NSF Nanoscale Science and Engineering Center for High Rate Nanomanufacturing

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The Center for High-rate Nanomanufacturing (CHN) is developing tools and processes to enable high-rate directed assembly and printing of nanoelements such as carbon nanotubes, nanoparticles, and polymer based nanostructures. The CHN has also synthesized new and novel nanomaterials such as Pentacene-Like Pyrylium Salts, a new N-type Organic Semiconductor, Tropylium Salts, LETS Compounds as N-type Organic Semiconductors, Polyenols as Organic Semiconductors, and Starphene. We have also significantly contributed to understanding of the assembly and alignment mechanism for carbon nanotubes and other materials and the means to transfer them to various substrates, such as polymer film. Electrophoretic directed assembly can now be carried out on insulating organic and inorganic substrates to enable rapid, large-scale assembly. A CHN novel method for high-rate interfacial convective assembly for the fabrication of 2D and 3D nanostructures with controlled dimensions has been shown to be capable of being material and surface independent. 3-D nanostructures were made of metals, oxides, polymers, or hybrid materials comprised of metal-polymer, metal-oxide and metal-polymer-metal heterostructures. A new type of reusable Damascene template was developed for the high-rate and scalable assembly and transfer of nanoelements. Based on this technology, the CHN in collaboration with a Massachusetts company has developed a fully-automated manufacturing system. The Nanoscale Offset Printing System (NanoOPS) can print nanoscale devices for electronics, energy, medical and functional materials applications. The Damascene template also has been used for the assembly and transfer of conducting polymer in a roll-to-roll continuous process. We have developed a new battery architecture of alternating multi layers of MWNT and lithium ion active material (LMO and NMC) to enhance the rate capability or power output of lithium ion cells up to 25X higher capacity at 10C charge/discharge compared to conventional cells. A life-cycle assessment methodology was used to address ethical, legal, and societal impacts in decision-making as nanomanufacturing scales to commercial production. We also applied the LCA approach to three carbon nanotube-enabled applications as they apply to manufacturing, use, and end-of-life management, including recycling and disposal.

Through our industrial outreach and nanoscience research, the Center for High-rate Nanomanufacturing is having an impact on established and emerging industries in sensors, electronics, bio/medical, energy, and materials fields. The developed NanoOPS has the potential to transform nanomanufacturing and nano-enabled technologies, and will spur innovation by drastically overcoming the high cost entry barrier to the fabrication of nanoscale devices without endangering workers or harming the environment. CHN also has continued its highly successful partnership with the Museum of Science, Boston (MOS), with live presentations, podcasts, YouTube videos, and The Nano Brothers Juggling Show all designed to educate the general public about nanomanufacturing. The audience for these programs was over 24,000 people in 2013-2014. During summer 2013, 13 undergraduate researchers, including 6 women and 6 members of underrepresented groups, participated in the REU program and its unique cross-university professional development program, and five undergraduates were employed as researchers during the academic year. The CHN sponsored an annual K-12 teacher conference (with an attendance of 48) in spring 2013, and K-12 outreach also included lectures, tours, hands-on activities, and programs like Project SMART and the Region IV Middle School Science and Engineering Fair. In a new effort, The Amazing NanoBrothers Juggling Show was presented to 5,400 school children in Massachusetts and New York. Science Communication Workshops have helped CHN's undergraduate and graduate participants and were replicated at nine other Centers in 2013. Sharing Science Workshops allowed CHN graduate students to present nanotechnology activities at the Museum's 2013 NanoDays and other events. Finally, CHN’s nanotechnology game, Geckoman!, has received over 50,000 plays since it was uploaded to a public website. Through these programs and other short events, CHN researchers have continued to present the technology, benefits, and societal impact of nanomanufacturing to a wide range of audiences.