Hydrogen Silsesquioxane Nano-posts as Decoys for Guiding the Self-Assembly of Block Copolymers

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Bottom-up lithography using block-copolymer (BCP) self-assembly is a promising approach to patterning dense high-resolution nanostructures over large areas. While this technique is a cost-effective approach to fabrication, accurate control of the order and positioning of individual BCP micro-domains still remains a challenge. Such control is crucial in lithography for some applications, such as bit-patterned storage media.

In this work, we present a technique for ordering the self-assembly of spherical-phase BCP using nano-structured hydrogen silsesquioxane (HSQ) posts fabricated using electron-beam lithography[1] (see Figure 1a). In contrast to previous work[2] where the topographical structures used for guiding the BCP were large and clearly identifiable after processing, these nano-posts are in the order of a single BCP sphere. Although challenging to fabricate, each 35-nm-tall 10-nm-diameter post acts as a decoy (or substitute) for a single BCP micro-domain. Then, by careful positioning of the posts in an ordered 2D hexagonal lattice, a template is provided over which the BCP self-assembles to achieve long-range translational and rotational order (see Figure 1b).

We used polystyrene-b-polydimethylsiloxane (PS-*b*-PDMS), with PS majority block as the BCP material[3]. Over a flat surface, the coherence length of this BCP was ~ 200 nm. However, when the post arrays were used, this correlation length increased significantly and was limited only by the size of our templated area which was 4 μm in diameter in our experiments.

The BCP ordering within the template was highly sensitive to the post pitch. While best ordering was achieved when the post pitch was commensurate to the pitch of unstressed BCP spheres (i.e. integer multiples of 38 nm), reduction in post pitch caused the BCP to preferentially pack in two alternate orientations (see Figure 2). Fourier transform analysis of BCP ordering over a range of post pitches shows a progression from this alternate packing to near-perfect ordering (see Figure 3).

The resultant PDMS and HSQ nanostructures are etch resistant and can be used for subsequent pattern transfers. We will present our work on template fabrication and BCP processing, and report on progress in this method of BCP ordering.

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[1] J. K. W. Yang and K. K. Berggren, Journal of Vacuum Science & Technology **25** (6), 2025 (2007).

[2] J. Y. Cheng, A. M. Mayes, and C. A. Ross, Nature Materials **3** (11), 823 (2004).

[3] Y. S. Jung and C. A. Ross, Nano Letters **7** (7), 2046 (2007).

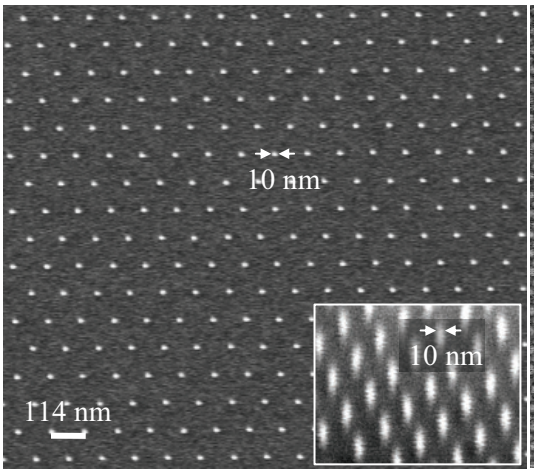

Figure 1a: SEM image of BCP template consisting of HSQ nano-post decoys 10-nm in diameter and 35-nm tall arranged in a hexagonal lattice with a center-to-center spacing of 114 nm. Inset is an angled view SEM of the post array.

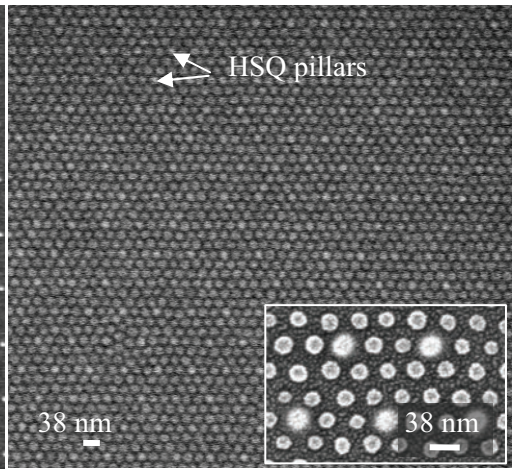

Figure 1b: SEM image of BCP spheres self-assembled among HSQ nano-pillars in an ordered lattice with 3 times the spatial frequency of the template. The HSQ posts appear brighter than the BCP spheres. Inset is an enlarged view of a portion of the BCP ordering from a different sample.

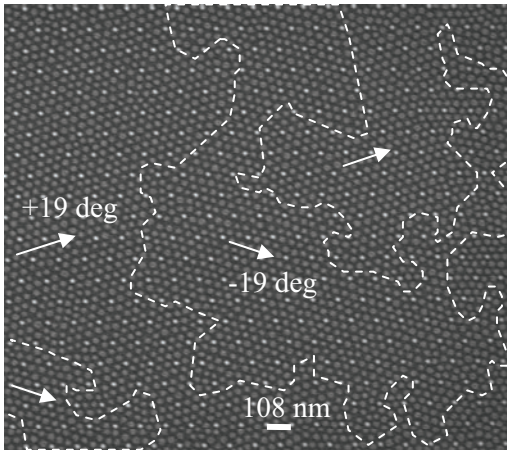

Figure 2: SEM image of alternate BCP orientations of +19 and -19 deg with respect to the nano-post template. The alternate orientations occur when the post spacing was 108 nm, i.e. 6 nm less than the optimal spacing. Dashed lines represent grain boundaries while arrows show grain directions.

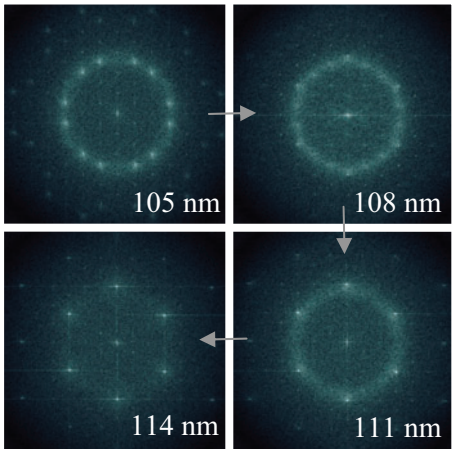

Figure 3: Clockwise from top left, Fourier transform of BCP ordering with nano-post pitches of 105, 108, 111 and 114 nm respectively. Peaks corresponding to the alternate 19 deg off-axis orientations are observable for the 105 and 108 nm post pitches. Ordering was best for the 114-nm-pitch.