

# Pattern Transfer from Directed PS-*b*-PMMA Films with Sub-25 nm Full Pitch

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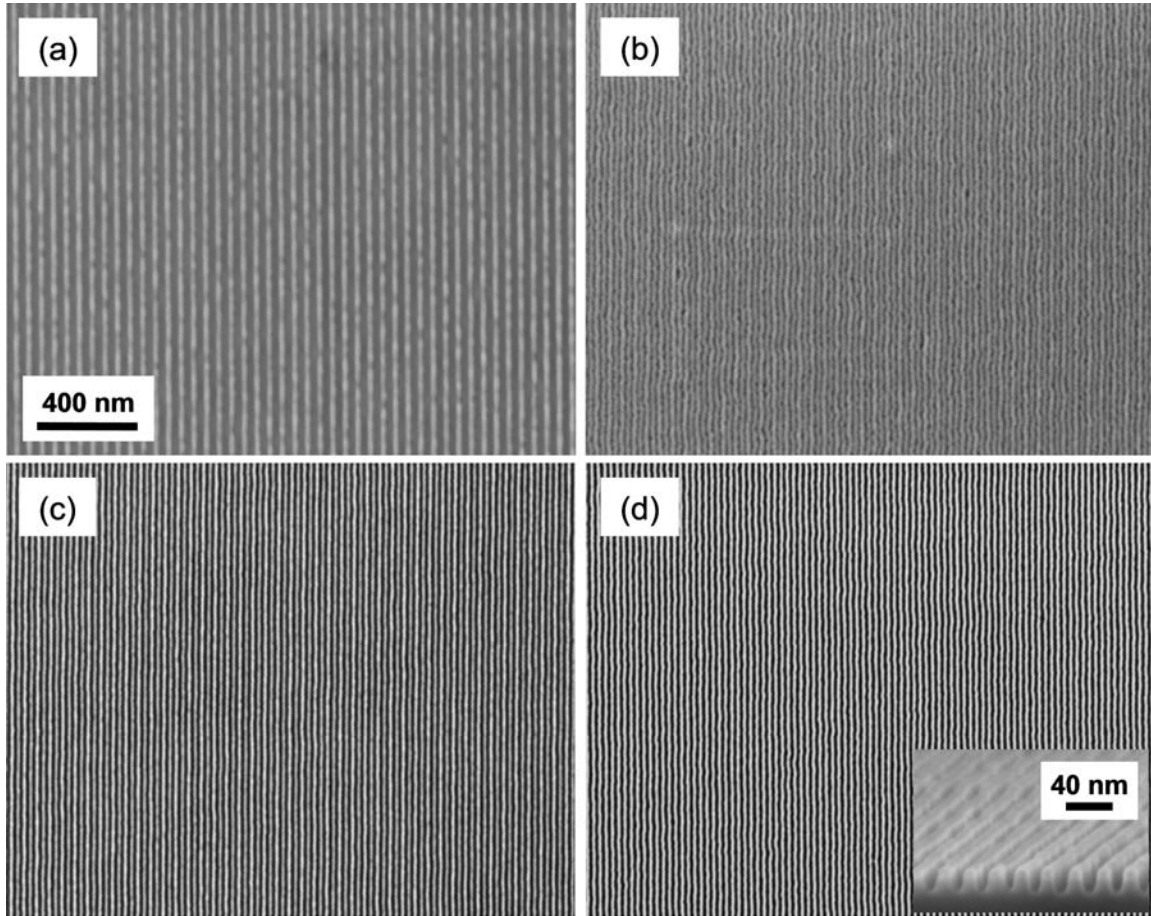
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**ABSTRACT:** Recent progress in block copolymer lithography indicates that directed self-assembly is a promising candidate for high density patterning, and can be inserted to magnetic recording and semiconductor applications. Given that the directed self-assembly of sub-25 nm PS-*b*-PMMA has been demonstrated on full wafer with low defect density, a robust and high-fidelity pattern transfer from the block copolymer patterns is vital for the success of block copolymer lithography. Here, we explore different pattern transfer methods from lamellae-forming PS-*b*-PMMA block copolymers with a full pitch down to 22 nm. Regular lift-off, dry lift-off, atomic layer deposition (ALD), and direct etching using hard mask have been investigated and compared. Our results suggest that pattern transfer is the most critical step for pattern perfection in terms of defect density, line edge roughness (LER), line positioning roughness (LPR), and line width roughness (LWR). By employing our knowledge of directed self-assembly and pattern transfer, we have demonstrated the fabrication of nanoimprint templates on 8-mm-wide full band circular tracks for bit-patterned media (BPM) application. The defect density is low enough to support a bit defect rate of  $\sim 10^{-4}$  once the lines are cut into rectangular bits. The  $3\sigma$  values of LER, LPR, and LWR are less than 3 nm. However, we note that as critical dimension approaches 10 nm, the processing window for pattern

transfer becomes narrower and a pattern transfer strategy has to be designed to match the material set used and the final feature specifications.

**KEYWORDS:** Block copolymer lithography, pattern transfer, PS-*b*-PMMA, lamellae, bit-patterned media



*Figure 1:* Top-down SEM images of (a) E-beam resist pattern after being trimmed in O<sub>2</sub> RIE with a full pitch of 49 nm. (b) Self-assembled PS-*b*-PMMA film on top of the chemical prepattern defined by the e-beam resist pattern. The lattice pitch on the block copolymer film is 24.5 nm. (c) PS line pattern after selective removal of PMMA block using O<sub>2</sub> RIE. (d) Si line pattern after pattern transfer the PS lines into Si substrate through a dry lift-off process. The inset in (d) shows the crosssectional SEM image of the Si lines.