

Special Section: Scalable Nanomanufacturing

Many fabrication techniques have demonstrated the ability to fabricate small quantities of nanomaterials, nanostructures, and nanodevices for device testing purposes. Such nanoscale devices have novel physical, chemical, and biological properties that derive from their nano-to-meso length scales, where unique properties between atomic and bulk behaviors can be obtained. The design and fabrication of such devices is a field of active research over the world. However, manufacturing such devices at an industrially relevant scale requires scalable production of nanomaterials, nanostructures, devices, and systems while retaining functional reliability, low cost, and high throughput. The innovation of new processes for large-area continuous manufacturing of nanomaterials and mesoscale structures assembled from these nanomaterials is a key component of this thrust. Such processes may include top-down and bottom-up approaches as well as self-assembly and hybrid processes, e.g., integration of top-down and bottom-up approaches via physical, chemical, biological, and thermal means. Control of such processes requires understanding of the process physics, thus creating the need for theoretical and computational developments related to nanoscale phenomenon that are relevant to control of product quality, reliability, and throughput. Another critical need is reliable, high-speed, high-resolution, online metrology and real-time control. This includes design principles and architectures for nanoscale measurement and processing as well as new design automation tools for assembling systems of large numbers of heterogeneous nanocomponents.

To advance research in the above areas, the Scalable Nanomanufacturing Symposium was initiated at the 2016 ASME Manufacturing Science and Engineering Conference (MSEC) held in Blacksburg, VA. This special section of the *ASME Journal of Micro- and Nano-Manufacturing* publishes peer-reviewed research papers from presentations given at this symposium. Zhao et al. presented a generic method for scalable nanomanufacturing of metal nanoparticles via thermal drawing. This method was based on droplet break-up emulsification of immiscible glass/metal systems, and a strategy for particle diameter control was also proposed. Promyoo et al. developed an AFM-based nanomachining process for fabrication of nanofluidic channels with potential savings of up to 47% in manufacturing time and

up to 60% in manufacturing cost as compared to traditional processes. Keynton et al. combined a three-axis robotic dispensing system for drawing micro/nanoscale suspended polymer fibers at prescribed locations, dry film resist photolithography, and replica molding to create a fluidic platform with embedded micro- or nanoscale channels. This technique provided greater control of the micro- and nanochannel location with the flexibility to create multiple channels of varying sizes embedded in a single fluidic platform. Atwater et al. explored the foundations for scalability in the constrained formation of fibrous nanostructures (CoFFiN) process to create three-dimensional bulk-nanostructured macroscale products from catalytically deposited carbon nanofibers. The macroscale carbon growth was characterized as a function of the process parameters. Desai et al. used molecular dynamics to study the motion of nanometer scale water droplets and understand size scaling effects on temperature at which the Leidenfrost effect is observed. This has special significance in processes like inkjet, aerosol jet, and other atomized droplet processes where droplet deposition dynamics controls the morphology of the printed feature. Duenner et al. introduced a low-cost, automated alignment system capable of submicron positioning repeatability to support applications where pattern overlays between fabrication steps or repeated measurements of the same spot throughout the manufacturing process are needed. It was shown that this simple system achieved a high throughput with nanometer scale repeatability in positional alignment and at a low capital cost.

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