

Influence of Thickness of PS-PMMA Block Copolymers on the Pattern Formation of Directed Self-Assembly

X. Tong, M. Patel, G.P. Watson and G.L. Kim

Singh Center for Nanotechnology, University of Pennsylvania, Philadelphia, PA 19104

xiaolei4@seas.upenn.edu

Directed Self-Assembly (DSA) of block copolymers (BCP) enables high-resolution patterning by circumventing the diffraction limit of conventional photolithography.¹ The process has the potential for large-scale, cost-effective manufacturing compared to other techniques with similar resolution.¹ We demonstrate vertically aligned cylindrical DSA patterns of polystyrene-block-polymethyl methacrylate (PS-*b*-PMMA) BCP with a nominal feature size of 20 nm. To explore the relation between the thickness of PS-*b*-PMMA BCP and the formation of DSA patterns, a template with trenches is fabricated on a SiO₂ substrate with electron beam lithography followed by reactive ion etching. The thickness of BCP is controlled by varying the width of trenches while the depth of trenches is constant. Results show that 1% PS (46.1k)-*b*-PMMA (21k) BCP solution in toluene forms DSA patterns when the width of the trench is between 80 nm and 200 nm. Scanning electron microscopy (SEM) and atomic force microscopy (AFM) are employed to characterize the pattern size and depth. We also demonstrate the chemical process for DSA that can be completed in 1 hour when the template is ready. This chemical process includes spin coating, thermal annealing on the hot plate and grafting.

¹ Y. Chen and S. Xiong, Directed Self-Assembly of Block Copolymers for Sub-10 Nm Fabrication, *International Journal of Extreme Manufacturing* 2, 032006 (2020).

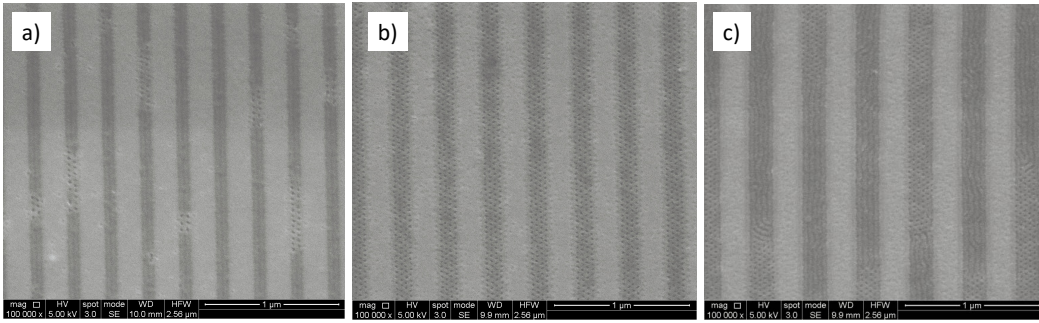


Figure 1: SEM images taken from the same sample on which DSA patterns of PS(46.1k)-b-PMMA(21k) BCP. The nominal depth of trenches is 45 nm. (a) 80 nm wide trenches, cylindrical DSA patterns were observed in specific areas. (b) 140 nm wide trenches, all the trenches showed desired cylindrical patterns. In (c) 200 nm wide trenches, cylindrical DSA patterns were not observed in most of the trenches.

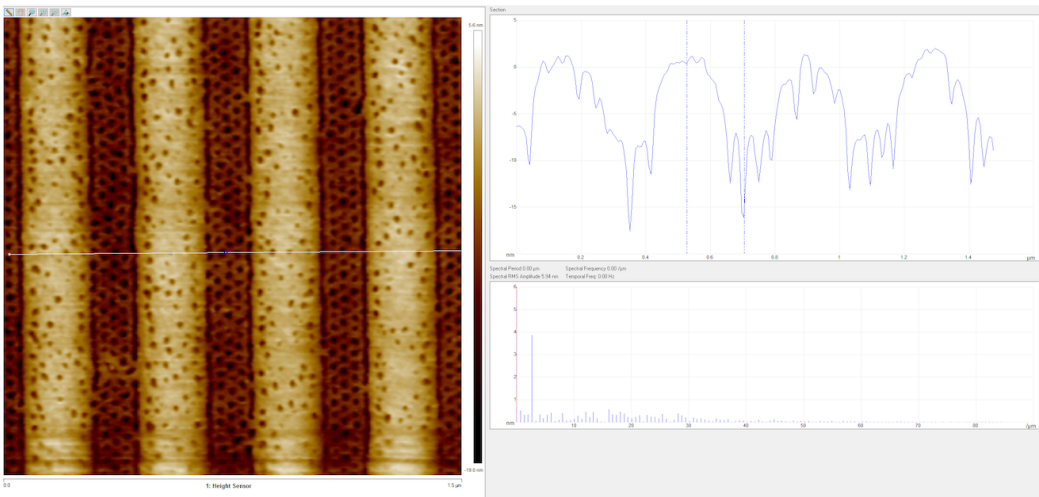


Figure 2: AFM data of DSA pattern on 180 nm wide trenches. The height measurement shows the 16.5 nm of step height between top and bottom of the BCP.