Synthesis and Characterization of low χ Block Copolymer for Large Periodicity Patterning using Directed Self-Assembly and Legacy Exposure Tools

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One of the most expensive processes in chip manufacturing is the lithographic patterning of wafers. Improving this process often involves changing from an older generation lithographic tool to a newer generation tool, which is typically a very expensive prospect since the newer generation tools tend to be far more expensive, in addition to requiring a change in setup. For companies already in possession of a 248 nm lithographic tool, the prospect of being able to use this older generation tool to reach 193 nm length scales is very attractive. Block copolymers (BCPs) are known to microphase separate into various morphologies with length scales around the length of a polymer chain itself. While much work has been done to reach feature sizes smaller than can be printed with 193nm lithography, little work has been done into reaching larger feature sizes, which would be useful in order to apply BCP lithography to older generation tools. The pitch of a BCP is very dependent on N (the degree of polymerization of the BCP) and weakly dependent on the Flory-Huggin's parameter χ (chemical dissimilarity between the blocks). Therefore, when trying to form a BCP with a small pitch, typically the strategy is to find a high χ, low N material. For a larger pitch BCP as we desire here, a higher degree of polymerization is desired. However, defects are prone to be kinetically trapped with higher χN, and annealing is expected to require longer time and/or higher temperatures with higher χN. Therefore , a lower χ is desired for the high N polymers. Also in some cases, larger features than can be prepared by current DSA materials are desirable, particularly for hole type patterns.

Here, we synthesize and characterize the BCP poly(4-tertbutylstyrene)-b-poly(propyl methacrylate) (PtBS-b-PPMA) as a useful block copolymer for 248 nm lithography. Small angle X-ray scattering (SAXS) is used to calculate the χ value of PtBS-b-PPMA as well as to measure the pitch. The χ for PtBS-b-PPMA is expected to be lower than that of PS-b-PMMA, leading to a BCP that permit less kinetically trapped defects, and makes annealing of large features easier than for PS-b-PMMA. A neutral underlayer is crafted for the BCP to phase separate on in order to form perpendicular features. Kinetics of phase separation are then estimated by the amount of time needed to form defect free morphologies.