Directed Assembly of Nanoelements for High-rate Nanomanufacturing of Devices and Sensors

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Abstract

The transfer of nano-science accomplishments into technology is severely hindered by a lack of understanding of barriers to nanoscale manufacturing. Commercial products cannot be realized without first answering many questions, such as how one can assemble and wire billions of nano-scale devices together, or how one can prevent failures and avoid defects. The Center for High-rate Nanomanufacturing is developing tools and processes that will enable high-rate/high-volume bottom-up, precise, parallel assembly of nanoelements (such as carbon nanotubes, nanoparticles, etc.) and polymer nanostructures. The center nanotemplates are utilized to conduct fast massive directed assembly of nanoscale elements by controlling the forces required to assemble, detach, and transfer nanoelements at high rates and over large areas. Successful use of these templates requires understanding the interfacial behavior and forces required to assemble, detach, and transfer nanoelements, required for guided self-assembly at high rates and over large areas. The center has developed and fabricated templates with nanostructures and used them to direct the assembly of nanoparticles (down to 10 nm) into nanoscale trenches (down to 30 nm) in a short time (30-90 seconds) and over a large area (> 2.25 cm^2). This technique enabled the directed assembly of SWNTs into nanoscale trenches (down to 80 nm) in a short time (30-90 seconds) and over the same large area. We have demonstrated that nanotemplates can be used to pattern conducting polymers and that the patterned polymer can be transferred onto a second polymer substrate. Modeling has provided insight and guidance to the nanomanufacturing research. In addition, the center concurrently assesses the environmental, economic, regulatory, and ethical impacts of nanomanufacturing.

The Center for High-rate Nanomanufacturing is leveraging current and future efforts in nanoscience and technology by bridging the gap between scientific research and the creation of commercial products by established and emerging industries, such as electronic, medical, and automotive. Long-standing ties with industry will also facilitate technology transfer. Over the past year, CHN has presented the technology, benefits, and societal impact of nanomanufacturing to a wide range of audiences. The undergraduate modules introduced 570 students to nanotechnology. Four new courses, including two three-University courses, were attended by 165 students. Undergraduate researchers, including 38% women and 19% underrepresented minorities, participated in undergraduate research programs. K-12 teacher conferences, a summer institute, research experiences for teachers and faculty presentations have introduced 350 teachers to nanotechnology. The Summer Institute and RET program have provided nanotechnology modules that are implemented into classrooms, and five participants in the RET program have been sharing their modules and implementation experiences with other teachers. Over 1125 K-12 students have been introduced to nanotechnology through CHN programs. The joint program between CHN and the Museum of Science has started its mission of educating the general public about nanomanufacturing.

Ahmed A. Busnaina, Ph.D. is the William Lincoln Smith Chair Professor and Director of National Science Foundation's Nanoscale Science and Engineering Center (NSEC) for High-rate Nanomanufacturing and the NSF Center for Nano and Microcontamination Control at Northeastern University, Boston, MA. He is internationally recognized for his work on nano and micro scale defects (particulate and chemical) mitigation and removal in semiconductor fabrication. He also involved in the fabrication of nanoscale wires, structures and interconnects. He specializes in directed assembly of nanoelements and in the fabrication of micro and nanoscale structures. He served as a consultant on micro contamination and particle adhesion issues to the semiconductor industry. He authored more than 300 papers in journals, proceedings and conferences. He is on the editorial advisory board of Semiconductor International, the Journal of Particulate Science and Technology. He is a fellow of the American Society of Mechanical Engineers, and the Adhesion Society, a Fulbright Senior Scholar and listed in Who's Who in the World, in America, in science and engineering, etc.).