Center for Hierarchical Manufacturing

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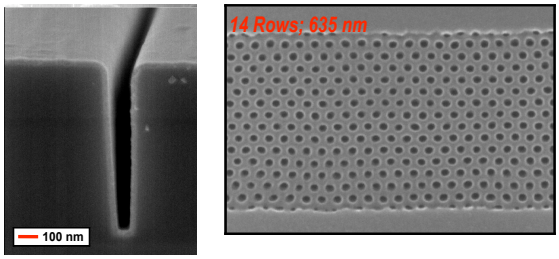
The Center for Hierarchical Manufacturing (CHM) is a comprehensive research and education platform that fosters key advances in nanotechnology from laboratory innovation to manufacturable, nanostructured components and devices. The CHM technology focus includes complete specification of device elements by combining directed self-assembly and imprinting with methodologies for 2-D and 3-D template replication, and advanced deposition techniques. Bottom-up processes are seamlessly integrated with conventional fabrication methods to yield performance enhancements in semiconductor devices, microelectronics, biomedical applications, and other areas. The CHM's academic research/education partners include the University of Puerto Rico, Mt. Holyoke College and Springfield Technical Community College. The Center offers a new strategic model to bridge the innovation-to-implementation gap through test beds that combine breakthrough technology, professional market analysis, capable partners and facilitated technology transfer. Strong collaborators including leading R&D consultant TIAX and prototyping partner Lucent Technologies allow the Center to drive concepts to commercialization. Students educated in this environment are well prepared for careers that partner innovation with implementation. The CHM hosts the National Nanomanufacturing Network (NNN)--a catalyst for U.S. nanomanufacturing-based economic development, a dynamic web-based information clearinghouse, and a meeting point for university-industry-government partnerships.

Research and Test-Bed Program

The research structure of the CHM includes three Technical Research Groups (TRGs) and multiple proof-of-concept test beds. The TRGs provide multi-disciplinary collaborative platforms to enable high-impact fundamental research and are the scientific core of the Center. TRG science flows into test beds for prototyping and application verification.

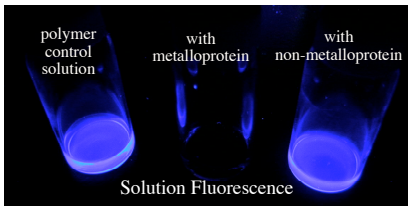
TRG 1: Nanoscale Materials and Processes is focused on the fundamental processes that underpin a toolbox of techniques for nanostructure generation that can be integrated seamlessly with existing large scale manufacturing processes. Specific activities within the TRG include the development of biased block copolymer (BCP) self assembly, capillary force and nanoimprint lithography (NIL), stable 3-D porous structures via template replication and the preparation of functional particles, surfaces and device layers. One area of emphasis is the development of conformal deposition techniques for high AR nanoscopic structures. With TRG 2 and the test beds, materials and structures generated by these approaches are integrated into next generation components including capacitors, interconnects, memory and logic elements and energy conversion devices.



Device Elements via High Rate Processing: Conformal HfO_2 film deposited in high AR feature by supercritical fluid deposition (L); Highly ordered PS-b-PMMA, block copolymer microdomains have been obtained where the placement error of each of the microdomains is <5%, which meets industry specifications for use in magnetic storage media (with Seagate).

TRG 2: Nanoelectronics is focused on the development of active electronic, magnetic and photonic nanostructures and systems. Hierarchical nanomanufacturing techniques that integrate

block copolymer templates, nanoimprint, electron-beam and photo lithographies are employed. This work includes: ultrahigh density data storage based on arrays of nanomagnets; design, simulation and fabrication of NASIC circuits and architectures; nanostructured device development for photonic applications in energy conversion and light manipulation; and development of nanomanufacturing standard operating procedures (SOPs) and advanced methods of characterization.



Detection of metalloproteins: Fluorescence of non-conjugated amphiphilic polymers, indicating metalloprotein binding

TRG 3: Bionanotechnology combines expertise in self assembly, soft materials research and biomolecular recognition to address fundamentals and applications. Specific activities within the TRG include development of novel biocompatible BCP gels that utilize stereochemistry and incorporation of nanoparticles to tune mechanical response and the use of nanoparticles and functional polymers as drug, protein, and DNA delivery vectors and detection arrays.

Test Beds: Nanomanufacturing platform technologies are demonstrated through focused product-oriented test beds with strategic industrial partners. The test bed program is dynamic and the projects will be operated under an efficient management cycle with typical life-times between twelve and thirty months after which they will either graduate to commercialization, continue with support independent of the CHM or be discontinued. *Test Bed 1: Hierarchical Nanomagnetic Data Storage* targets hierarchically-patterned perpendicular magnetic media suitable for implementation in next-generation commercial data storage systems. *Test Bed 2: 3-D Capacitor Arrays for Memory Scaling* targets recent advances in conformal metal and dielectric depositions to produce high aspect ratio capacitor structures resulting in performance enhancements and a significant reduction in chip area. *Test Bed 3: Directly Patterned and Ultra-Low Dielectric Constant Films* targets films with dielectric constants (k) below 2.1 for use at the sub-45 nm technology node.

The National Nanomanufacturing Network

The National Nanomanufacturing Network (NNN) hosted by the CHM will provide a synergistic and efficient means of interconnecting the nanomanufacturing and nanoscience communities. The NNN will be built using input from major stakeholders including other nanomanufacturing NSECs, government laboratories and U.S. industry. The NNN includes InterNano, a digital library-inspired clearinghouse that will provide a valuable service and reference point for the nanomanufacturing community. Beyond providing public databases, resources on manufacturing and implementation, and forums on technology transfer and information exchange, the NNN will actively identify and mold emerging trends and societal perceptions of nanoscience through data-mining and professionally managed technology visioning workshops for corporate, government and public audiences in which unsolved market needs are addressed through collaboration.

Education and Societal Implications

As part of a comprehensive education program the CHM creates and disseminates research-based multimedia instructional materials to stimulate and educate audiences ranging from K-12 students and teachers, community college learners, and the public. Leveraging an existing Science, Technology and Society initiative at UMass, the Center will put emphasis on the nanotechnology-society interface, with a national survey study on how society values nanotechnology production and products in balance with other issues; an annual conference series on emergent technology policy and public communications; and a clearinghouse focus on health effects of exposure to nanoscale materials.