Extensive tunability of self-assembled block copolymer patterns for nanolithography

Y. S. Jung, W. I. Park and J. W. Jung
Department of Materials Science and Engineering, Korea Advanced Institute of Science and Technology (KAIST), Daejon, 305-701 Korea
ysjung@kaist.ac.kr

Nanoscale block copolymer (BCP) patterns have been pursued for applications in sub-30 nm nanolithography. BCP self-assembly processing is scalable and low cost, and is well-suited for integration with existing semiconductor fabrication techniques. However, one of the major technical challenges for BCP self-assembly is limited tunability in pattern geometry, dimension, and functionality.

First, we suggest methods for extending the degree of tunability by choosing highly incompatible polymer blocks and utilizing solvent vapor treatment techniques. Siloxane BCPs have been developed as self-assembling resists due to many advantages such as high etch-selectivity, good etch-resistance, long-range ordering, and reduced line-edge roughness.[1] The large incompatibility leads to extensive degree of pattern tunability since the effective volume fraction can be easily manipulated by solvent-based treatment techniques. Thus, control of the microdomain size, periodicity, and morphology is possible by changing the vapor pressure and the mixing ratio of selective solvents. This allows a range of different pattern geometry such as dots, lines and holes and critical dimension simply by changing the processing conditions of a given block copolymer without changing a polymer chain length. We demonstrate highly extensive tunability (critical dimension ~ 5 – 30 nm) of self-assembled patterns prepared by a siloxane BCP with extreme incompatibility. (Fig.1)

Second, we introduce a new templating technique based on metal films deposited on BCP films. The top metal film significantly affects the equilibrium height/diameter ratio of microdomains. (Fig.2) Non-uniform distribution of polymer chains due to the strong confinement given by the top surface as well as the bottom interface, internal tension may be developed and change the shape of microdomains. Thus, by patterning the top metal layer, we can obtain the regional controllability of BCP pattern formation. Various kinds of pattern formation will be demonstrated using the top-templating technique.

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[1] Y. S. Jung and C. A. Ross, Nano Letters 7, p.2046 (2007); Y. S. Jung and C. A. Ross, Advanced Materials 21, p.2540 (2009)

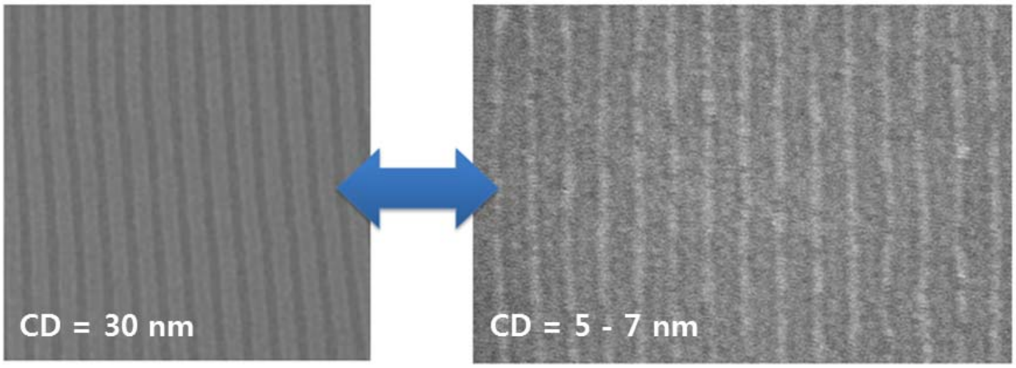

Figure 1: Large tunability of critical dimension. These patterns can be controlled simply by changing solvent vapor treatment conditions.

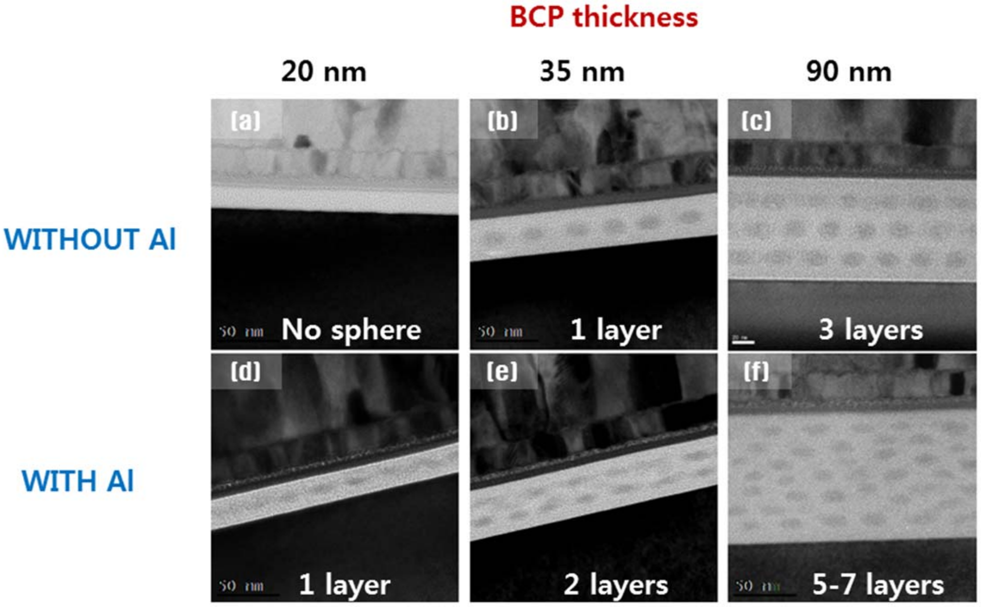

Figure 2: Tuning the aspect ratio of microdomains by top metal layers. By selectively depositing metal films on top of BCP films, the aspect ratio and area of pattern formation can be adjusted.