NANO HIGHLIGHT
Template Directed Assembly of Nanoscale Elements for High-rate Nanomanufacturing of Devices and Sensors

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The transfer of nano-science accomplishments into technology is severely hindered by a lack of understanding of barriers to nanoscale manufacturing. The Center for High-rate Nanomanufacturing is developing tools and processes to enable massive fast directed assembly of nanoelements (such as carbon nanotubes, nanoparticles, etc.) and polymer nanostructures over large areas using nanotemplates. 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 template directed assembly is conducted using electrophoresis, dielectrophoresis, chemical functionalization, geometrical confinement and capillary forces. The center has successfully demonstrated the use of the templates 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 cm2). The Center also demonstrated the directed assembly of SWNTs bundles into wires that are 80 nm wide and 100,000 nm long in a short time (30-90 seconds) and over the same large area using nanotrench based templates. The assembly is consistent and complete over a large area with no gaps in the assembly demonstrating the feasibility of our approach to producing nanoscale features at high rates/high volumes.

We have selectively assembled a conducting polymer (PANi) onto a prefabricated patterned template assisted by a DC electric field and developed techniques to transfer the patterned polymer onto a flexible polymeric substrate. We have also demonstrated the patterned conducting polymers can be transferred onto a second polymer substrate such as polystyrene or polyurethane). This method allows for the template to be reused, unlike many conventional lithographic technologies, but also provides the potential to fabricate all-plastic electronics, paper-like displays, and biosensors in a cost-efficient and high rate process.

In addition, two new AFM based methods to pattern substrates have been developed. Field-assisted nanopatterning of organics (FANO) utilizes an organic film on an AFM tip and a conducting substrate. An improved charge writing method has also been developed allowing the formation of features with subsequent assembly of nanoelements onto the charged lines. The charge-writing technique is especially relevant to reel-to-reel process in which nanotemplates can charge line patterns onto flexible plastics followed by rapid assembly of nanoelements.