikos



David J. Arthur
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 SouthWest NanoTechnologies
 Inc



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 Assemblies of Soft Matter
 Laboratory
 Corporate Research & Innovation
 Solvay



Dan Russell
 Senior Vice President
 Pixelligent Technologies, LLC



Vincent Caprio
 Executive Director
 NanoBCA



Andrew Baluch
 Special Counsel
 Foley & Lardner LLP



The Nanomanufacturing Summit 2013 will showcase technical contributions by experts and practitioners in the field of nanomanufacturing.

- For topical sessions including:
- Emerging processes
 - Scaled manufacturing platforms
 - Innovative products and applications
 - Nanoinformatics
 - Legislative and regulatory activity



A block of rooms has been reserved with a special room rate of \$165/night. The rate will be available until the group block is sold-out.

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Nanofabrication Technologies for Scaled Roll-to-Roll and Print Manufacturing October 23-24, 2013 - Barcelona

Attendees are invited to prepare remarks addressing technical topics such as:

- Generating low-cost, commodity-scale materials sets
- Demonstrating precision cooperative assembly
- Utilization of surface directed/guided assembly of critical features via imprint stamping
- Fabrication of ordered hybrid nanocomposites at high rates
- Nanoimprint processes
- Process integration
- Online and off-line metrology
- Global R&D efforts and developing manufacturing capabilities, especially in Europe and the U.S.



Workshop Outcomes: Needs cited including

- Standards efforts are critical
- Metrology remains a challenge
- Process modeling and control needed
- Cluster type public private partnerships desired
- Materials remain limited
- Vacuum/thermal processes limited



Mariona Sanz,
Hans Hartmann Pedersen
Jeffrey Morse
Network
James Watkins
Jouni Ahopelto
Marc Verschuuren
Vivek Subramanian
Antonio Facchetti
Theodor Nielsen
Helmut Schift
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Lee Richter
Paul Poodt
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Carolyn Ellinger
Mark Poliks
Arne Schleunitz
Ken Carter

Ministry of Economics, Catalan
European Commission
National Nanomanufacturing
Network
CHM/University of Massachusetts
VTT/Printocent
Philips
University of California Berkeley
Polyera, Northwestern University
NIL Technologies
PSI/Eulitha
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Princeton University
ICN
NIST
TNO/Holst Center
Xaar Corporation
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Binghamton University/CAMMS
MicroResist Technologies
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Workshop on Nanofabrication Technologies for Roll-to-Roll Processing

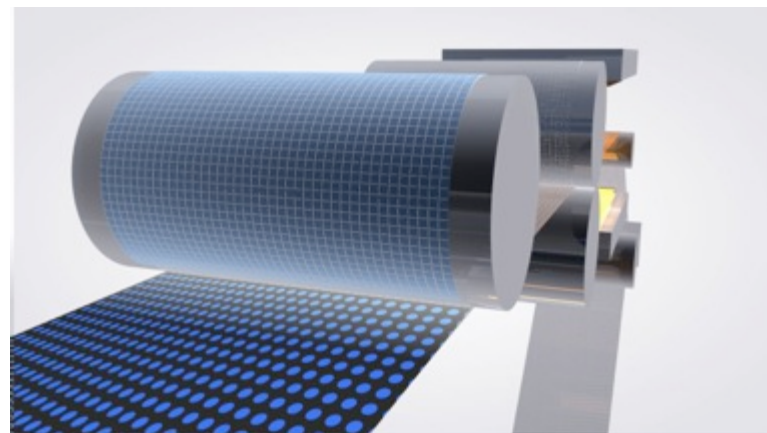
September 27-28, 2011 - Seaport Convention Center, Boston MA

An Academic-Industry Workshop on Technologies for American Manufacturing Competitiveness

This workshop will bring together invited researchers, institutions, and leading companies involved in roll-to-roll processing and scalable nanomanufacturing methodologies, to identify and discuss challenges for successful merging of these technologies in advanced device manufacturing

Technical Topics to be Addressed will include:

- Generating low-cost, commodity-scale materials sets
- Demonstrating precision cooperative assembly
- Utilization of surface directed/guided assembly of critical features via imprint stamping
- Fabrication of ordered hybrid nanocomposites at high rates
- Nanoimprint processes
- Process integration
- Online metrology
- Global R&D efforts and developing manufacturing capabilities, especially in Europe and Asia



Scope

- nanomanufacturing processes
- tools for nanomanufacturing
- nanoscale objects and nanostructured materials
- nanomanufacturing characterization techniques
- environmental, health and safety considerations for nanomanufacturing
- social and economic implications of nanomanufacturing
- informatics and standards for nanomanufacturing
- commercialization, regulation and intellectual property



The screenshot shows the InterNano website homepage. At the top, it features the InterNano logo and the text "Resources for Nanomanufacturing". A search bar is located on the right. Below the header, there is a navigation menu with links for "For Researchers", "For Industry", "Resources", "Events", "News", "About", and "Login". Social media icons for Facebook, LinkedIn, Twitter, and RSS are also present. The main content area is divided into several sections: "Browse by Subject" with a grid of icons, "Expert Reviews" with a featured article titled "Virtual Design Methods Provide Strategy for Innovation through Nanomaterial Database Development", "Highlights" and "Processes" with image thumbnails, "Regional State Local Initiatives in Nanotechnology" with a map, "Nanoscale Science and Engineering Centers" with the NSF logo, "User Facilities" with a photo, "What is Nanomanufacturing?" in an orange box, "Industry News" with a list of articles, "Directory" with the Optofluidics logo, "Library" with a book icon, and "Calendar" with a Penn State event poster.

Process Database

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66. Aligned Carbon Nanotube Patterning Via Dry Contact Transfer Printing

The approach of transferring CNT thin films from one surface to another via a soft lithography technique suffers from limited ability to achieve good adhesion of the CNT films to the transferred substrate and imprecise alignment of the CNT patterns. A transfer technique that can be scaled to large area with high throughput processing at low temperature is being reported in this paper, demonstrating a scalable means to create aligned CNT thin film patterns on both rigid and flexible substrates.

Contributors: Pint CL, Xu YQ, Moghazy S, Chenkuri T, Alvarez NT, Haroz EH, Mahzooni S, Doorn SK, Kono J, Pasquali M, and Hague RH

Deposited by: Amulya Gullapalli

Manufactured Nanomaterial or Structure: CNT's patterning

Process:

- Lithographic patterning of wafer-scale traces of Al_2O_3 (10 nm thick) followed by 0.5 nm of Fe catalyst.
- Growth in diameter and diameter.
- This is followed by the transfer of the CNTs from the wafer to the substrate.
- Transfer to substrate arrays.

Notes: A key step in the process is the transfer of the CNTs from the wafer to the substrate. This is achieved by the use of a transfer layer on the substrate contact.

Equipment: Chemical

References: (1) Some reports the process for dry contact transfer of aligned CNTs as described in the text. (2) SEM image of an upright patterned growth prior to transfer. (3) Picture showing a complete transfer to a 5 mm x 5 mm size diamond window.

Tags: Carbon nanotubes, Nanopatterning/Lithography, Nanotubes, Thin films

DOI: 10.4053/jn066-130307

Views: 231



NNN Newsletter

National Nanomanufacturing Network
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Newsletter

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Alternative Test Strategies, Predictive Models to Assist Nanomaterials Safety Assessment

With the exponential growth of engineered nanomaterials (ENMs) extending from research and development to commercial products, the daunting challenge of conducting effective risk assessment and life-cycle analysis for these materials is presented. Of primary concern is the potential for human exposure that may lead to adverse outcomes, which traditionally utilizes animal studies and specific protocols to identify exposure risks. With increasing emphasis on understanding the basis for adverse outcomes, numerous approaches incorporating predictive modeling combined with expanded *in vitro* and short term *in vivo* studies have fostered a conceptual shift in toxicological studies of ENMs.

Driven by advances in chemical testing methodologies, a new paradigm for understanding exposure risks for ENMs will combine high throughput screening (HTS), high content screening (HCS), and predictive modeling to significantly reduce the reliance on animal studies while increasing the rate of data driven knowledge and the understanding of nanomaterials. While this should draw a collective sigh of relief from government regulators and industry alike, specific data are limited to establish effective policies for risk assessment covering emerging ENMs without the need for further extensive studies and financial burdens.

More...

New Grayscale Technique Opens a Third Dimension for Nanoscale Lithography

Engineers at the NIST Center for Nanoscale Science and Technology (CNST) have developed a new technique for fabricating high aspect ratio three-dimensional (3D) nanostructures over large device areas using a combination of electron beam (e-beam) lithography, photolithography, and resist spray coating. While it has long been possible to make complicated 3D

August 2013

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Expert Reviews

Directory

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Home » Resources » Expert Reviews » Virtual Design Methods Provide Strategy for Innovation through Nanomaterial Database Development

Virtual Design Methods Provide Strategy for Innovation through Nanomaterial Database Development

Written by Jeff Morse, PhD
September 26, 2013

Recent materials informatics initiatives are fostering the establishment of open-access, federated databases that catalogue the properties of materials. While an initial emphasis, particularly in the case of nanomaterials, is to understand the toxicological properties of materials, a key goal is to establish model-based materials design methodologies wherein materials properties can be computationally predicted. Such a virtual design approach to materials represents a powerful paradigm in which tools become openly available to design new products, optimize materials performance, and understand the risk associated with human and environmental exposure before the materials has been synthesized. Such an infrastructure will benefit industry, academia, and government agencies alike in providing low cost, rapid turnaround approaches to design, and manufacture materials, incorporate into product designs, and establish the regulatory pathway for workforce and consumer protection.

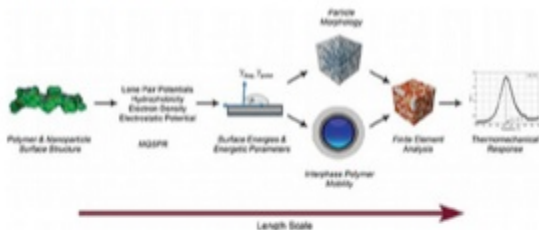


Figure 1. A schematic showing the genomics approach to predicting the thermomechanical response.

From left to right shows: MQSPR is used to relate the polymer and nanoparticle surface structure to the polar and dispersive components of the polymer and nanoparticle surface energy. The surface energies are then used to quantitatively predict the dispersion state of the nanoparticles and the properties of the filler/polymer interface. Using Finite Element Analysis (FEA), the microstructure is reconstructed and the filler, polymer, and interphase properties used as input. The FEA provides an a-priori prediction of the thermomechanical properties from MQSPR calculated surface energies.

While this scenario presents a futuristic vision, the necessary steps in this direction are being taken with the establishment of the Materials Genome Initiative and the NanoFormatics Initiatives, which include activities in areas such as materials database development, data mining tools, and materials design/design for manufacturing virtual tools. A prime example of implementation of materials design tools was recently reported by Breneman, et al. in which a data-driven approach to the virtual design of nanostructured polymers was introduced. In this work, the authors implemented materials quantitative structure-property relationship (MQSPR) models to develop a numerical analysis approach to predict the thermomechanical properties of spherical nanofilled polymer composites. The model was validated through a systematic investigation of silica nanoparticles having three different surface chemistries in several polymers.

The work reported is the first time that the MQSPR technique has been utilized across multiple length scales providing the connection between underlying chemistry of the polymer and nanoparticle surface, physics of nanoparticle composite dispersion, and bulk properties of resulting materials. In addition, this approach can further determine the compatibility between the polymer and nanoparticle materials. In combining the MQSPR

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- UC Center Receives \$24 Million to Transform How Nanomaterials are Tested for Safety

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Nanometrics is a leading provider of advanced, high-performance process control metrology and inspection systems used primarily in the fabrication of semiconductors and other solid-state devices, such as data storage components and discretics including high-brightness LEDs and power management components. Nanometrics' automated and integrated metrology systems measure critical dimensions, device structures, overlay registration, topography and various thin film properties, including film thickness as well as optical, electrical and material properties. The company's process control solutions are deployed throughout the fabrication process, from front-end-of-line substrate manufacturing, to high-volume production of semiconductors and other devices, to advanced wafer-scale packaging applications. Nanometrics' systems enable advanced process control for device manufacturers, providing improved device yield at reduced manufacturing cycle time, supporting the accelerated product life cycles in the semiconductor market.

Nanometrics was incorporated in California in 1975. Nanometrics has been publicly traded since 1984 and is listed on NASDAQ (NANO). We have been a pioneer and innovator in the field of optical metrology. Nanometrics has an extensive installed base of more than 6,500 systems in over 150 production factories worldwide. Our major customers and original equipment manufacturer (OEM) partners include the largest semiconductor and process equipment manufacturers in the world.

Tags: high-performance process control metrology, Metrology, inspection systems, Semiconductors, solid-state devices, data storage, high-brightness LEDs, power management, Thin films, optical metrology, high-volume production, wafer-scale packaging, Tool development

Home » Resources » Directory » Expert

Mehlika Ayla Kiser
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Mehlika Ayla Kiser is a postdoctoral research fellow in the Department of Chemistry and is developing a characterization roadmap of nanoparticles, biomimetic syntheses and applications of nanomaterials.

Professional Affiliations
Safer Nanomaterials and Nanomanufacturing Initiative, International Council on Nanotechnology


Tags: Nanoparticles, nanomaterials, Chemical surface functionalization, etc.



Research Library

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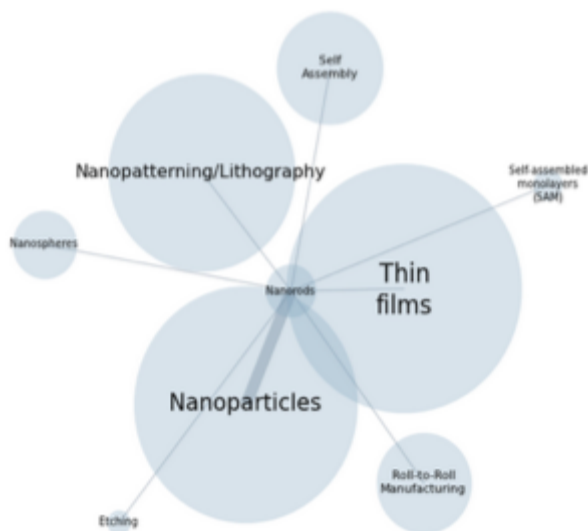
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This project is supported by the National Science Foundation under Grant No. [CMMI-1025020](#)
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All Resources are linked by the taxonomy



Home > Resources > Taxonomy

Taxonomy

Click on the **B** to expand each category. Click on the category name to view related content.

- ▶ Areas of Application
- ▶ Environment, Health, and Safety Informatics and Standards
- ▼ Nanomanufacturing Characterization Techniques
 - ▶ Charge Transport Characterization
 - ▶ Diffraction and Scattering
 - ▼ Electrochemical Characterization
 - Cyclic voltammetry (CV)
 - Electrochemical quartz crystal microbalance (QCM)
 - Impedance spectroscopy (IS)
 - Linear sweep voltammetry (LSV)
 - ▶ Magnetic Characterization
 - ▶ Mechanical Property Characterization
 - ▶ Optical Spectroscopy
 - ▶ Other Characterization Techniques
 - ▶ Scanning Electron Microscopy (SEM)
 - ▶ Scanning Probe Microscopy
 - ▶ Thermal Analysis
 - ▶ Transmission Electron Microscopy (TEM)
- ▶ Nanomanufacturing Processes
- ▶ Nanoscale Objects and Nanostructured Materials
- ▶ Social and Economic Impacts
- ▶ Tool development

Comments

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ISO: Nanomanufacturing Processes: Major Sections

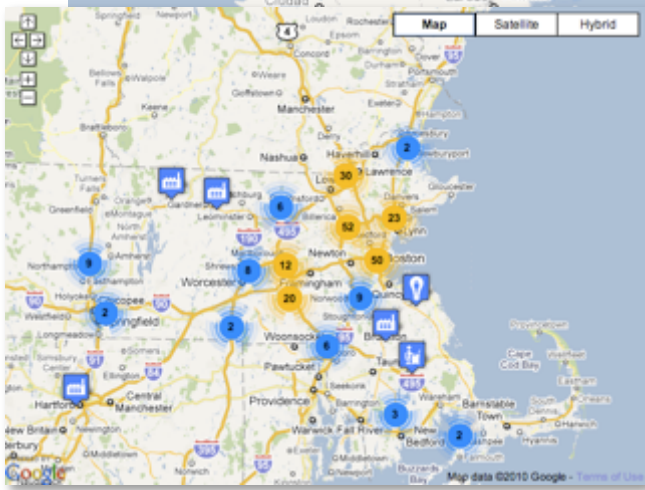
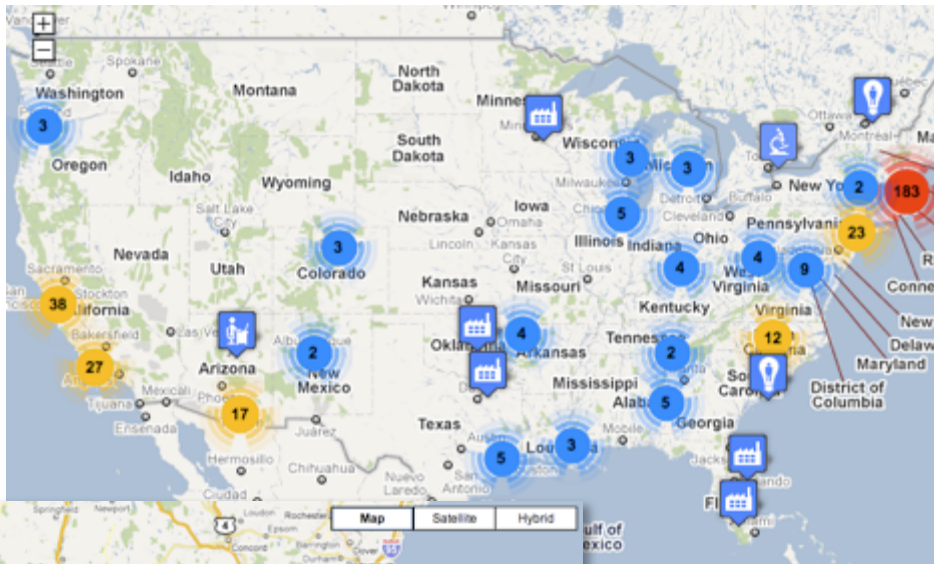
Taxonomy

- General Terms
- Assembly Techniques
- Biological Techniques
- Nanostructured Materials Synthesis Methods
- Deposition Methods
- Etching Methods
- Nanocomposite Manufacturing Methods
- Nanoparticle Synthesis
- Nanopatterning Lithography
- Roll-to-roll Manufacturing Techniques
- Self-Assembly and Directed Self-Assembly



Future NNN Focus and Industry Outreach

Economic Analysis



Database Assessment Tools for:

- Industry sector trends
- Supply chain analysis
- Workforce, Best Practices

Technical Approaches

- Data Mining/Analysis
- Business/Industry Analytics

Measured Outcomes:

- Economic Impact
- Forecasting
- Strategic Partnering

Benefits

- Technology matching
- Diffusion index of nanotech
- Identification of business & technology challenges

Scalable Nanomanufacturing Technologies

Guiding Questions

What technologies, applications or commercial products are most enabled by nanomanufacturing and nanofabrication processes?

What are the biggest barriers or process bottlenecks that need to be addressed to realize scaled nanomanufacturing?

What enabling/emerging process technologies need to be further developed in order to realize scaled nanomanufacturing?

Are there specific materials and/or metrology needs that are needed to realize scaled nano manufacturing?

What emerging nanomanufacturing processes will impact present manufacturing platforms and infrastructure?

Does an adequate infrastructure (materials, tools, metrology) exist to sustain scaled nanomanufacturing? Where is more focus needed?

What sorts of partnerships (public, private, academic, consortia) are needed to accelerate progress towards volume nanomanufacturing? What areas of collaboration between Asia and US institutions may enable the highest impact to accelerate nanomanufacturing?