



TAPPI **VTT**
**INTERNATIONAL CONFERENCE ON NANOTECHNOLOGY
FOR THE FOREST PRODUCTS INDUSTRY**
September 27-29, 2010 • Otaniemi, Espoo, Finland
Technical Advances and Applications in Nanotech Products



Federally-funded Nanotechnology Research in the United States

Chris Risbrudt, PhD
Director
USDA Forest Service
Forest Products Laboratory
Madison, WI (USA)

29 September 2010
Co-Authors: Theodore Wegner & World Nieh



Abstract:

The National Nanotechnology Initiative (NNI) is the U.S. Government's crosscutting program that coordinates Federal research and development (R&D) activities in nanoscale science, engineering, technology, and related efforts among various participating agencies. The NNI was launched in 2000 to accelerate the development of nanotechnology and includes 25 Federal agencies --15 of which (including Forest Service R&D) have their own individual budgets for nanotechnology R&D. The NNI has a cumulative Federal spending of \$12 billion and is playing a key role in positioning the U.S. as a leader in both nanotechnology R&D and commercialization.

Nature's own nanocomposites, among them bone, shell, and wood, are simultaneously strong, light, and tough and are composed from assemblies of materials available through biological evolution. The secret to these enviable combined properties is that natural materials are organized hierarchically at the nano, micro, and larger scales to achieve orders-of-magnitude increases in, for example, strength, and toughness compared to their constituent phases. Wood is a cellular composite with four levels of structure spanning the molecular to the macro scale. Its stiffness and strength per unit weight are comparable to steel, and its toughness is 10 times that of a conventional fiber-reinforced composite with a comparable loading of fibers. The individual nanodimensional building blocks of wood: (1) have strength properties greater than Kevlar® and piezoelectric properties equivalent to quartz, (2) can be manipulated to produce photonic structures, (3) are remarkably uniform in size and shape, (4) possess self-assembly properties, and (5) can be renewably produced in quantities of tens of millions of tons. Nanotechnology offers the way to efficiently and effectively capitalize on a major U.S. national asset to make forest-derived materials the "materials of choice for the 21st century." A challenging vision for the next 10 and 20 years is to emulate proven natural designs in manufacturable architectures where the ultimate properties of engineered nanoconstituents can be fully realized and enhanced.

Recognizing that the values of wood and wood-based materials at the nanoscale are virtually untapped, government, industry and academia technology leaders have developed a shared vision for wood-based nanotechnology and identified priority focus areas. The Forest Service R&D (FS R&D) has established a foundation in forest products nanotechnology research and development and is partnering with other federal entities, industry, and academia to develop the precompetitive science and technology critical to the economic and sustainable production and use of new high-value, nano-enabled, forest-based materials and products.



US National Nanotechnology Initiative (NNI)

- NNI was established in 2001 (The 21st Century Nanotechnology Research and Development Act, PL 108-153)
- Focused on Precompetitive Science & Technology
- Currently: 25 federal agencies
- FY10 NNI budget: €1.34 billion
- FY11 NNI Budget: €1.36 billion (proposed)
- Cumulative budget since NNI inception: €9 billion

PUBLIC LAW 108-153—DEC. 3, 2003

117 STAT. 1923

Public Law 108-153
108th Congress

An Act

To authorize appropriations for nanoscience, nanoeengineering, and nanotechnology research, and for other purposes.

Dec. 3, 2001
[S. 180]

Be it enacted by the Senate and House of Representatives of the United States of America in Congress assembled,

21st Century
Nanotechnology
Research and
Development Act.
15 USC 7001
note.

SECTION 1. SHORT TITLE.

This Act may be cited as the "21st Century Nanotechnology Research and Development Act".

SEC. 2. NATIONAL NANOTECHNOLOGY PROGRAM.

15 USC 7001

(a) NATIONAL NANOTECHNOLOGY PROGRAM.—The President shall implement a National Nanotechnology Program. Through appropriate agencies, councils, and the National Nanotechnology Coordination Office established in section 3, the Program shall—

President.

(1) establish the goals, priorities, and metrics for evaluation for Federal nanotechnology research, development, and other activities;

(2) invest in Federal research and development programs in nanotechnology and related sciences to achieve those goals; and

(3) provide for interagency coordination of Federal nanotechnology research, development, and other activities undertaken pursuant to the Program.

(b) PROGRAM ACTIVITIES.—The activities of the Program shall include—

(1) developing a fundamental understanding of matter that enables control and manipulation at the nanoscale;

(2) providing grants to individual investigators and interdisciplinary teams of investigators;

(3) establishing a network of advanced technology user facilities and centers;

(4) establishing, on a merit-reviewed and competitive basis, interdisciplinary nanotechnology research centers, which shall—

(A) interact and collaborate to foster the exchange of technical information and best practices;

(B) involve academic institutions or national laboratories and other partners, which may include States and industry;

(C) make use of existing expertise in nanotechnology in their regions and nationally;

(D) make use of ongoing research and development at the micrometer scale to support their work in nanotechnology; and



**President's Council of
Advisors on Science &
Technology**

**National Science & Technology
Council**

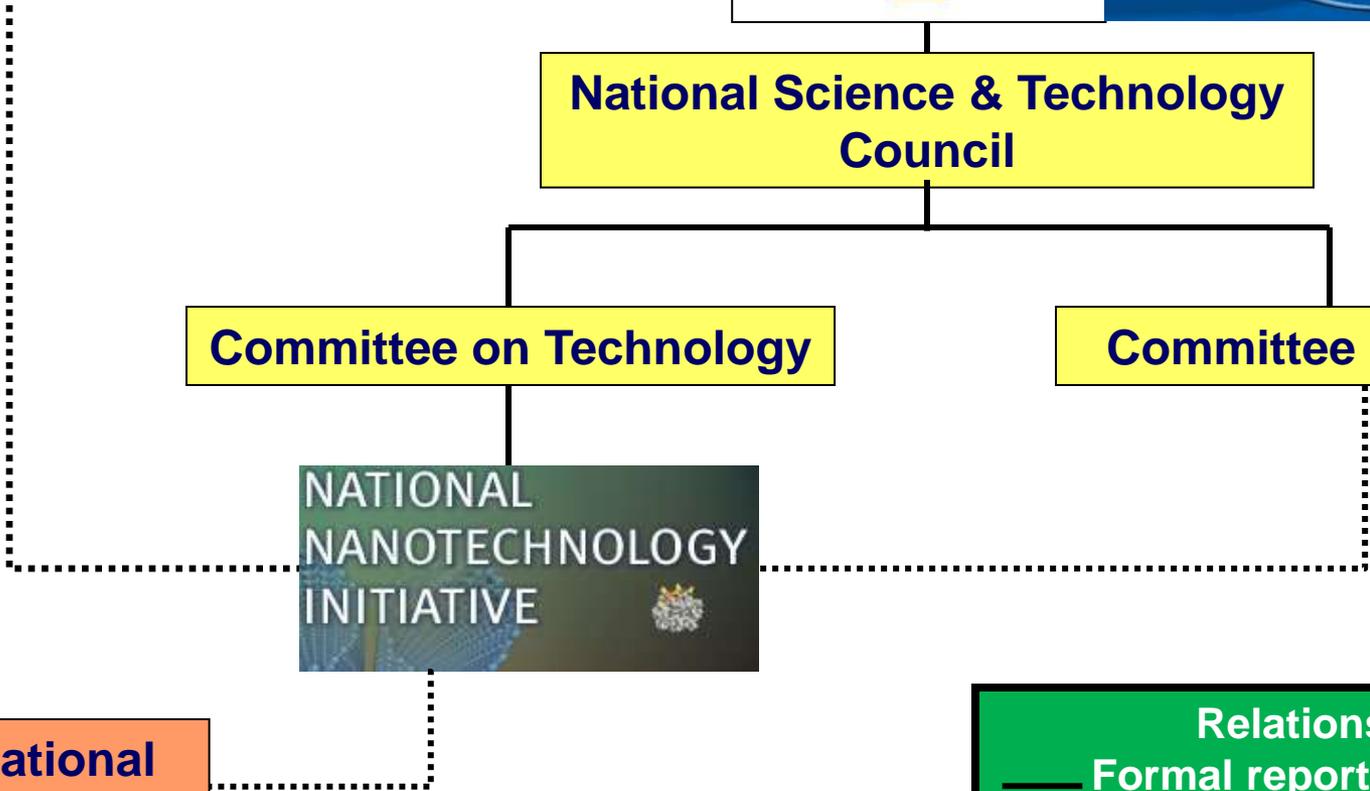
Committee on Technology

Committee on Science

**NATIONAL
NANOTECHNOLOGY
INITIATIVE**

**National
Academies**

Relationship
—— Formal reporting
..... Informal reporting



NNI Federal Participation

- NNI participating Departments & Agencies have grown to 25





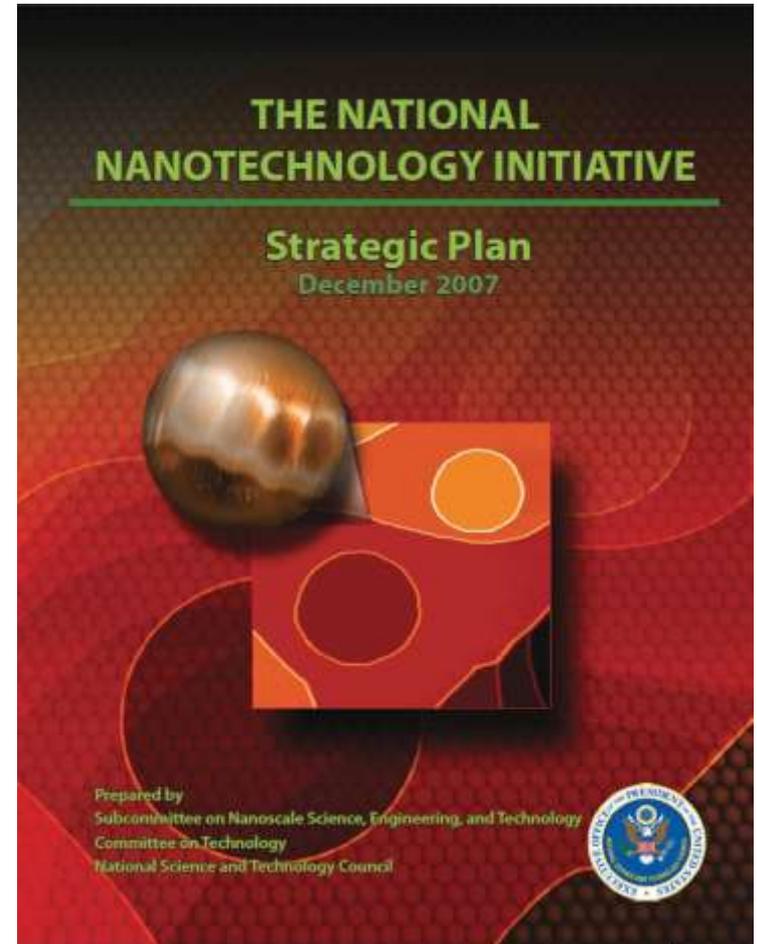
Federal Departments & Agencies with Nanotechnology R&D

Department/Agency	FY2010 Nanotechnology R&D Budget (Euros in millions)
National Science Foundation	319
Dept. of Energy	351
Dept. of Defense	286
Dept. Health & Human Services (NIH)	265
Dept. of Commerce (NIST)	69
Environmental Protection Agency	14
Nat. Aero.& Space Administration	13
Dept. of Health & Human Services (NIOSH)	9
USDA Forest Service	4
USDA Res, Education & Extension	2
Dept. of Transportation (FHWA)	2

NNI Vision and Goals

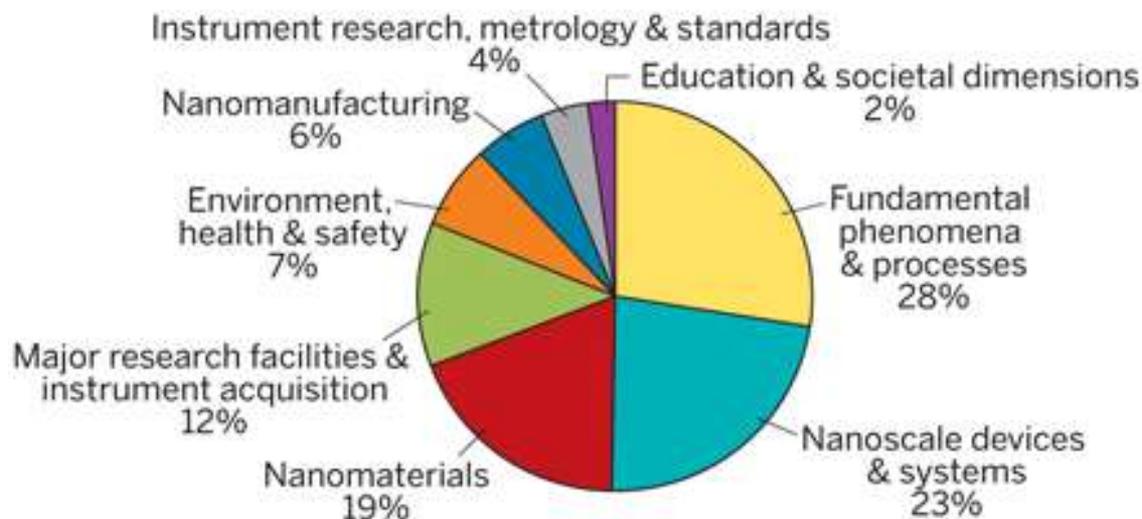
Vision: a future in which the ability to understand and control matter on the nanoscale leads to a revolution in technology and industry that benefits society

- Goal 1: Advance a world-class nanotechnology research and development program.
- Goal 2: Foster the transfer of new technologies into products for commercial and public benefit.
- Develop and sustain educational resources, a skilled workforce, and the supporting infrastructure and tools to advance nanotechnology.
- Goal 4: Support responsible development of nanotechnology.





Investments by Component Area



Proposed 2011 federal funding = €1.36 billion

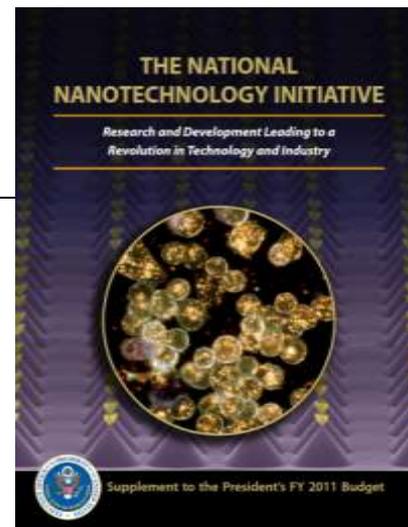
Eight Component Areas



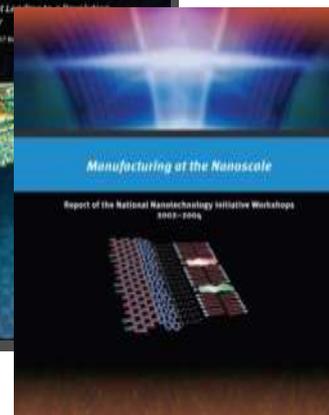
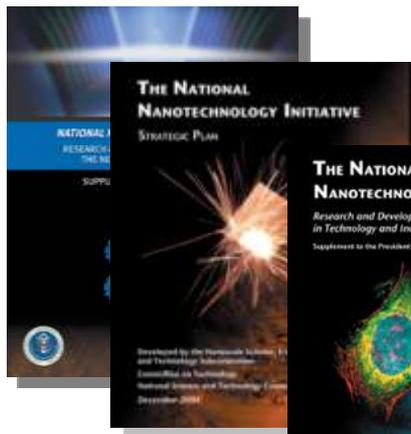
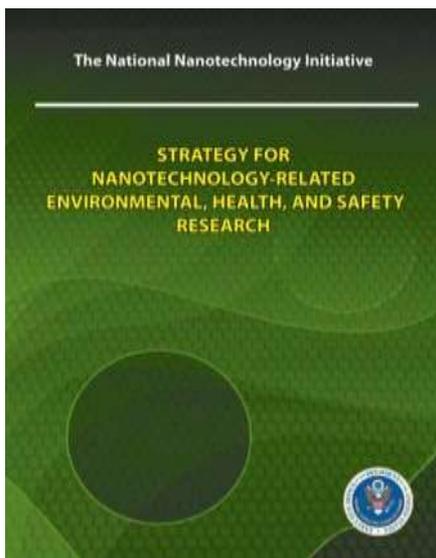
INTERNATIONAL
CONFERENCE ON
NANOTECHNOLOGY FOR
THE FOREST PRODUCTS
INDUSTRY

A Sampling of NNI Publications

Supplement to the
President's FY 2011 Budget



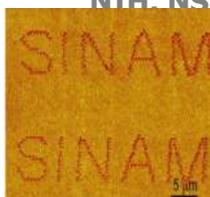
Environmental, Health, and
Safety Research Strategy



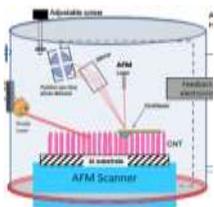
Federal NNI Nanotechnology R&D



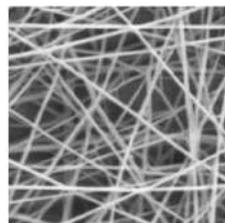
4-D image of atomic motion
Air Force, NTH, NSF



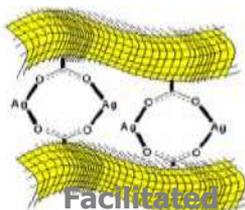
Nano Lithograph,
NSF



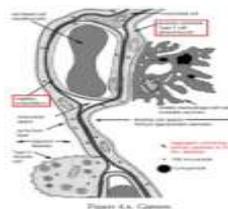
Carbon nanotubes in electronics, NSF



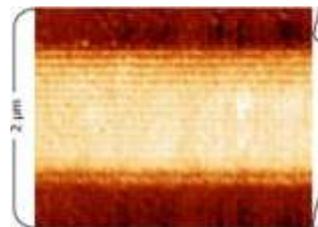
Chitosan nanofibers, EPA



Facilitated intermolecular crosslinking,
EPA and NSF



Human toxicity, EPA



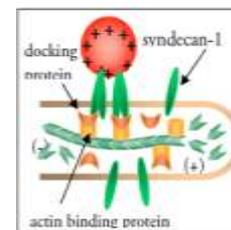
Highly ordered polymer layers
DOD/ONR/ORL



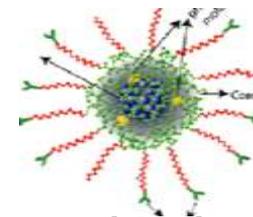
Nanobatteries,
DEO and NSF



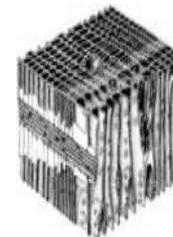
Nanomaterials
NIH and DOE



Fate of nanomaterial in living cells, EPA



Tumor detection, NIH



Wood Cellulose Nanomaterials, USDA FS

NNI Industry Collaborations for Development of Nanotechnology



- **Electronic Industry (Semiconductor Research Corporation lead), October/2003 - Collaborative activities in key R&D areas 5 working groups, Periodical joint actions and reports; NSF-SRC agreement for joint funding; other joint funding**



- **Chemical Industry (Council for Chemical Research lead) - Joint road map for nanomaterials R&D; Report in 2004; 2 working groups, including one EHS Use of NNI R&D results, and one to identify R&D opportunities**



- **Organizations and business (Industrial Research Institute lead) - Joint activities in R&D technology management; 2 working groups (nanotech in industry, EHS) Exchange information, use NNI results, support new topics**



- **Forest Products Industry (AF&PA Agenda 2020 Technology Alliance lead), April 2007 – Facilitate forest products industry input to and communication with NSET**

Third PCAST Review of the NNI -- 2010

Priority Applications for Nanotechnology

- **Extending the Capabilities of Information Technology**
- **Health Care in the 21st Century**
- **Energy and the Environment**
- **National Security**
- **Beyond Steel: High Strength Materials**

REPORT TO THE PRESIDENT
AND CONGRESS
ON THE THIRD ASSESSMENT OF
THE NATIONAL NANOTECHNOLOGY
INITIATIVE

Executive Office of the President
President's Council of Advisors on
Science and Technology

March 12, 2010





PCAST Third NNI Assessment

- **Federal programs have had a catalytic and substantial impact on the field of nanotechnology**
- **Increase NNI funding for nanomanufacturing research while maintaining support for basic research**
- **Commercial activities have gained momentum**
- **Metrics need to be developed to track the benefits of nanotechnology (e.g. job creation, contributions to GDP, etc.)**
- **The scarcity of standardized commercialization data challenges the tracking of benefits**
- **Global economic competition has dramatically increased**



PCAST NNI Recommendations

- **Increase focus on integration of components and processes that lead to commercialization**
- **Develop a cross industry strategy that links environment, health and safety research with knowledge gaps and decision-making needs**
- **Strengthen NNI coordination with additional funds and a broader mandate**
- **The lack of a skilled workforce presents a significant challenge to the nanotechnology-related business community--expedite the citizen review process for those receiving advanced degrees in science and engineering**

NNI Signature Initiatives—2010

- **Nanoelectronics for 2020 and Beyond**
- **Solar Energy Collection and Conversion**
- **Sustainable Nanomanufacturing – Creating the Industries of the Future**



... if you want to know more about the NNI

NATIONAL NANOTECHNOLOGY INITIATIVE

The National Nanotechnology Initiative (NNI) provides a multi-agency framework to ensure U.S. leadership in nanotechnology that will be essential to improved human health, economic well being and national security. The NNI invests in fundamental research to further understanding of nanoscale phenomena and facilitates technology transfer.

Home Site Map Search Contact Us

Leading to a Revolution in Technology and Industry

\$34 Million Awarded to Inform Public and Explore Implications of Nanotechnology

The National Science Foundation (NSF) has announced a series of initiatives that will greatly expand efforts to inform the general public about nanotechnology, and to explore the implications of this fast-moving field for society as a whole.

NSF's largest research grant ever awarded to a non-NSF is providing \$20 million to a national Nanoscale Informal Science Education network led by the National Center of Science Education. This award will be used to train public nanotechnology experts and educational program staff at US science museums.

NSF has also made four awards totalling \$14.3 million for research on the societal implications of nanotechnology. The University of California, Santa Barbara, and Arizona State University in Tempe, have been selected to create two Centers for Nanotechnology in Society. These centers will support research and education on nanotechnology and social change, as well as educational and public outreach activities, and international collaborations. In addition, building on previously supported efforts, NSF has funded nanotechnology-in-society projects at the University of South Carolina and at Harvard University. [Read more.](#)

NCI Announces Awards of \$26.3 million for Centers of Cancer Nanotechnology Excellence

The National Cancer Institute (NCI), part of the National Institutes of Health (NIH), announced the implementation of a major component of its \$144.3 million five-year initiative for nanotechnology in cancer research. First year awards totaling \$26.3 million will help establish seven Centers of Cancer Nanotechnology Excellence (CCNEs). Each of the CCNE awardees is associated with one or more NCI-designated cancer centers, affiliated with schools of engineering and physical sciences, and partnered with not-for-profit organizations and/or private sector firms, with the specific intent of advancing the technologies being developed. [Read more.](#)

Brookhaven Lab Breaks Ground

NSF Centers Will Use Nano Design

NIH Announces Nanomedicine

NHLBI Announces Four Proteomics

NNI Environment and Health

Nano Coalition Unveils Environmental Nanotechnology (CBEI) Findings

The International Council on Nanotechnology (ICN) has released findings related to the benefits and risks of nanotechnology. [Clicking here](#) This environmental health and safety report is the first of its kind.

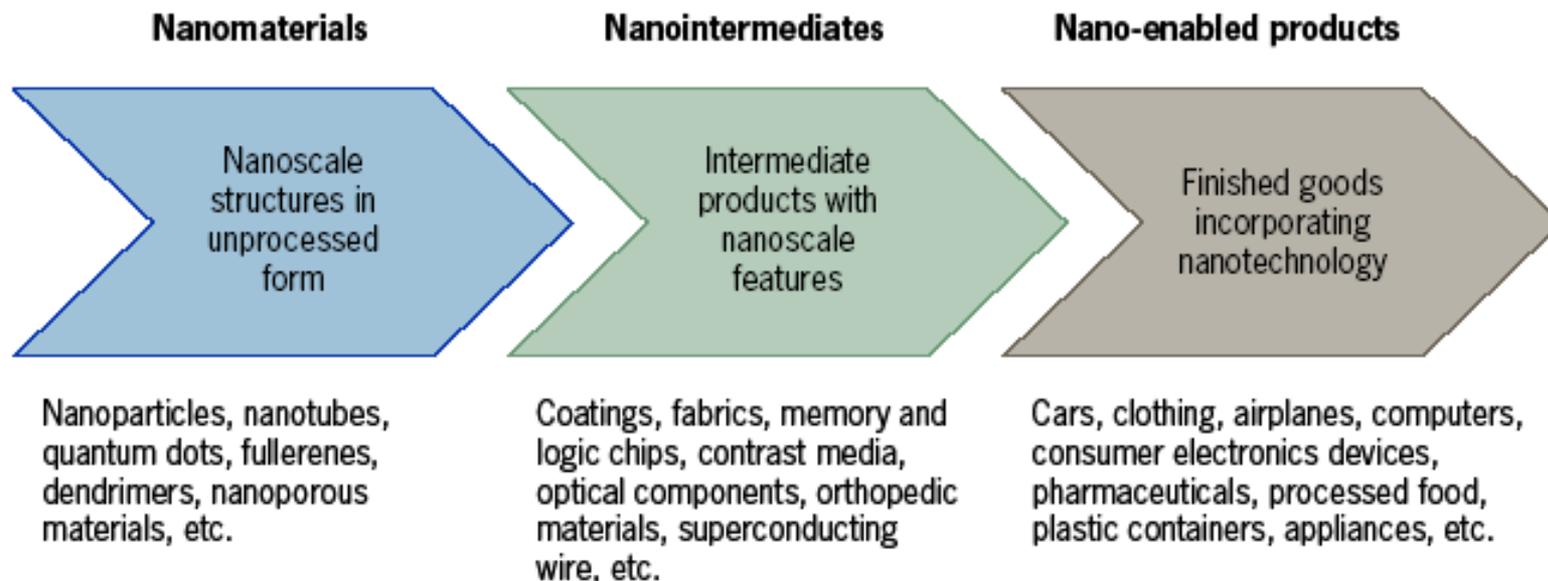
www.nano.gov

Forest Products Industry Nanomaterials Issues

- **Current Federal funding is largely directed at non-biological nano-materials**
- **Nano-scale science, technology and engineering is not publicly available for business leadership to determine economic returns**
 - **Research drives business models and economy**
- **Nanotechnology/Cellulose Nanotechnology Research is extremely expensive.**
- **Universities and Government Labs have much of the needed equipment and research capacity**
- **Industry cannot afford to invest in the basic research equipment but has the know-how and infrastructure to develop it commercially**

Industry Focus on Product Platform Value Chain

The nanotechnology value chain



Source: October 2004 Lux Research report "Sizing Nanotechnology's Value Chain"



INTERNATIONAL
CONFERENCE ON
NANOTECHNOLOGY FOR
THE FOREST PRODUCTS
INDUSTRY



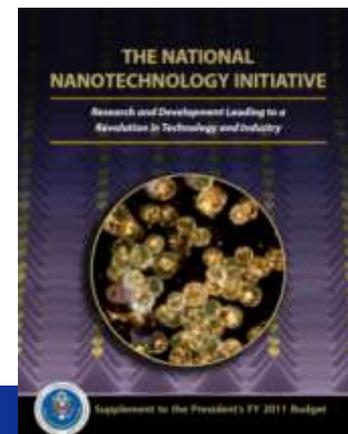
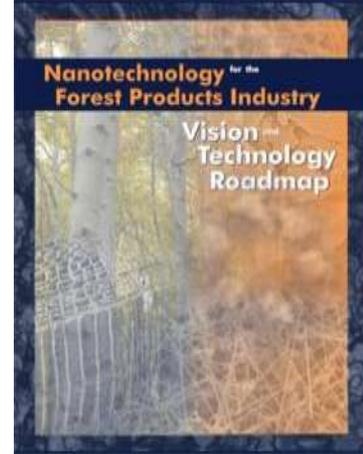
Federal Forest Products Nanotechnology R&D

- **USDA Forest Service lead Federal Agency**
- **Collaborating Federal Entities—NIST, NSF, DOD, EPA, NIH**
- **Form Public-Private Partnership with Forest Products industry & Academia**
 - **Develop a common vision and priorities for nanotechnology**
 - **Focus on research, development & deployment**
 - **Define roles and expectations**
 - **Strategies**
 - **Produce nanomaterials from wood**
 - **Incorporate a variety of nanomaterials into forest products to improve performance and multifunctionality**
 - **Develop a program implementation plan**



Federal & Forest Products Industry Cooperation

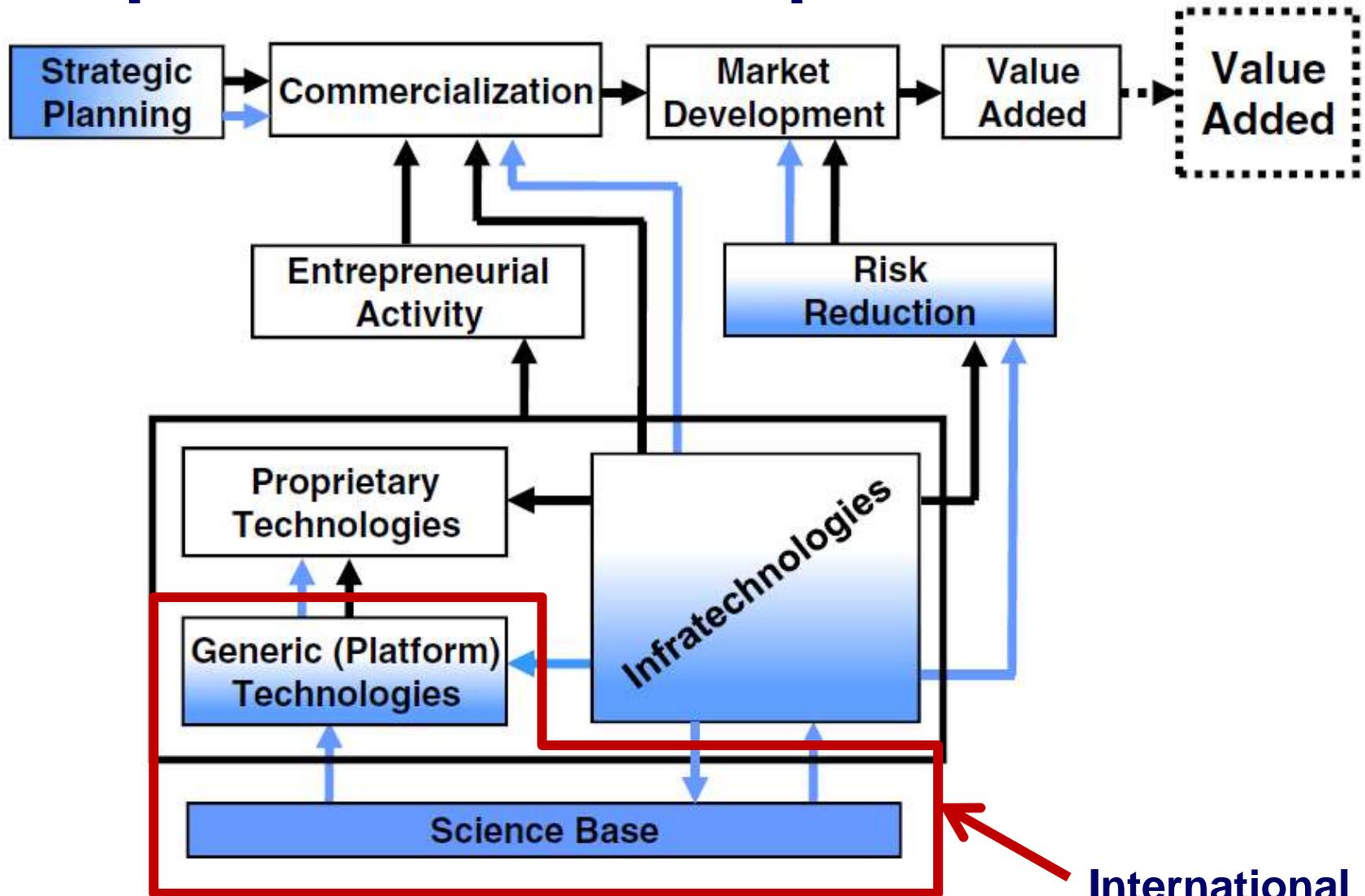
- 2005 FPI Nanotechnology Roadmap
- 2006 & 2010 AF&PA Agenda 2020 FPI Technology Roadmaps
- 2007-2009 NNI Forest Products Industry Liaison
 - Conversion of industry goals using industry jargon to underlying fundamental science needs
 - Link with other industry sectors to explore commonalities in fundamental science needed
- 2009/2010 Engaged to seek increased funding



US FPI Priority Nanotechnology Applications

- **Improve strength/weight performance ratio of paper, paperboard, and wood-based structural materials**
- **Develop new value-added features for paper, paperboard, and forest products (e.g. photonic properties, piezoelectric properties, etc.)**
- **Create new revenue streams based on innovative forest-derived nanomaterials**

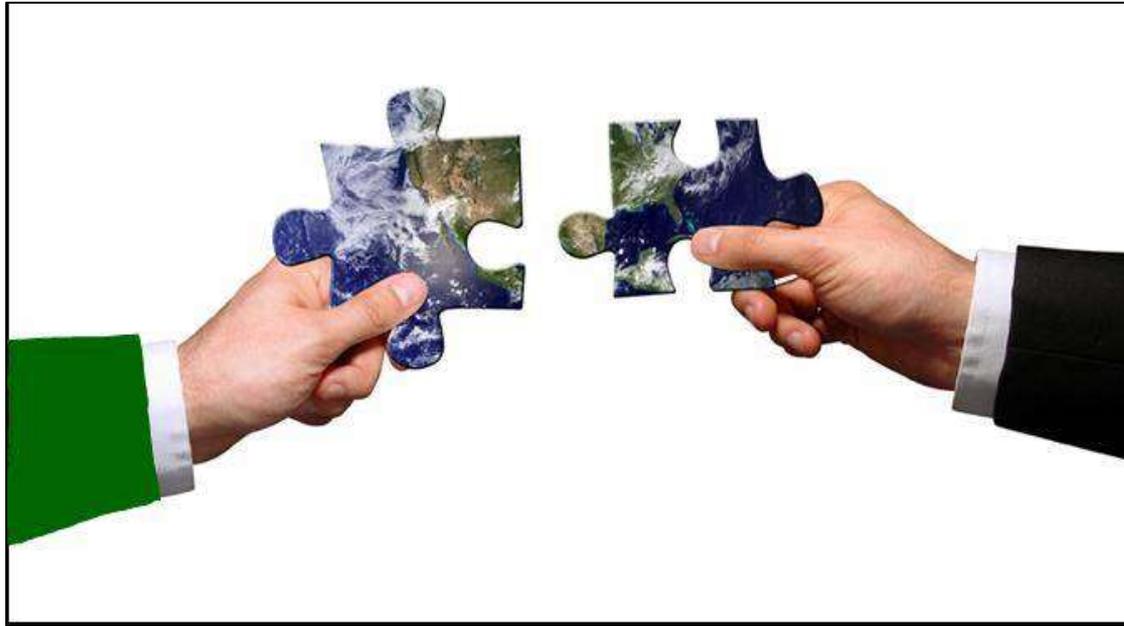
Opportunities for International Cooperation in a Competitive World



Technology-element model. *Source*: Tassey (2007a)

**International
Cooperation**

International Cooperation

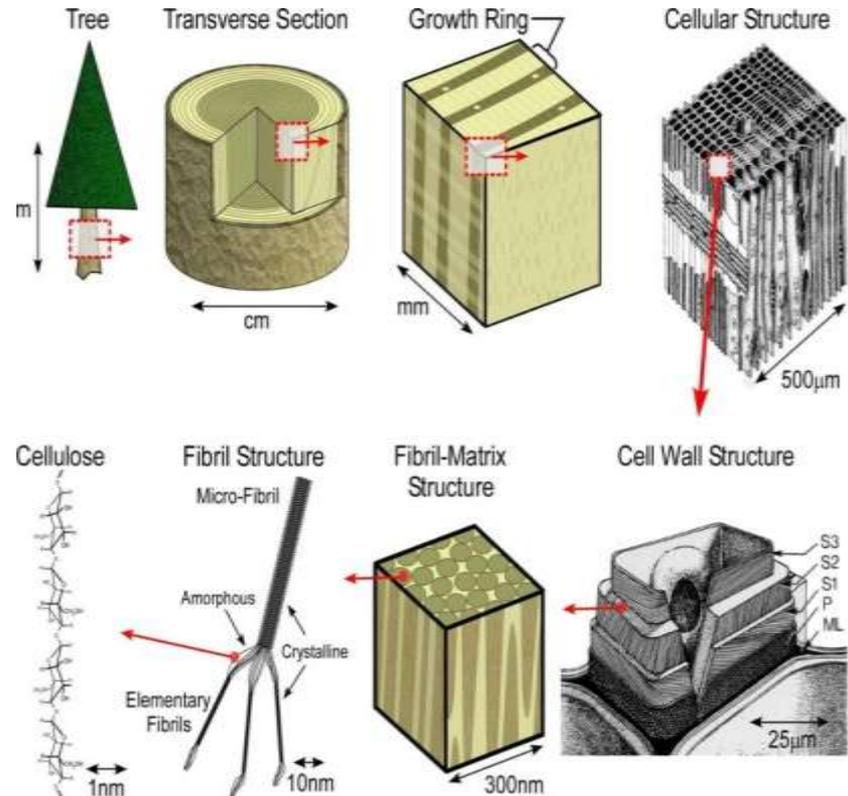


- Focus on precompetitive R&D avoids issues of intellectual property
- Permits findings to be freely shared (open communication)
- Creates the underlying science and technology for new innovations
- Allows for creative higher risk/higher reward research to be undertaken
- Achieves critical mass and speeds up research progress
- Reduces cost and unnecessary duplication of effort
- Allows industry within each nation to use the research

Potential Areas of International Collaboration

Nanotechnology

- Develop standard nomenclature for wood-derived nanomaterials and get it adopted by ISO.
- Develop methodologies for the manufacture, characterization, modification of nanocellulosic materials.
- Develop methodologies for incorporating nanomaterials into multifunctional hyper-performance wood-based products.
- EHS/ELSI studies on wood-derived nanomaterials
- Characterize the photonic effects achievable from wood-derived nanomaterials for light scattering, light absorption, light transmission and wavelength shifting.
- Characterize the wood-derive nanomaterial piezoelectric effects
- Develop methodologies to manipulate cell wall nano-scale architecture in growing trees





TAPPI **VTT**
**INTERNATIONAL CONFERENCE ON NANOTECHNOLOGY
FOR THE FOREST PRODUCTS INDUSTRY**
September 27-29, 2010 • Otaniemi, Espoo, Finland
Technical Advances and Applications in Nanotech Products



Thank you

Chris Risbrudt

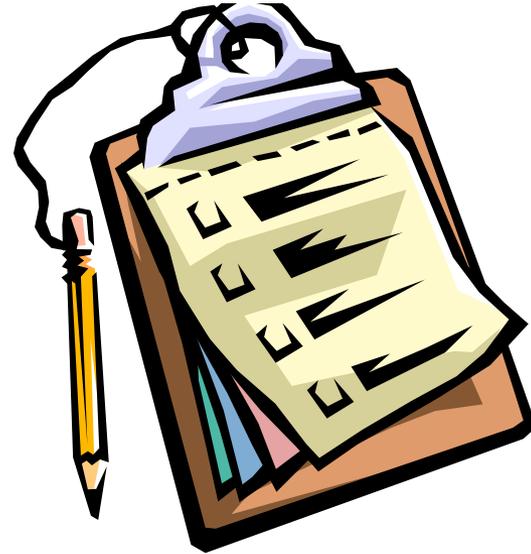
E-mail: crisbrudt@fs.fed.us

Telephone: 608-231-9318

**USDA Forest Service
Forest Products Laboratory
One Gifford Pinchot Drive
Madison, WI 53726**

USA

Website: www.fpl.fs.fed.us



Please remember to turn in your evaluation sheet...

