NIST's Nanotechnology Strategy

Meeting of NIST's Visiting Committee on Advanced Technology

October 29, 2008

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Questions for the VCAT

- Are we addressing the right technology sectors, societal needs, and NIST needs?
- Is NIST missing other opportunities?
- Is NIST using the right metrics to evaluate program performance? Other metrics?

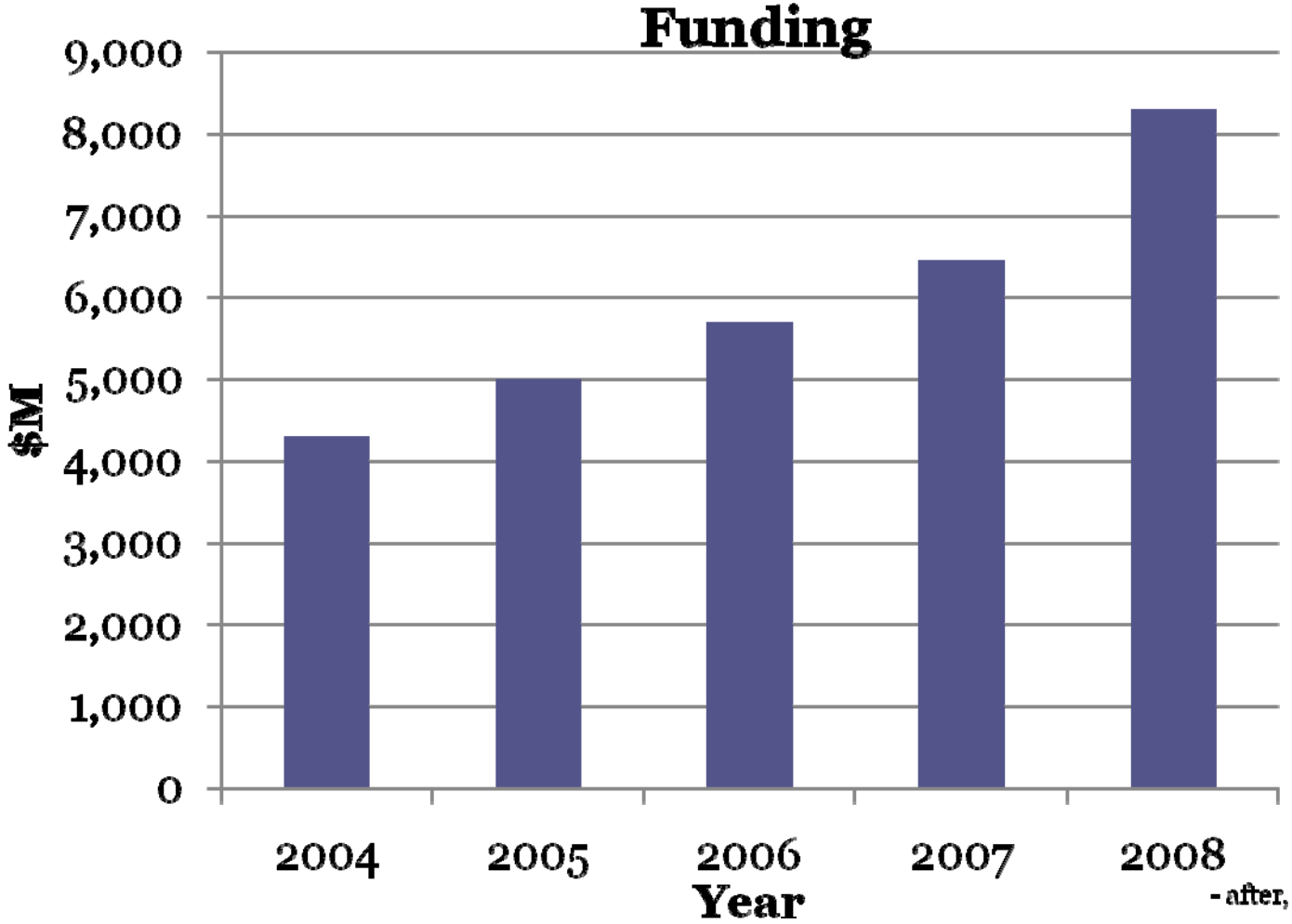
Outline

- The Breadth of Nanotechnology
- NIST's Role in Nanotechnology
- Organizing Nanotechnology at NIST
- Our Current Portfolio
- Areas of Future Investment
- External Relationships
- Performance Metrics

The Breadth of Nanotechnology

- biosensors enabling early treatment of diseases, biosensors applied to drug discovery, radiative cooling paint, cold lighting systems, dye solar cell, biosensors for diagnostics, molecular electronics, nanoparticles for total UV protection, food wraps that use nanoparticles to improve gas barriers, nano-enhanced windows - self cleaning, solar control, switchable, photovoltaic, paint additives to allow dark surfaces to stay relatively cool and light surfaces to absorb heat, sensors of temperature, stain resistant fibers for clothing, air quality monitors and enhancers, stress sensors embedded in building materials, "smart spaces" that sense and act, communicate, reason, and interact, magnetic sensors, magnetic storage, electronic switches, optical filters, new lasers, nanostructured catalysts, reinforced materials, probes, thermal barriers, ink-jet inks, molecular sieves, high hardness tools, antimicrobials, nanocomposite materials, contrast agents, labs-on-a-chip, water purification materials, enhanced batteries, stronger materials, lubricants, rocket propellant, improved coolants, synthetic bone, cosmetics, wear resistant materials, porous membranes, translucent ceramics, radar absorbing coatings, hydrogen storage devices, coal liquefaction systems, conductive plastics, displays, lightning arrestors, electron microscopes, electrostatic dissipation, antistatic materials, conductive adhesives, nanomechanical systems and sensors, x-ray zoneplates, fast-absorbing drugs and nutrients, ultra-capacitors, novel semiconductor devices, novel optoelectonic devices, quantum computers, light aerospace materials, food storage and packaging materials, scratch resistant optics, tissue engineering materials, functional food, functional fertilizer, all optical information processing, neural prosthetics, nanoplasmonics, polymer films used in displays for laptops, cell phones, digital camera, smart goods; nanoelectronics, pervasive electronics, imaging systems, nanosurgery, transistors, nanofluidics, molecular scale motors, atomically precise assembly, space elevator, tennis, golf, and bowling balls, water repellants, magnetic disk materials, disk drive heads, bandages, man-made skin, packaging to sense spoiled food, high density phase change memory, dental bonding agent, compasses, self repairing materials, tags and markers, nanofabrication, nanoscale analysis, etc.

Investment in Nanotechnology Continues to Grow Worldwide



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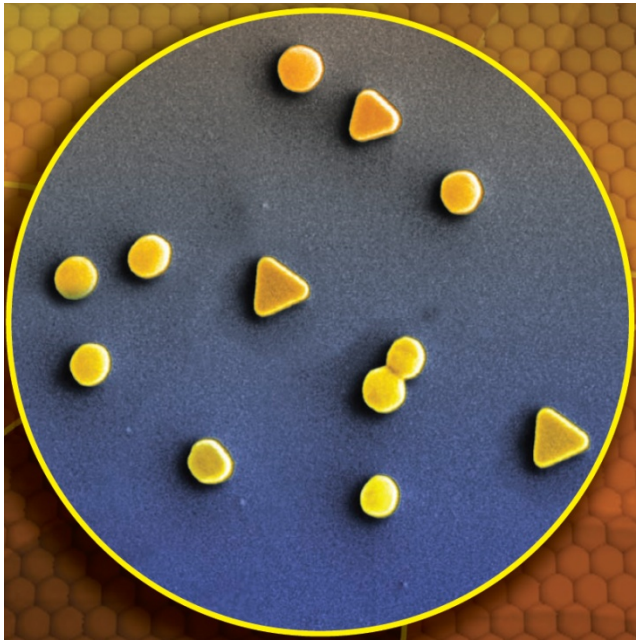
NIST's Responsibility is for Measurement



Imaged using helium ion microscopy (NIST/MEL)

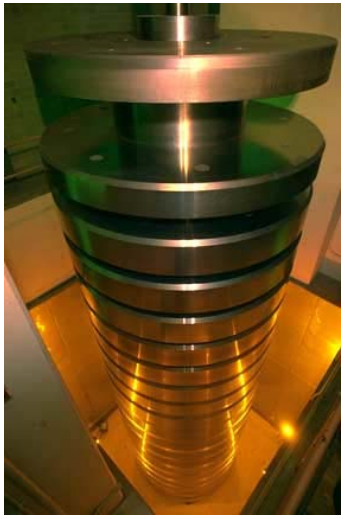
- 60 nm gold particles
- What might you want to know?

NIST's Role

- To advance measurement science
- To provide needed standards
- To support the critical measurement needs of industry
- To support national priorities

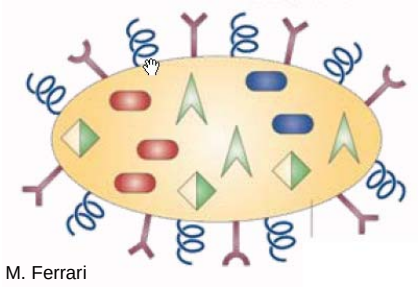
Nanotechnology: The Logical Imperative

- Most of NIST's nanotechnology flows as a logical extension from our responsibility for the same measurement on a larger scale
- milli > micro > nano



Nanotechnology: New Directions

- Many of the best new opportunities in nanotechnology involve multiple disciplines
- Example: Engineered drug delivery
- Example: Molecular electronics


M. Ferrari

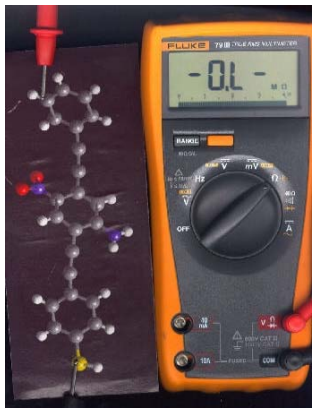
Chemists

Biologists

Physicists

Materials Scientists

Toxicologists



Chemists

Physicists

Electrical Engineers

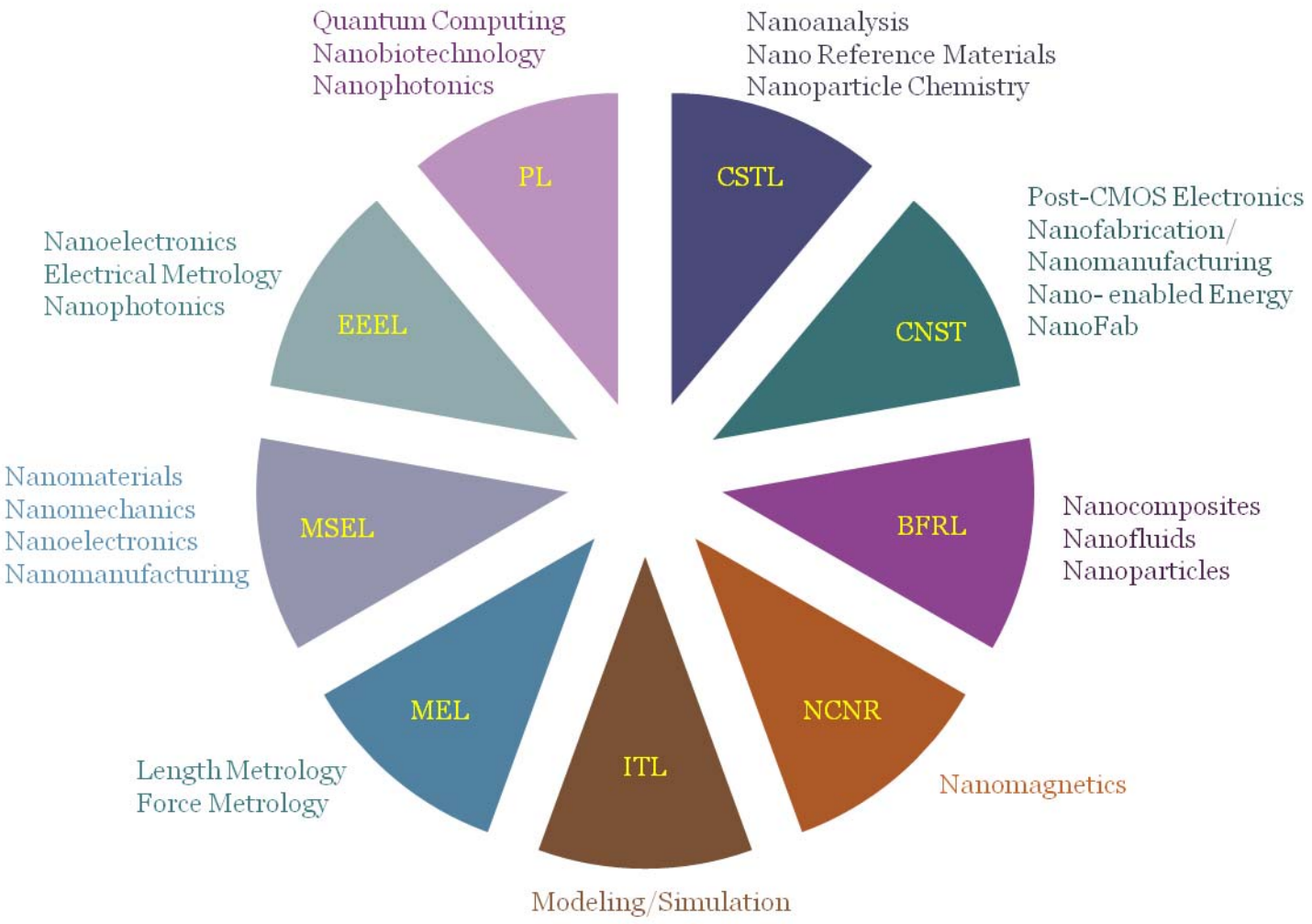
Materials Scientists

Biologists

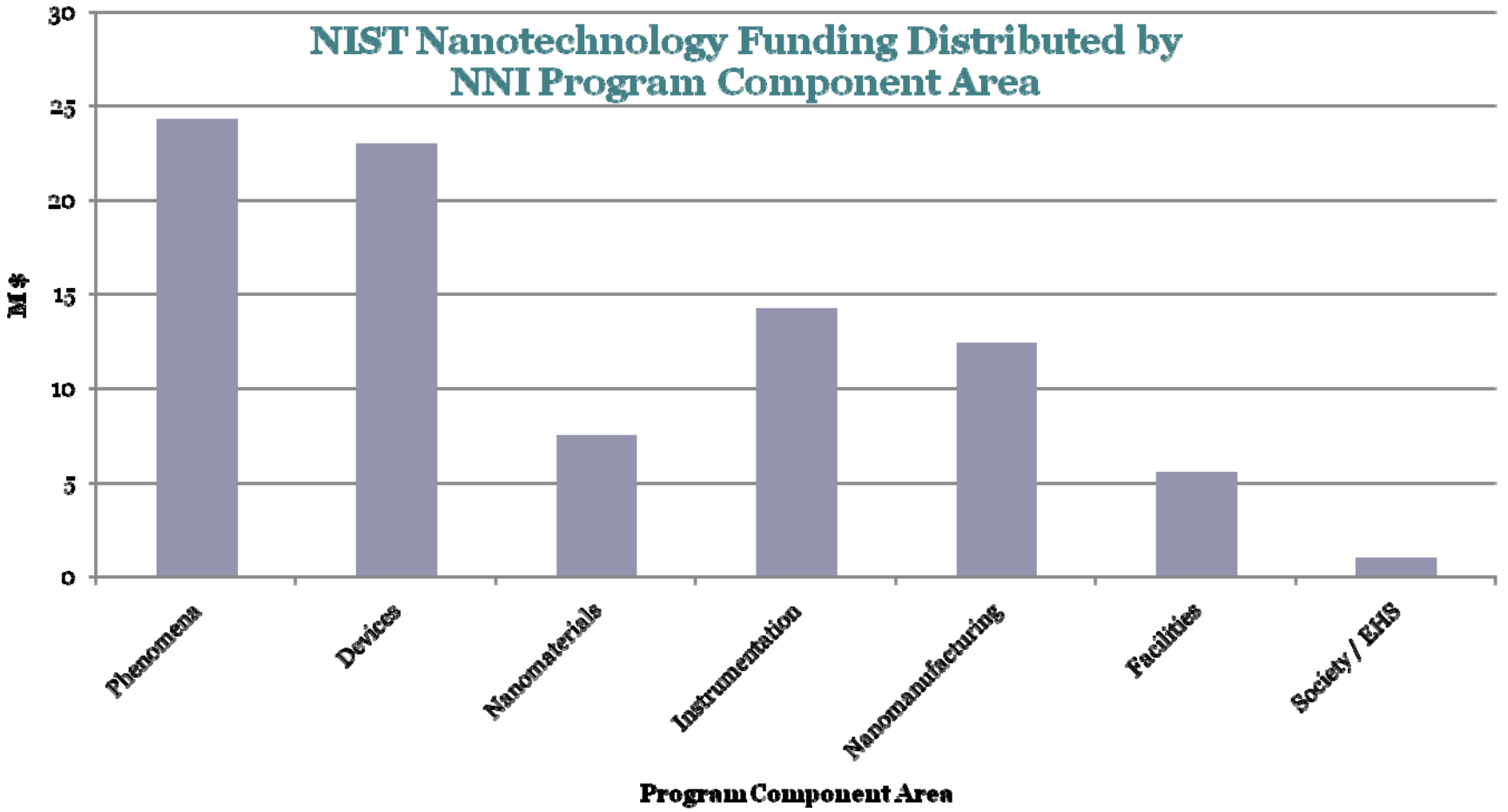
Organizing NIST for Nanotechnology

- Discipline taxonomy
  - Logical imperative, milli>micro>nano
- Multidisciplinary approach
  - Center for Nanoscale Science and Technology
    - Shared resources
- Multilateral strategic planning is essential
  - Information sharing
  - Coordination

Match to Mission: Examples



NIST's Nanotechnology Portfolio



Areas of Strong Demand for Measurement Solutions

- Nano-EHS
  - Protect the population
  - Reduce the risk barrier to innovation
- Post-CMOS Electronics
  - Extend the electronics enterprise
- Nano-enhanced energy
  - Optimize the first step in conversion, storage, transport
- Nanomanufacturing
  - Allow industry to capitalize on discovery
- Nano-bio/medical
  - Enable personalized medicine
  - Reduce costs
- Nanophotonics
  - Enhance communications, lighting, and inspection

How Do We Determine Need?

- Knowledge of the field
  - Staff expertise
  - Professional meetings, seminars, etc.
  - Expert consultants
- Directed Workshops
  - Specifically designed to determine need
- Industrial Community Interactions
  - Trade organizations, government representatives, etc.
  - Industrial collaborations, consortia
  - Industry roadmaps, e.g., ITRS
- Committed Partners
  - Nanotechnology Research Initiative
- Government Reports
  - NNI, European NanoStrand, etc.
  - US Measurements Survey

External Relationships

- Objectives
  - Inform our program decisions
    - Semiconductor Research Corporation, Telecommunications Industry Association, National Storage Industry Consortium, Council for Chemical Research, Vision 2020, Nanobusiness Alliance, NIOSH, etc.
  - Complement the abilities of our staff and facilities
    - Center for Nanoscale Science and Engineering (University at Albany), U. of Texas (Austin), NASA, IBM, Intel, Micron, etc.
  - Participate in important research programs
    - Nanoelectronics Research Initiative, National Cancer Institute, DARPA - Atomically Precise Assembly
  - Develop widely accepted standards
    - NIST represented on multiple standards committees, e.g., ASTM, ISO, iNEMI, VAMAS, etc.

Performance Metrics

- Accomplishments
  - Innovations transferred, instruments introduced, publications, measurement protocols established, standards released, discoveries made, patents filed, facility users, postdocs trained, SRMs offered, fabrication processes established, etc.
- Peer Recognition
  - Citations, lecture invitations, prizes, awards, postdoctoral applications, fellowships, visiting professor applications, etc.
- Associations
  - Collaborations, institutional pairings, industrial partnerships, industry associations, etc.

Summary

- Nanotechnology: a rapidly growing, ubiquitous technology
- A natural and critical extension of most of NIST's measurement responsibilities
- A field known to benefit greatly by a multidisciplinary approach and the economical use of shared facilities
- Strategic planning for nanotechnology at NIST must involve both:
  - Extension of measurements to nano realm
  - Multidisciplinary solutions to new measurement problems
- Areas of need and opportunity are selected based on the evaluation of an abundance of inputs from multiple sources
- Integration of NIST-wide planning for nanotechnology currently identifies six areas as requiring added attention over the next few years:
  - Nano-EHS
  - Post-CMOS Electronics
  - Nano-enhanced Energy
  - Nanomanufacturing
  - Nano-bio/medical
  - Nanophotonics

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