NSF-NNN Workshop on Scalable Nanomanufacturing for Integrated Systems
Embassy Suites Hotel, Old Towne, Alexandria, VA
October 30-31, 2017

A decade and a half of investment in the NNI has fostered advances in nanomanufacturing processes that bridge the gaps from fundamental nanoscience to reliable materials and process methodologies. However, outside of the semiconductor industry, the transition of these advances to scalable manufacturing to date has largely focused on the preparation of materials and intermediates, or in some cases, simple devices and device components. To harness the potential of nanotechnology for a broad range of applications including sensors, energy and power, environment, structural, biomedical and healthcare, photonics, and flexible electronics, pathways for scaling up of low cost, large area or high throughput nanomanufacturing processes and for the cost-effective customized nanomanufacturing of integrated systems must be established. The focus on integrated systems recognizes that nanomaterials and nanostructures need to be assembled into larger-scale components and devices, which, in turn, need to be integrated into higher-order subsystems and systems. This transition of nano-enabled integrated systems will lead to the development of a range of novel and useful products impacting a variety of applications resulting in societal and economic benefits. Integration will need to be across material sets (0D, 1D, 2D, 3D, hierarchical nanostructures), length-scales (molecular to nano to micro to meso to macro), function (mechanical, electrical, optical, chemical, biological, thermal), and processes (top-down, bottom-up, bio-assisted). Integration will involve the study and implementation of hybrid manufacturing and assembly processes and methods. The lack of clear roadmaps to achieve these goals increases the risk of capital investment into new tooling and processes and limits the contribution of emerging nanomanufacturing technologies to new markets and applications.

This 1-day workshop will bring together invited researchers from academia, national labs and leading companies involved in scalable nanomanufacturing methodologies to identify and discuss challenges for extending these approaches and integration strategies to realize the manufacturing of nano-enabled advanced devices and integrated systems. The workshop will further encompass related topics and application areas including multi-process platforms, methods for control of material compositions, and integration across multiple length scales, materials, processes and functions. The workshop goals are to establish a vision for scalable nanomanufacturing integrated systems (SNM-IS) and identify gaps, needs, and capabilities necessary to transition towards more complex, nano-enabled products and systems. Development of such a vision will guide progress and potential collaborations towards integrated systems nanomanufacturing development activities.

Attendees are invited to prepare remarks addressing technical topics including:

- Defining and designing nano-enabled integrated systems
- Determining the needs, benefits and impacts of such integrated systems
- Generating low-cost, commodity-scale materials sets
- Demonstrating precision cooperative assembly
- Utilization of surface directed/guided assembly of critical features
- Fabrication of ordered hybrid nanocomposites at high rates
- Identifying top-down (lithography) and bottom-up (assembly) processes that will drive the creation of integrated systems
- Direct write or printing approaches for 1-D. 2-D and 3-D nanoscale features
- Process, multi process integration, materials integration, and strategies
- Online and off-line metrology
- High throughput nanomanufacturing and mass customization approaches
- Precision multi-layer alignment, registry and overlay
- Design principles for production systems, including nanomodular systems leading to nanomanufacturing tools, and platforms
- Identification and implementation of control methodologies, including cyber control
- Standards needed for process monitoring and control and to assess quality and yield
- Determination of process models and simulations to guide processing and integration
- Identification of environmental impacts and energy footprints

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Questions to be addressed by speakers and participants:

1) What is your conception of a nano-enabled integrated system?
2) What nano-enabled integrated systems will be needed for future products for energy, electronics, sensor, structural, environmental, security, and other applications?
3) What would be your scalable nanomanufacturing and/or mass customization approaches to realize the integrated system?
4) What would be your component integration strategy?
5) What are the fundamental technical gaps that need to be filled through basic research and how?