19. Templated Self Assembly

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A large variety of materials can self assemble into large-area, nanometer-scale periodic structures. However, typical self-assembled materials have only short-range order, limiting their usefulness in applications. Templated Self Assembly (TSA) utilizes lithographically defined structures on a surface to guide the self-assembling behavior and induce long-range spatial-phase coherence.

Templates made using scanning-electron-beam lithography have been employed to study the TSA effect on block copolymers. Based on a simple free-energy model describing the layering behavior of block copolymers in a one-dimensional topographical confinement (Figure 1a) and experimental data (Figure 1b), we were able to predict the design window (Figure 2a) for templates to make a particular arrangement of polymer domains (Figure 2b). The understanding of templated self-assembled of block copolymers will facilitate the design of hybrid systems that combine "top-down" and "bottom-up" processing. This, in turn should enable new nanofabrication technologies with the potential to reach molecular-level spatial resolution.

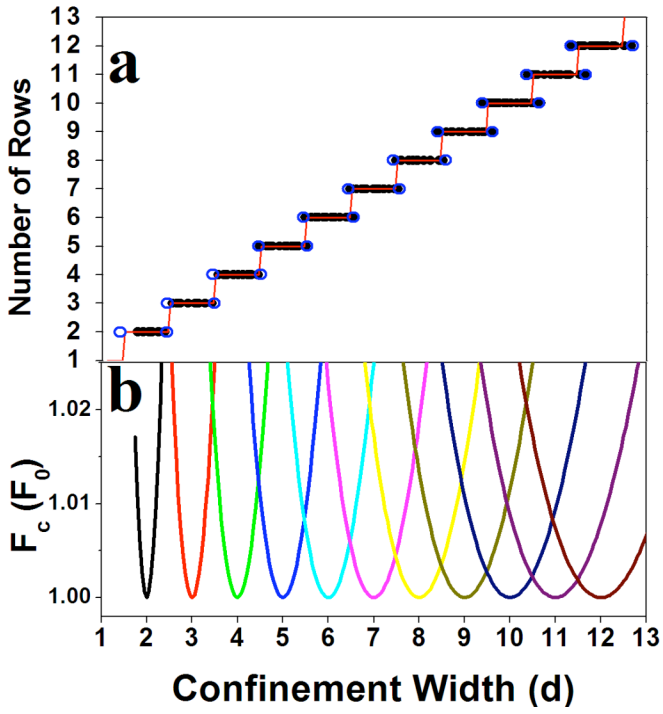

Figure 1: a. The number of rows in the groove, N, vs. confinement width, W, showing the widths at which arrays with N rows are stable. b. Energy vs. confinement width of block copolymer system. The confined block copolymer system, of given W, will ideally select the value of N with the lowest free energy. A transition in the number of rows from N to N+1 occurs when W ~ (N+0.5)d, in agreement with the experimental data of Figure. 1a.

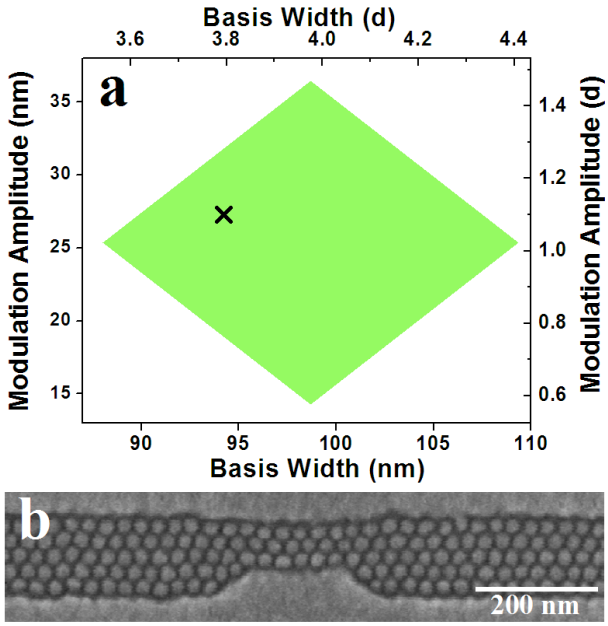

Figure 2: The creation of a specific block copolymer array geometry by the use of a modulated template. a. The modulation conditions that are expected to produce an array consisting of 5p-long 3-row arrays interspersed with 20p-long 5-row arrays. b. Scanning electron micrograph of a section of an ordered array with 3 and 5 rows of domains, created using a template with dimensions indicated with a cross on part a.

Reference:

[1] J. Y. Cheng, A. M. Mayes, C. A. Ross, "Nanostructure Engineering by Templated Self-Assembly", Nature Materials, vol. 3, pp823-828, 2004.

[2] J.Y. Cheng, C.A. Ross, E.L. Thomas, H.I. Smith, G.J. Vancso "Templated self-assembly of block copolymers: Effect of substrate topography", Adv. Mater. vol. 15, pp1599-1602, 2003.