Advantages and challenges in the directed block copolymer assembly approach for bit patterned media

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Directed self-assembly of the block copolymer (BCP) approach has been recently considered as a promising lithographic solution for bit pattern media (BPM) applications due to its several unique advantages over the conventional e-beam lithography. Considerable gains in the patterning quality were observed relative to conventional e-beam lithography in terms of the dot size variation, the placement accuracy, the pattern uniformity, and the exposure latitude. We have integrated the P(S-*b*-MMA) BCP process into our imprint template fabrication and demonstrated a quartz template at a density of 1 Tb/in.^{2} This 1 Tb/in.^{2} template was used for the imprint, reverse-tone, and magnetic island formation process development. BCP patterning with density up to 3.8 Tb/in.^{2} has been achieved by using P(S-*b*-DMS).

However, the BCP approach still has several of its own challenges besides the resolution consideration: First, the equilibrium structure for all commonly used BCP materials is a hexagonal lattice that may not be the best structure for BPM designs. Any non-hexagonal BCP pattern requires the synthesis of new BCP architectures to form a non-hexagonal lattice configuration, such as a staggered pattern. Second, the maximum skew angle that BCP materials can tolerate is less than 10° in the most BCP materials, and this may not satisfy the current mechanical design of hard disk drives. The maximum skew angle may be increased by adding a blend of polymer into the BCP material to increase the dimensional latitude of the polymer chains, but it may induce the co-existence of more than one lattice configuration in the BCP patterns. Third, since the BCP patterns only exhibit one lattice structure with a fixed dimension (pitch), this approach is suitable for forming the data bit area but it may not be suitable for the servo pattern area that consists of periodic and non-periodic structures with different dimensions. Due to the flexibility of the conventional e-beam lithography process, it can more easily handle the servo pattern area than the BCP process. Therefore, the practical solution will be to integrate two processes into one BPM template fabrication process by using the BCP process for the data bit area and using the conventional e-beam process for the servo pattern area. Then how to integrate these two processes along with tight overlay requirements becomes the next challenge. In this presentation, we will present our recent progress that addresses the above challenges.

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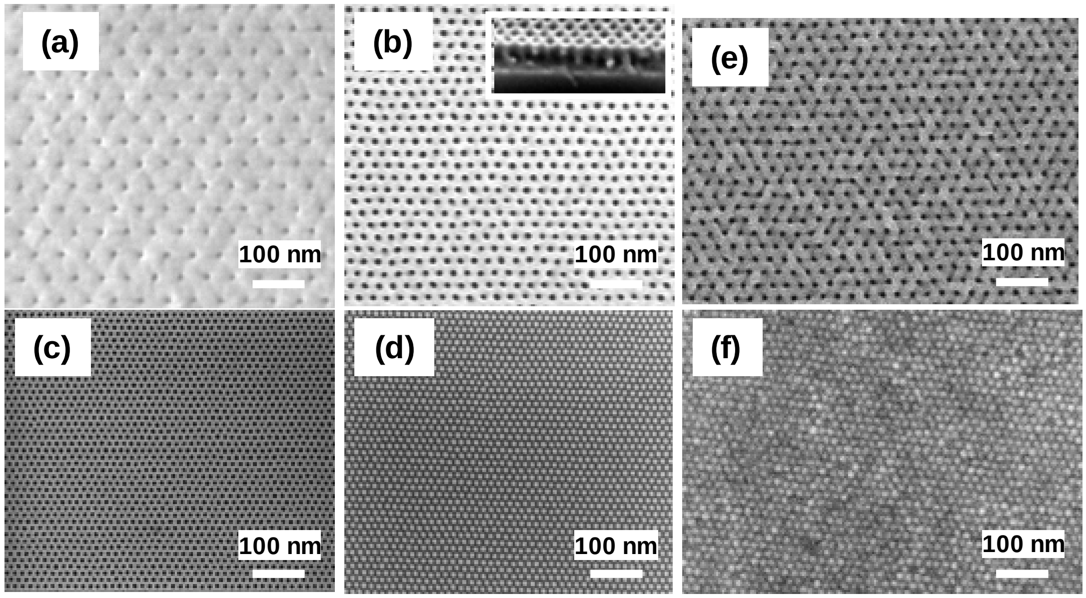

Figure 1 Top-down SEM images: (a) e-beam resist ZEP hexagon pattern with pitch=56 nm; (b) Cylinder-forming P(S-*b*-MMA) pattern with pitch=28 nm (~1Tbpsi); (c) Hole-tone quartz template at ~1Tbpsi; (d) pillar-tone quartz template at ~1Tbpsi; (e) imprinted resist holes, and (f) magnetic dots at ~1Tbpsi.

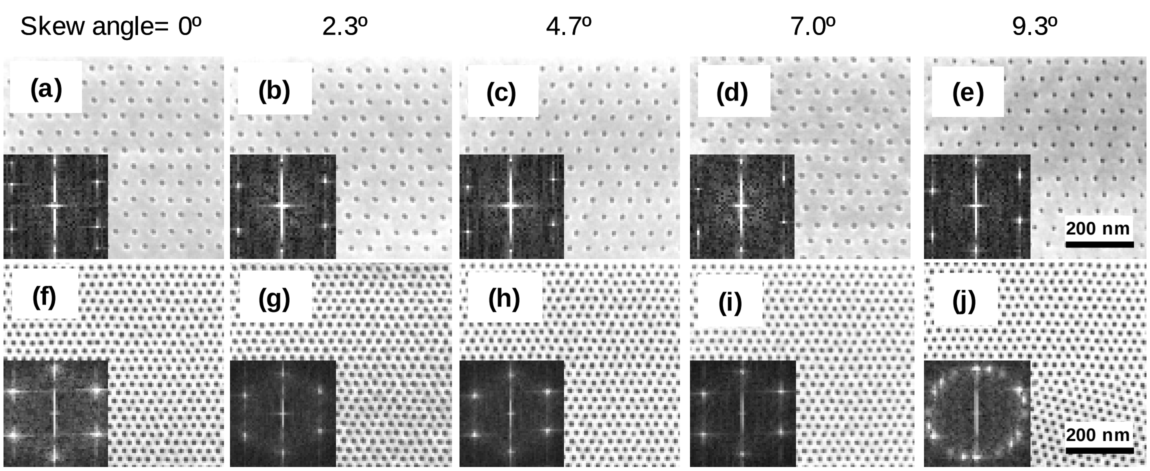

Figure 2 Top-down SEM images: (a)-(e) developed ZEP resist hexagon patterns (pitch= 56 nm) with skew angles of 0°, 2.3°, 4.7°, 7.0°, and 9.3°, respectively. (f)-(j) corresponding P(S-*b*-MMA) patterns but with pitch=28 nm (~1Tbpsi).