Block Copolymers for High-Resolution Nanopatterning

N.L.Y. Wu, K.D. Harris, J.M. Buriak
University of Alberta, Edmonton, Alberta, Canada T6G 2R3
nwu@ualberta.ca

The rapid development of semiconductor technologies has largely been dependant on the ability to create devices of increasingly high-resolution [1,2]. However, as the critical dimensions of such devices approach the limits of photolithography, new technologies must be introduced to complement lithography for these remarkable advances to continue. The self-assembly of block copolymers offers great potential for the parallel processing of features down to 10 nm, making it possible to continue following the goals set by the Semiconductor Industry Association's International Technology Roadmap for Semiconductors (ITRS). Recently, we developed a simple yet novel technique to quickly achieve highly ordered structures of block copolymer with few defects [3]. By combining both thermal and solvent annealing concepts through the use of a solvent-assisted microwave system, straight lines aligned over several microns were easily obtained in times as short as 60 seconds. The anneal technique was found to be easily generalized for different sizes and families of block copolymers, and was also found to be compatible with graphoepitaxy, producing features that closely followed the sparsely patterned guiding features. In such cases, straight lines with no observable defects were achieved within 60 seconds. This powerful and versatile technique holds great promise in patterning highly ordered lines of low defect density, a key requirement for implementation into current industrial processes. While the anneal times and the defect densities of the polymer have been greatly reduced by this technique, one challenge that must be addressed is how to continually reduce feature resolutions to make block copolymer patterning a competitive and viable patterning option. Therefore, we also discuss methods to increase the feature densities of the polymer films.

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[2] J. Chai and J. M. Buriak, ACS Nano **2**, 489-501 (2008).
[3] X. Zhang, K. D. Harris, N. L. Y. Wu, J. N. Murphy, and J. M. Buriak, ACS Nano **4**, 7021-7029 (2010).

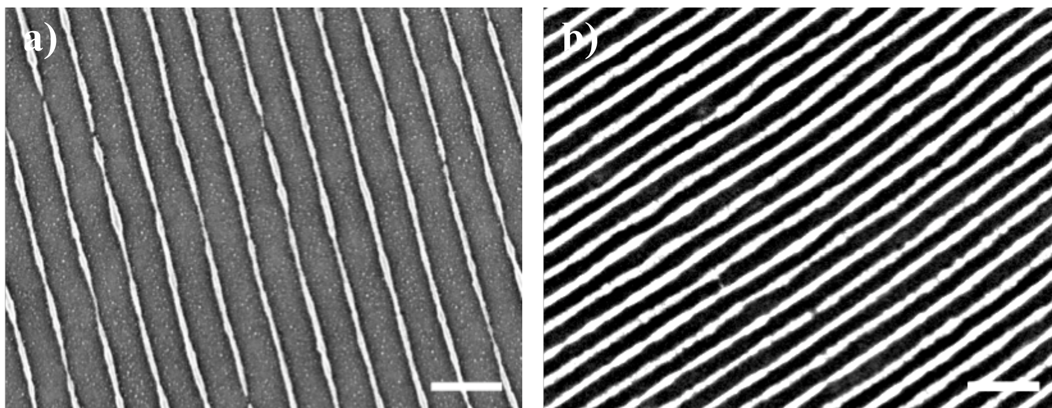

Figure 1: Metallized lines from cylindrical block copolymer templates: Using various methods to increase feature density. In this case, the line spacings can be reduced from (a) 60 nm to (b) 30 nm. The scale bars are 100 nm.