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Resources for Nanomanufacturing
a project of National Nanomanufacturing Network

National Nanomanufacturing Network

Scalable Nanomanufacturing Technologies

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

Breakthrough Theatrette
Matrix Building, Biopolis
February 25-26, 2016

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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

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NSF

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

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- 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.

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CHM

Center for Hierarchical Manufacturing

www.umass.edu/chm

www.r2rnano.org

www.internano.org

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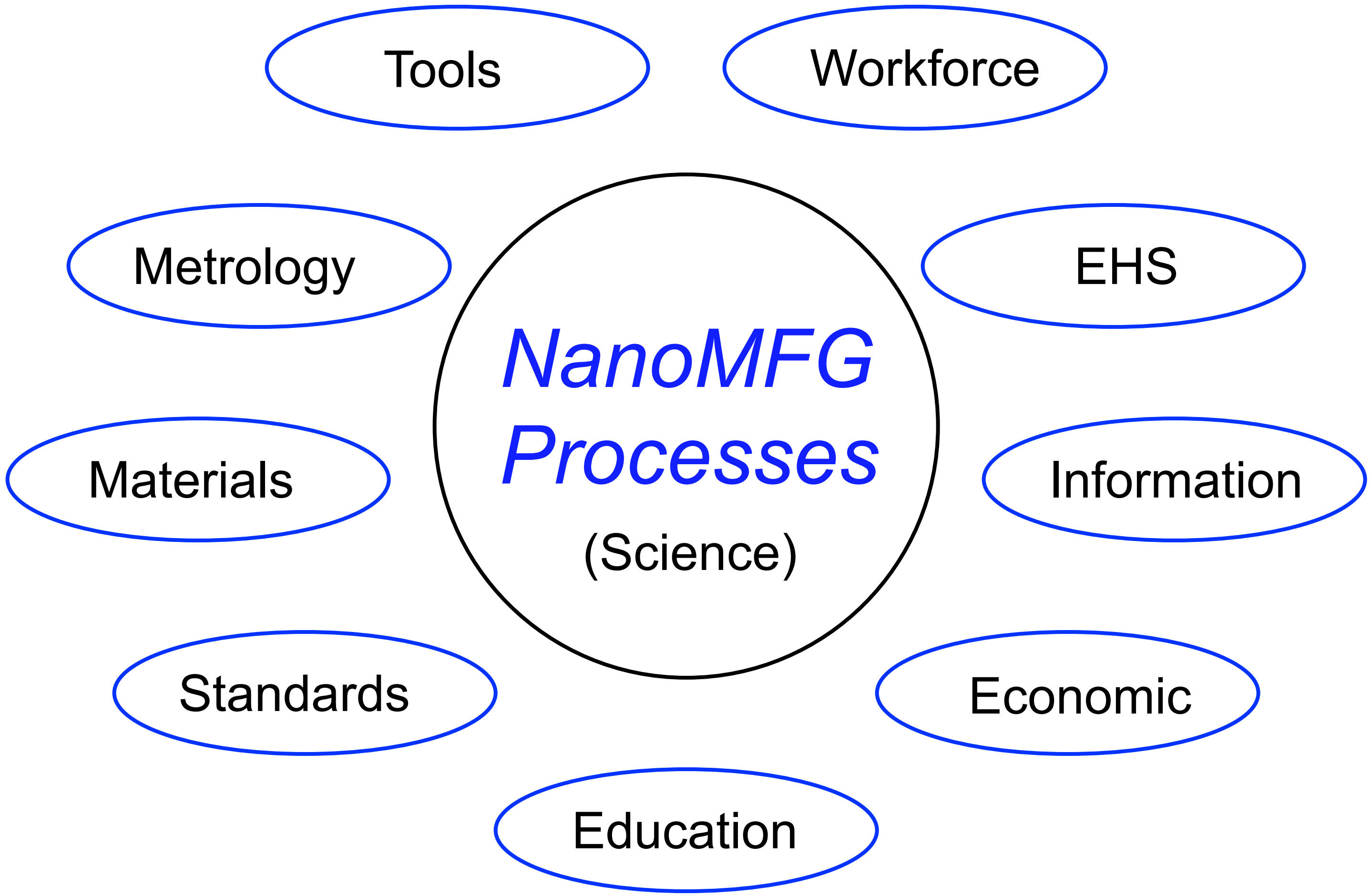
NNN Working With Stakeholders to Establish a Sustainable Nanomanufacturing Ecosystem



Information • Tools • Know-how • Roadmaps

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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, 3013, 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(Septemebr 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"**

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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

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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

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Nanomanufacturing Summit 2013

& 12th Annual NanoBusiness Conference

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

National Nanomanufacturing Network | NanoBusiness Commercialization Association | Penn University of Pennsylvania | Ben Franklin Technology PArtners

- 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

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R2R

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,	Ministry of Economics, Catalan
Hans Hartmann Pedersen	European Commission
Jeffrey Morse	National Nanomanufacturing Network
James Watkins	CHM/University of Massachusetts
Jouni Ahopelto	VTT/Printocent
Marc Verschuuren	Philips
Vivek Subramanian	University of California Berkeley
Antonio Facchetti	Polyera, Northwestern University
Theodor Nielsen	NIL Technologies
Helmut Schift	PSI/Eulitha
Jay Guo	University of Michigan
Michael Mühlberger	Profactor
Stephen Chou	Princeton University
Clivia Sotomayor Torres	ICN
Lee Richter	NIST
Paul Poodt	TNO/Holst Center
Werner Zapka	Xaar Corporation
Carolyn Ellinger	Kodak
Mark Poliks	Binghamton University/CAMMS
Arne Schleunitz	MicroResist Technologies
Ken Carter	CHM/University of Massachusetts

R2R

Workshop on Nanofabrication Technologies for Roll-to-Roll Processing

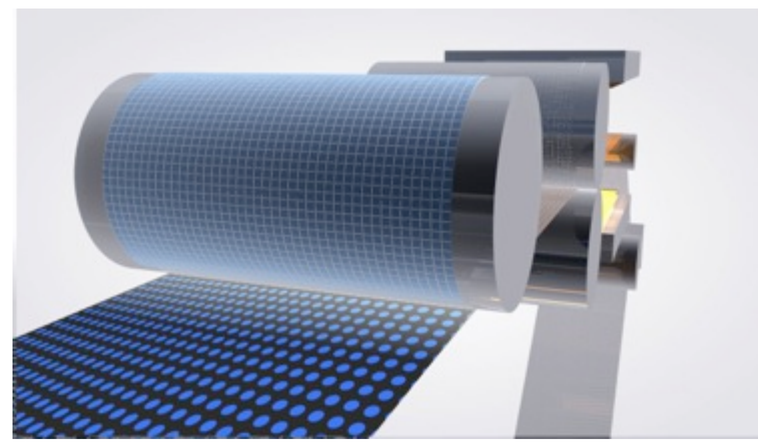
September 27-28, 2011 - Seaport Convention Center, Boston MA

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 Addresses 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**



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NIST National Institute of Standards and Technology U.S. Department of Commerce

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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

www.internano.org

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Process Database

NNN Newsletter

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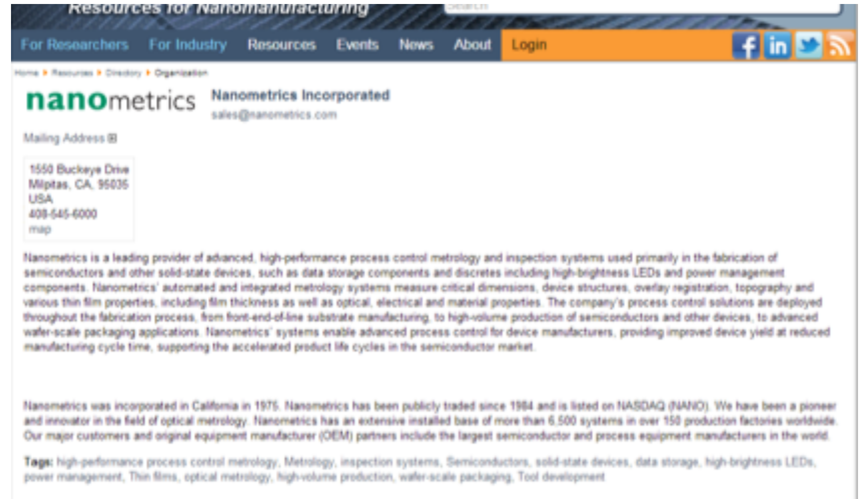
Expert Reviews

Directory



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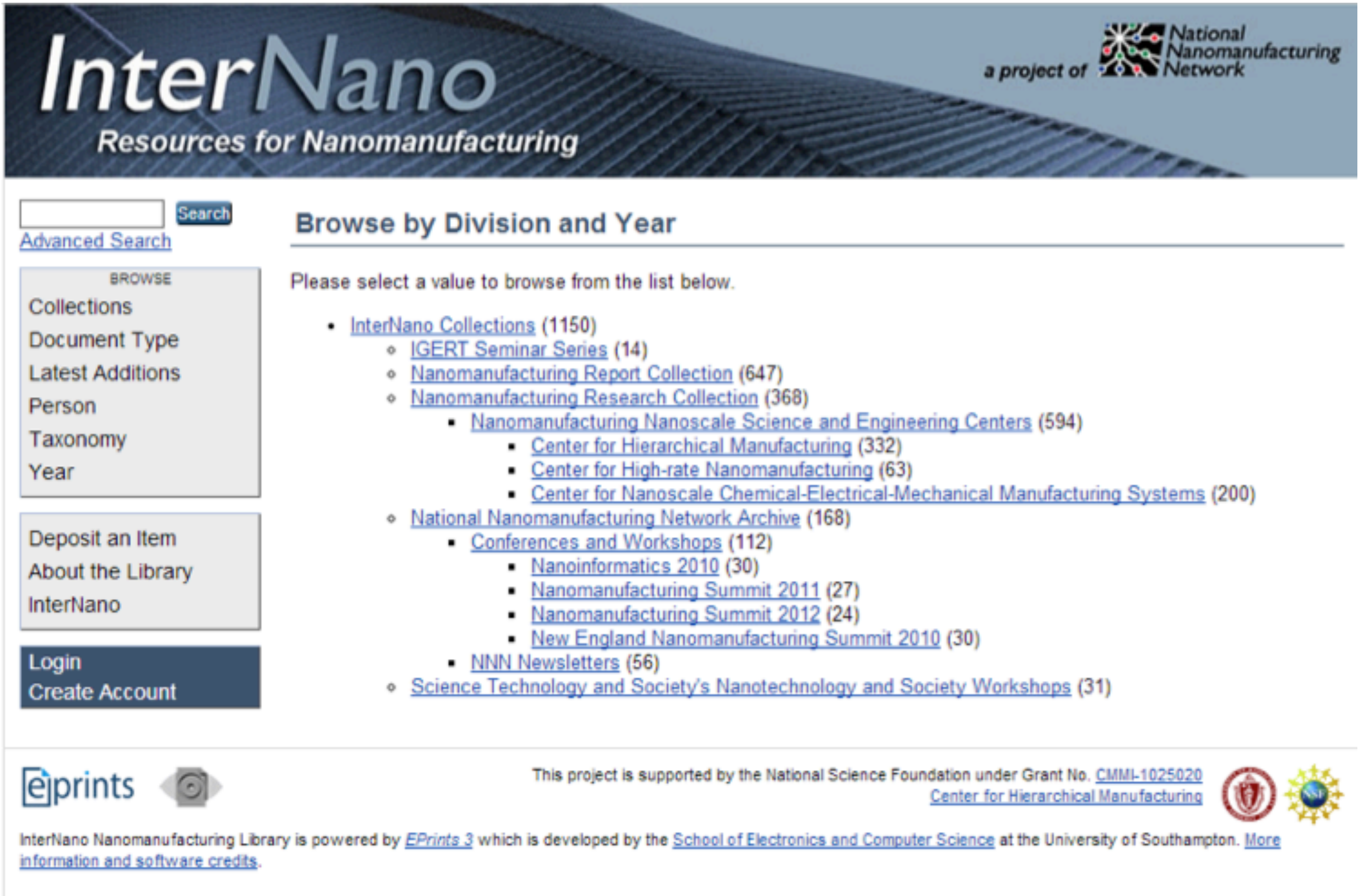
Research Library



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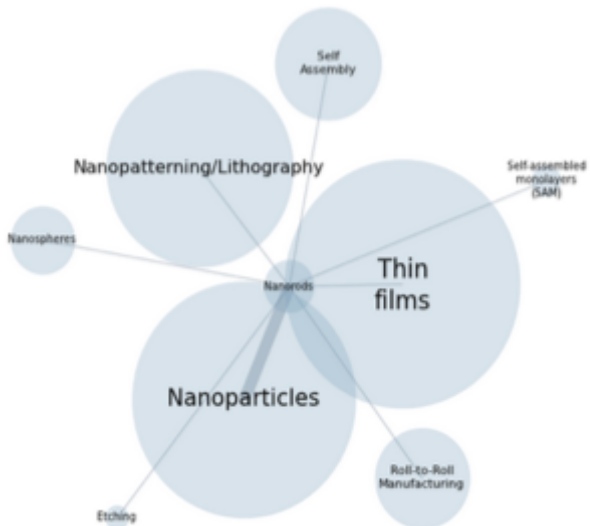
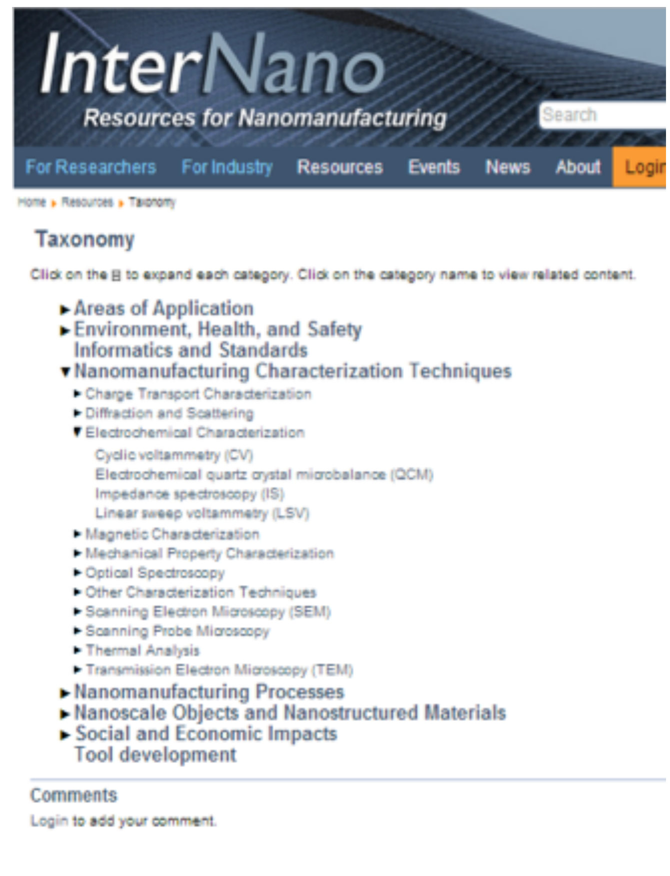
All Resources are linked by the taxonomy





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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

ISO

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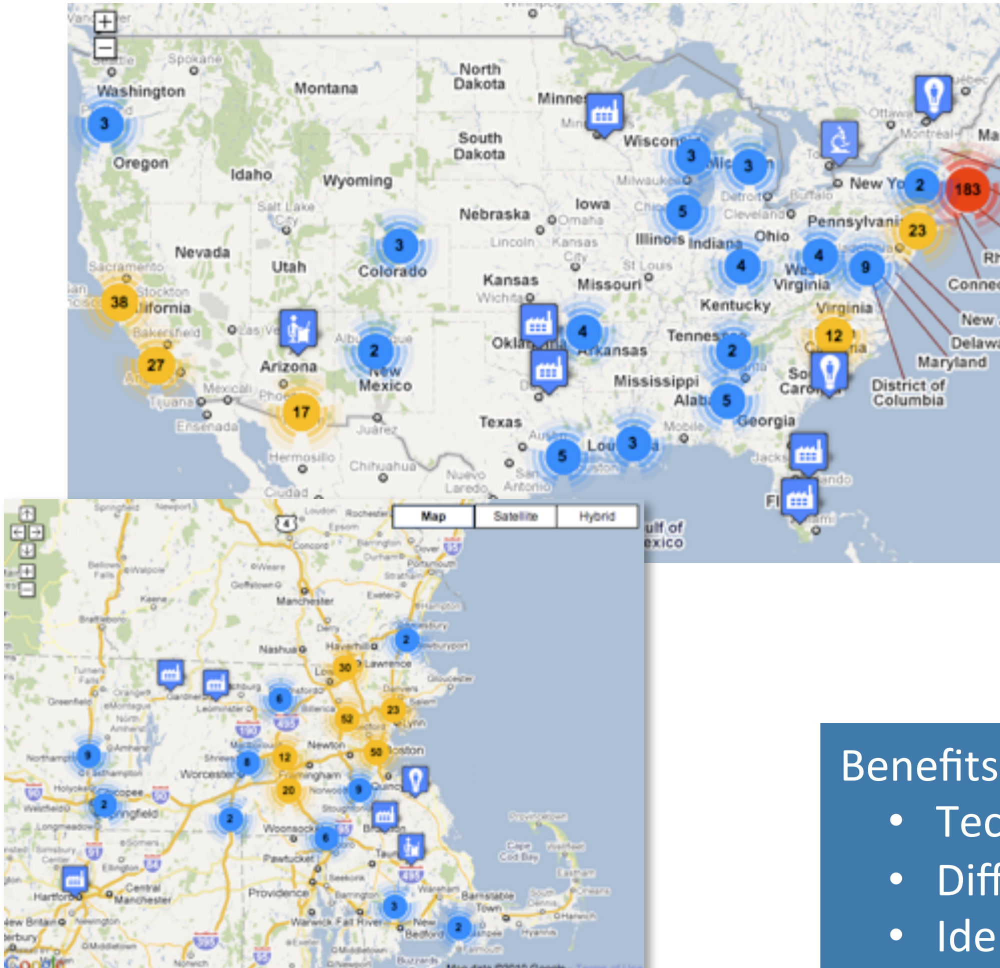
Future NNN Focus and Industry Outreach
Economic Analysis



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

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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?

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