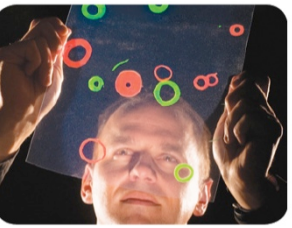

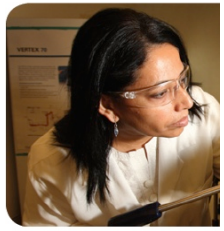

Nanotechnology Infrastructure Needs

2013 NNI Strategic Planning Stakeholder Workshop

Julia M. Phillips, Ph.D.
Vice President and Chief Technology Officer

June 11, 2013

Sandia National Laboratories

Exceptional service in the national interest

U.S. DEPARTMENT OF ENERGY

NNSA National Nuclear Security Administration

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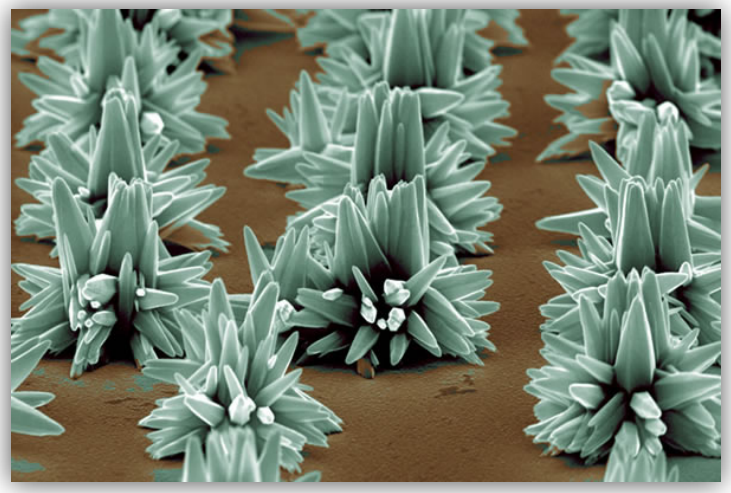
Overview

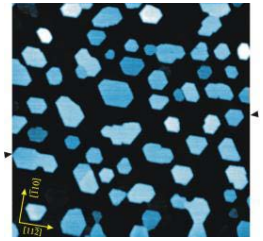
- Where We've Been
- Where We're Going
- What We'll Need

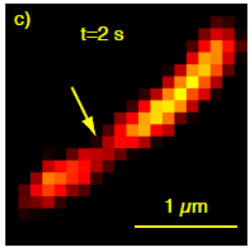


ZnO Nanostructures

Where We've Been

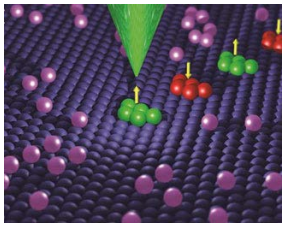
- Nano research has matured
  - What nanostructures can we observe?



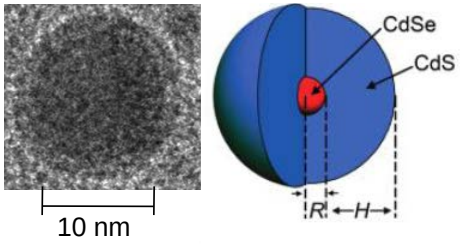


Atoms, clusters, molecules, thin films… static structures and kinetics

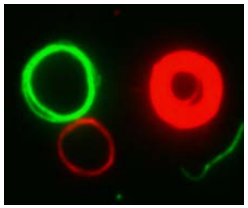
  - What nanostructured materials can we create, assemble and manipulate?



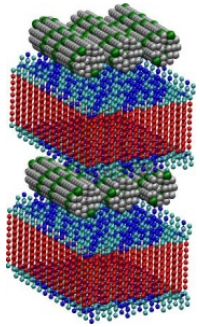
Five-atom iron magnets
(courtesy of NIST)



Core-shell nanoparticles



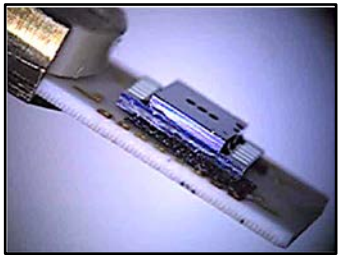
Ring nanocomposites



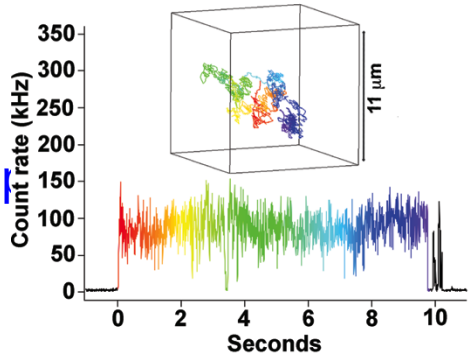
Integrated nanostructures
(courtesy of LANL)

Where We've Been

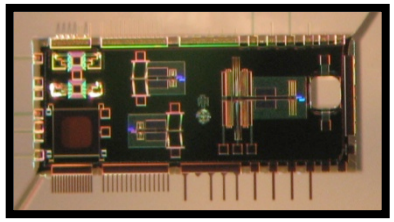
- Technology and techniques have evolved
  - Initially, existing techniques were used (e.g., electron microscopies, scanning probes, optical probes, etc.)
  - New techniques emerged as new discoveries were made



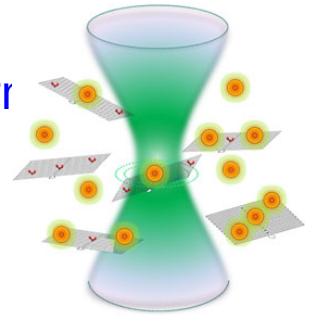
In-situ microscop



nanoparticle tracking



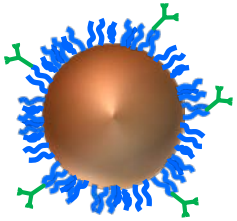
Discovery platforı



DNA origami

Where We're Going

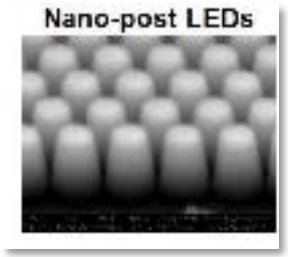
- Nanoscience research will continue to mature
  - How can we consistently and reliably create identical structures with high volume?

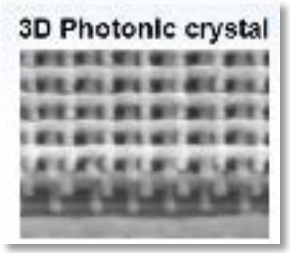


Magnetic particles with biocompatible coatings to detect cancer tumors

Developed by Senior Scientific LLC

  - What combinatorial methods can we use to create really interesting heterogeneous structures with tailored properties?





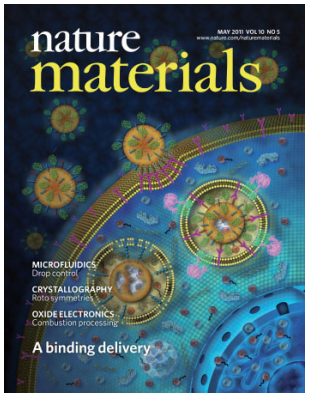
Combining nanoscale photon sources with a microscale photonic lattice to improve solid state lighting

  - Technologies and techniques will continue to evolve to address more complex nanomaterial systems and architectures

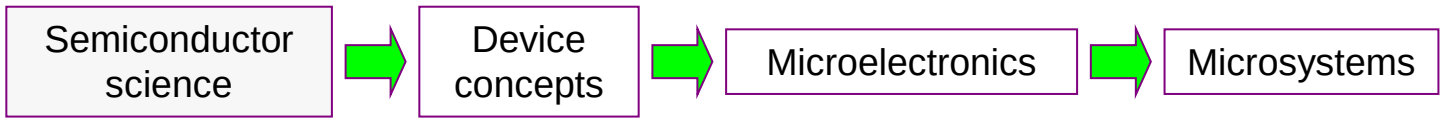
Poised to transform

Semiconductors transformed the electronics industry

Nanotechnology is poised to make a comparable transformation, but in a much broader way



A careful look at what was required for the semiconductor revolution can give us clues as to what we'll need



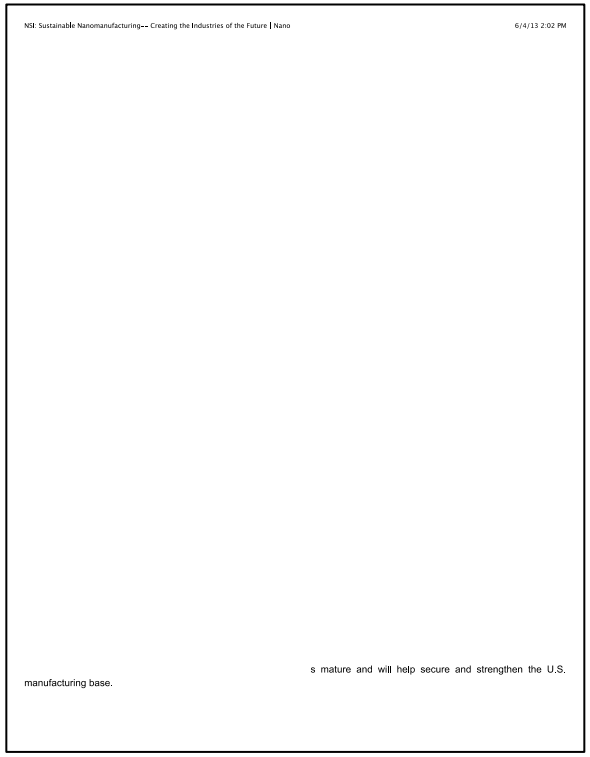
What We'll Need

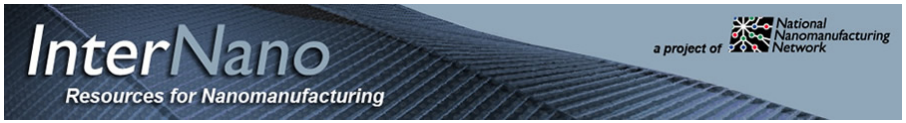
- Sustainment of the current research infrastructure with refinements and/or additions
  - Current wide distribution across the country is desirable; however, we need to truly be a national program
    - More specialized research at each institution
    - Facilitating access is critical – including virtual connectivity
    - Ongoing recapitalization needed
  - Add manufacturing extension centers to those facilities who are ready to move forward
- Six areas of opportunity relevant to infrastructure are…

(1) Nano-manufacturing

- Developing fast, cheap, robust methods to support the manufacture of low cost nanomaterials at scale.

- Providing the enabling environmental safety and health measurement science for consumer-confident manufacturing



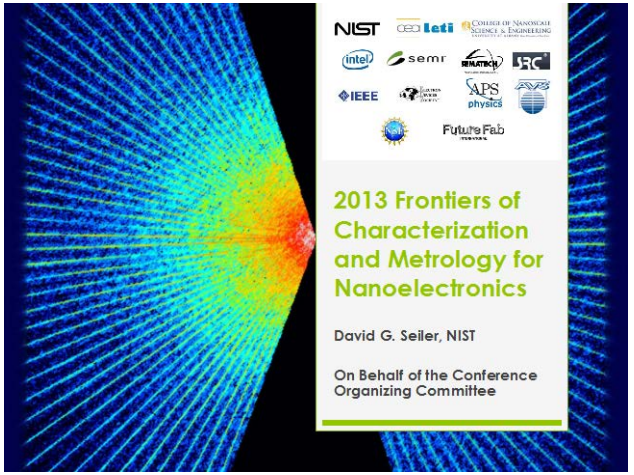


(2) Nanomaterial Metrology

- Providing the underlying metrology tools to do multi-technique analysis of nanostructure composition and properties on the same site

- Techniques for assessing quality against standards

- Techniques for characterizing ever more complicated architectures and composite materials systems



(3) Physical Infrastructure

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- Recapitalize: A state-of-the-art facility is key to joint ventures with industry partners; moving discoveries to technologies
- User facilities and networks can be more than research resources; innovation hubs that connect ideas to applications
- Industrial R&D landscape has irreversibly changed; roles for public/private nanotechnology infrastructure?
- International competition is rapidly building infrastructure

(4) Infrastructure Access = Value

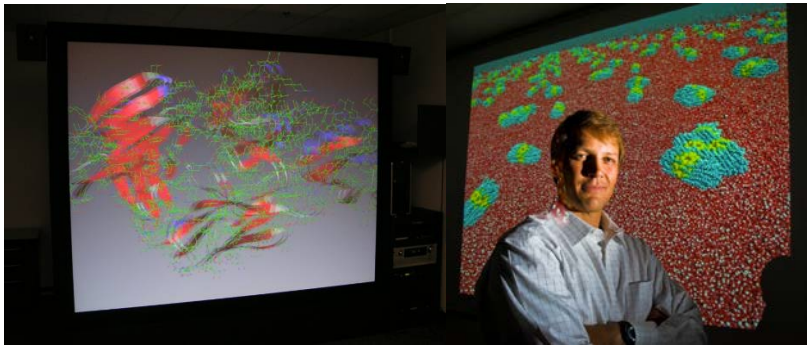
Sandia National Laboratories

- Keep barriers to entry of facilities that offer access to expensive or rare equipment as low as possible
- Intellectual property issues can be inhibiting
- Need a spectrum of access modes for resource networks that offer expertise as well as instrumentation or computation
- Pooling private resources for shared infrastructure needs; what is Federal/State role here?

(5) Approaches to Complexity

Sandia National Laboratories

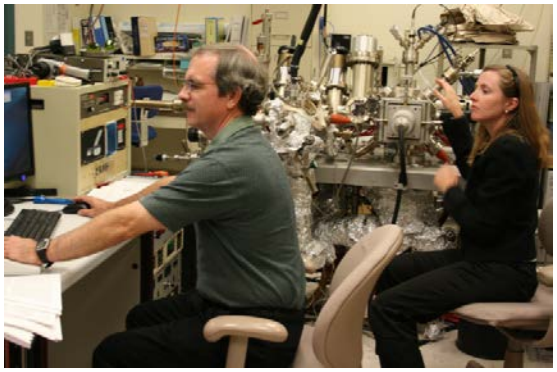
- Multi-scale integrated nanostructures: How to identify the relevant variables among too many others?
- Big data sets – challenge is not unique to nanoscience
- Information extraction: Real time image processing; coordinate transformation (e.g., Fourier transform)
- New methods for data analysis (for example: visualization)
- New concepts similar to the pseudopotential to simplify an overly complicated subject

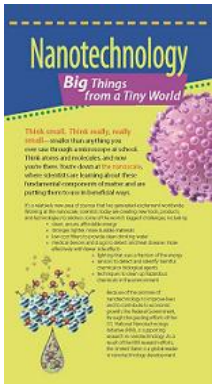


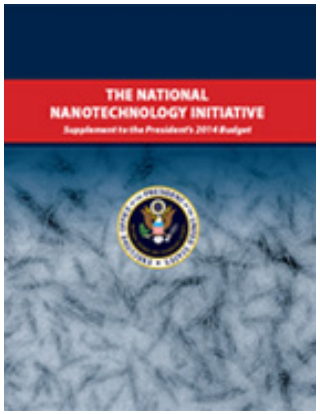
Visualization of large data sets to “see” correlations

(6) Qualified Talent Pipeline

- Researchers need interdisciplinary fluency yet deep technical expertise.
- Essential training and certification for nanotechnology development and production personnel?
- Foster nanoscience literacy in undergraduate and secondary education curricula







Summary

- Nanotechnology infrastructure is expanding worldwide.
- Current research infrastructure can grow in scope and impact by specialization with National-level coordination to facilitate broader access.
- Opportunities exist now to develop and optimize public/private infrastructure for predictable future needs beyond research.