

Monday Afternoon, October 31, 2011

Nanomanufacturing Science and Technology Focus

Topic

Room: 207 - Session NM+MS-MoA

Challenges Facing Nanomanufacturing (All Invited Session)

Moderator: S. Rosenthal, Vanderbilt University, S. Butler, Texas Instruments Incorporated

2:20pm **NM+MS-MoA2 Sustainable Nanomanufacturing, M. Roco, National Science Foundation** **INVITED**

Nanomanufacturing has been defined as an approach to design, produce, control, modify, manipulate, and assemble nanometer-scale elements or features for the purpose of realizing a product or system that exploits properties seen at the nanoscale. Nanomanufacturing R&D has as its goal enabling the mass production of reliable and economical nanoscale materials, structures, devices, and systems. The current relatively rudimentary capabilities for systematic control and manufacture at the nanoscale are envisioned to evolve faster after 2011 as we develop new models and instrumentation and enter production of nanosystems for revolutionary new products and processes. We have estimated the global market of final products that incorporate nanotechnology increases by about 25 percent per year reaching \$1 trillion by 2015. This estimation made in 2000 [1] holds in 2011, after passing two thirds of the interval.

Three challenges of nanomanufacturing will be discussed: supporting innovation (beyond scaling), realizing efficiency (beyond new functions) and sustainability (of nanoscale processes and of global development). The research trends and application opportunities in nanomanufacturing will be presented by considering four generations of products by 2020 [2]. Most of what has already made it into the marketplace is in the form of "First Generation" products (passive nanostructures with steady behavior) and more recently "Second Generation" (active nanostructures, such as advanced transistors, amplifiers, targeted drugs and chemicals, sensors, actuators, and adaptive structures), while embryonic "Third Generation" (nanosystems, such as bio-assembly; networking at the nanoscale, nanoscale robotics and multiscale architectures) products are in the pipeline. Concepts for the "Fourth Generation" products, including molecular nanosystems, are only in research. Convergence with modern biology, digital revolution, cognitive sciences and other areas is expected to accelerate nanotechnology manufacturing. The role of NNI Signature Initiative on Sustainable Nanomanufacturing will be discussed.

[1] Roco, M.C. and W. Bainbridge, Eds., "**Societal Implications of Nanoscience and Nanotechnology**", *NSF*, Springer (former Kluwer Academic Publishers), 350 pages, Boston, 2001.

[2] Roco, M.C., C.A. Mirkin and M.C. Hersam, "**Nanotechnology Research Directions for Societal Needs in 2020**", Springer, 2010 (www.wtec.org/nano2/)

3:40pm **NM+MS-MoA6 The National Nanomanufacturing Network: Opportunities, Challenges, and Strategies, M.T. Tuominen, University of Massachusetts Amherst** **INVITED**

Nanomanufacturing holds immense intellectual and economic potential for stakeholders who pursue it with a vigorous, long-term strategy. Although numerous nanomaterials are already in production and use, the breadth of possible applications and societal benefits is only in its infancy. To help nucleate and support communities of practice in the area of nanomanufacturing, the NSF provides funding for the National Nanomanufacturing Network (NNN), which facilitates cooperative activities between nanomanufacturing centers and projects in academia, industry and government, and provides a web-based information resource, InterNano. This presentation will distill key opportunities, challenges, and strategies emerging from thematic workshops, comprehensive summits, and other NNN activities focused on the issues associated with nanomanufacturing. Research, development, education and commercialization are all essential components of a robust nanomanufacturing value chain. Nanomanufacturing R & D both draws from and breaks away from conventional notions of manufacturing. Unique issues have emerged in the area of nanomanufacturing process development, scale-up, metrology, integrated nanosystems design for manufacturing, nanoinformatics, sustainable manufacturing, standards, and multiple issues associated with a robust national enterprise in nanomanufacturing.

4:40pm **NM+MS-MoA9 Nanomanufacturing: The Future of Manufacturing?, K. Cooper, Naval Research Laboratory** **INVITED**

Nanomanufacturing is the fabrication of building blocks with nano-scale features and their integration into useful engineered systems. Through the precise control of materials and processes at the molecular- and nano-scale, new properties and functionalities, determined by nano-scale physics and chemistry, are possible. If successful, such a capability will have a profound impact on the future of manufacturing, which should lead to the emergence of new industries and products. The challenges for nanomanufacturing are achieving the desired functionality, product quality, process repeatability, production scalability and cost affordability. Another challenge will be to achieve manufacturing platforms capable of producing systems for a variety of applications. The ONR Manufacturing Science Program is meeting these challenges though basic research in novel nano-scale production. For example, the program supports research in direct digital nanomanufacturing, massively parallel nano-scale processing, and high-throughput (e.g., roll-to-roll) nanofabrication. It encourages system-level integration and cyber-enabled manufacturing approaches. These concepts along with a few research examples will be described.

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