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Realization and Applications of High-Precision Nano-Manufacturing Based on Sub-20 nm Polymer Self-assembly and Nano-Transfer Printing

MAY 17
4 P.M.

Bldg. 101
Seminar room on the 1st floor

Special Guest Speaker

Directed self-assembly (DSA) of block copolymers (BCPs) can generate uniform and periodic patterns within guiding templates, and has been one of the promising nanofabrication methodologies for resolving the resolution limit of optical lithography. Based on these promising results, our research efforts have focused on resolving remaining challenges for DSA such as control over defects, resolution, and throughput for next-generation lithography with sub-10 nm resolution. This talk will introduce recent research results on the self-assembly of siloxane block copolymers for the achievement of sub-10 nm resolution and fast pattern generation.
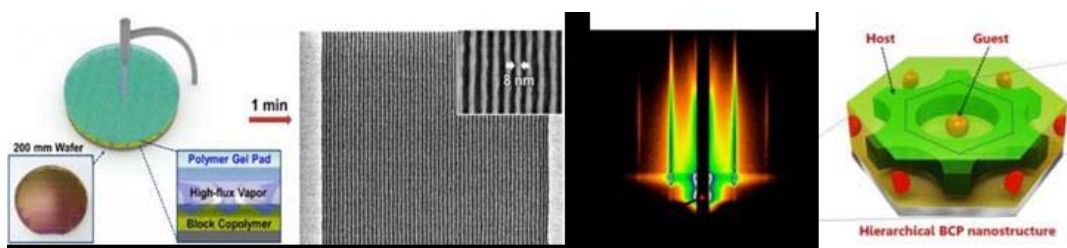
Figure 1. Sub-10 nm High-resolution Pattern Formation Using Si-containing Block Copolymers

The direct formation of ordered resistive memory nanostructures on metal and graphene electrodes can also be achieved by the self-assembly of the Si-containing BCPs. We found that both silicon oxide memristors of thin films (derived from a lamella-forming BCP) and nanodots (made from a sphere-forming BCP) present unipolar switching behaviors, and especially for the nanodots, the switching current was very low. This method offers a practical pathway to fabricate high-density resistive memory devices without using high-cost lithography and pattern-transfer processes.

Additionally, we will present a novel approach that can relieve the power consumption issue of phase-change memories by incorporating a thin SiOx layer formed by BCP self-assembly, which locally blocks the contact between a heater electrode and a phase-change material, effectively reducing the phase-change volume. The writing current decreases by 5 times (corresponding to a power reduction of 1/20) as the occupying area fraction of SiOx nanostructures varies. Finally, various functional nanostructures (e.g. graphene nanostructures) that can be prepared using the self-assembled nanostructures as a practical template will be introduced.
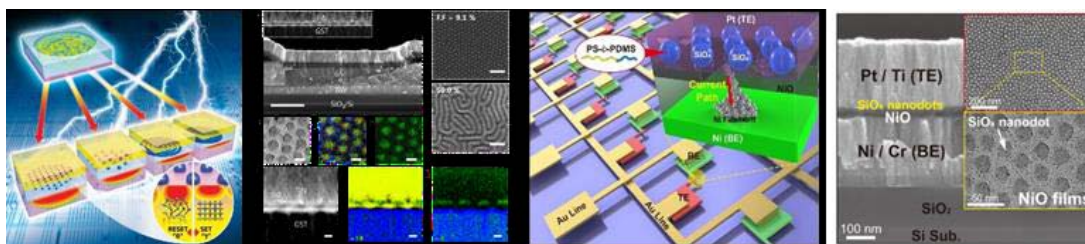
Figure 2. Application of Oxide Nanostructures Derived from Si-containing Block Copolymers for Nonvolatile Memory Applications

An extraordinarily facile nanofabrication approach that enables sub-10 nm resolutions through the synergic combination of nanotransfer printing (nTP) and DSA of block copolymers is also introduced. This simple printing method can be applied on oxides, metals, polymers, and non-planar substrates without pretreatments. The achievement of large-area sub-20 nm transfer printing capability has been hindered by the combined difficulties in the precise replication of high-resolution masters and the reliable release of functional nanostructures. We developed solvent-assisted nanotransfer printing (S-nTP) technique based on the high-fidelity replication of ultrahigh-resolution (9 – 20 nm scale) masters and the facile control of interfacial adhesive forces. For the uniform and fast release of metallic nanostructures on diverse receiver surfaces, the strategy of target-specific control of interfacial adhesion was realized using PDMS gel pad as a solvent-emitting transfer media, demonstrating unusually versatile and direct printing capability even on biological surfaces such as human skins and fruit peels. Moreover, we demonstrate the successful formation of 3-dimensionally stacked nanostructures with controlled alignment angles by implementing S-nTP by multiple times.
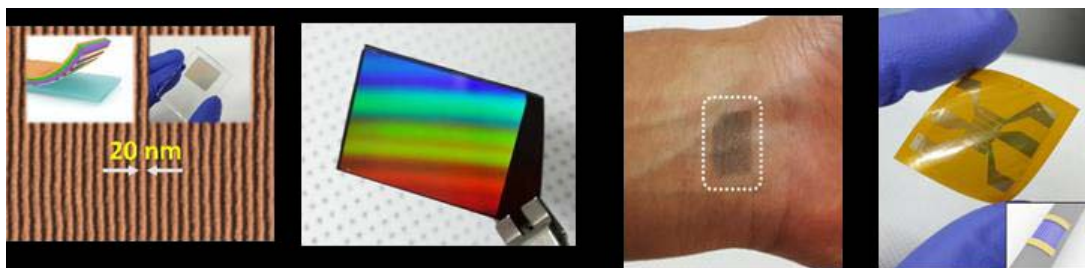
Figure 3. Ultrahigh-resolution functional nanostructures fabricated by solvent-assisted nanotransfer printing (S-nTP)

You are cordially invited to attend!

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