Rapid growth in 30 seconds of thermally induced microphase-separation of PS-*b*-PMMA for directed self-assembly lithography

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The directed self-assembly (DSA) lithography is eagerly researched as one of candidate processes for next-generation lithography. Industrial demands request the longest total DSA process period within 240 s [1,2.] The demands have not been satisfied yet[3]. The shortening of the process period of block copolymer self-assembly is an urgent issue for industrial application. In addition, it will be needed to densify a packing structure of block copolymer microphase-separation for decreasing fluctuation at nano-sized architecture. The purpose of this study is to reduce the process period of block copolymer self-assembly with closed-packed micro-separation for DSA lithography. We investigated the annealing period necessary for the highly ordered microphase-separated cylindrical structure of single-layer poly(styrene)-block-poly(methyl methacrylate) (PS-*b*-PMMA) by atomic force microscope (AFM) measurement. The AFM measurement revealed that the initial microphase-separated structure on a Si wafer was formed in 10 sec by annealing at 200 ^{o}C on a conventional hot plate [Fig.1]. The correlation length of PS-*b*-PMMA was saturated after 30 sec. The value was approximately 30 times faster than that of vertical cylindrical PS-*b*-PMMA annealed at the same temperature in comparison with a previous report[3]. In addition, the influence of the presence of a hydroxy-terminated polystyrene (PS-OH) graft layer on a Si wafer on DSA of PS-*b*-PMMA was also investigated. The annealing period for saturation of the correlation length was unchanged, but the period (L) of PS-*b*-PMMA microphase-separation was decreased to 26 nm from 29 nm by surface modification of PS-OH without an increase in annealing period. This result suggested that the presence of the PS-OH graft layer caused PS-*b*-PMMA microphase-separation to be close-packed.

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[3] F. F. Lupi, T. J. Giammaria, G.Seguini, F. Vita, O. Francescangeli, K. Sparnacci , D. Antonioli , V. Gianotti, M. Laus, and M. Perego., ACS Appl. Mater. Interfaces, **6** (2014), 7180.

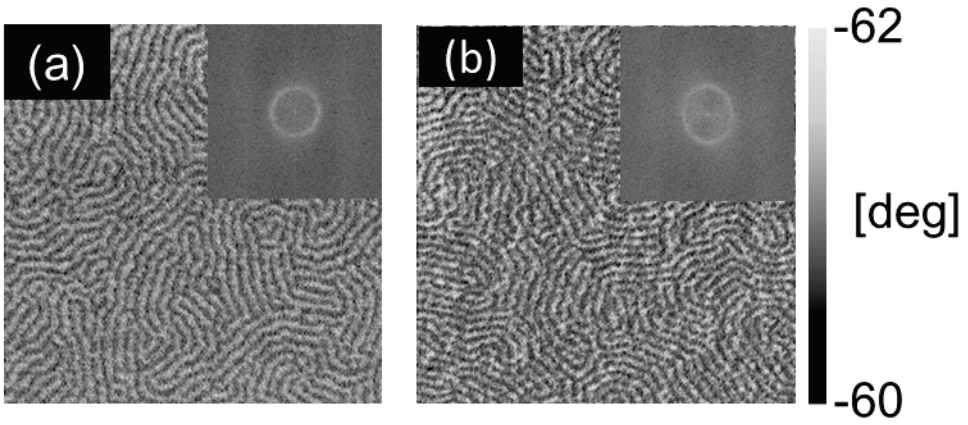

Figure 1: AFM phase images and 2D-FFT images (inset) of microphase-separated structures on (a) bare and (b) PS-OH modified Si substrates after annealing at 200 ^{o}C for 10 sec.