Directed Patterning for Electronics Using Multiple Block Copolymers Orthogonally

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High resolution, low line-edge roughness and reproducibility is a necessity for all patterning at nanoscale. Recent approaches have included molecular self-assembly using block copolymers. Block copolymers employ low energy techniques at low temperature. System energy minimization during processing leads to phase separation where small dimensions and ordered patterns are achieved. The drawback of this self-assembly is the limited set of geometries and a two-dimensional arrangement whose grain size is determined by the length scale of the surface diffusion processes. Electronics needs precise patterns – lines and other shapes – at precise positions, not just an ordered arrangement over an area.

We employ orthogonal processing, a technique where different films are processed independently together with pattern guiding, to achieve flexibility in feature sizes, location and geometry that is useful in electronics. Orthogonal solvents, that interaction dominantly with the desired films only, allow independent processing of different polymer films. For example, the first film may be a photoresist and the second film a block copolymer. By adding a cross-linker to the block copolymer, one can make it immiscible in solvent and thus introduce a second block copolymer using the same solvent.

Semi-perflourinated polymer (OsCOR) is used as photoresist and PHOST-a-MS as the block copolymer. PHOST-a-MS is cross linkable and while OsCOR is soluble in hydroflouroether solvents, PHOST-a-MS is soluble in PGMEA which is immiscible with hydroflouroethers, the solvent for OsCOR. This combination allows both additive and subtractive patterning to be accomplished.

Directed assembly of cylinders with a pitch of 48nm and spheres with pitch of 23nm pitch were obtained. Cylinders in an area of 1cm by 1cm with adjacent regions of spheres are possible, with patterns arranged in a rectangular arrays as shown in figure 2. With lines already demonstrated, this shows versatility of the approach.

We conclude with device examples, further optimizations possible and limitations of the approach. The limit questions include the numbers of different layers, of geometries, of the polarity of the solvent systems, and how these affect the underlying features.

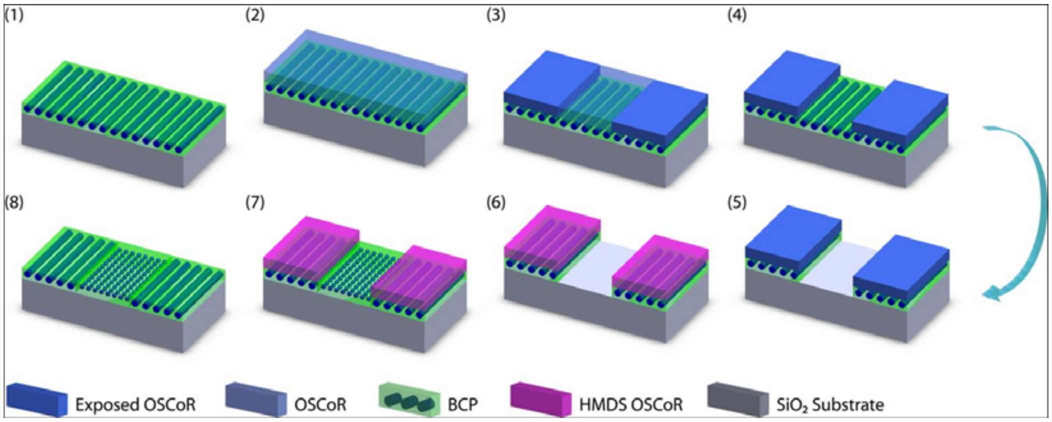

Figure 1: Process flow: The first block copolymer is annealed and then OsCOR is applied and used for subtractive patterning, then the second block copolymer is applied while the OsCOR is used for additive patterning. This leads to patterns of both block copolymers arranged in a grid array.

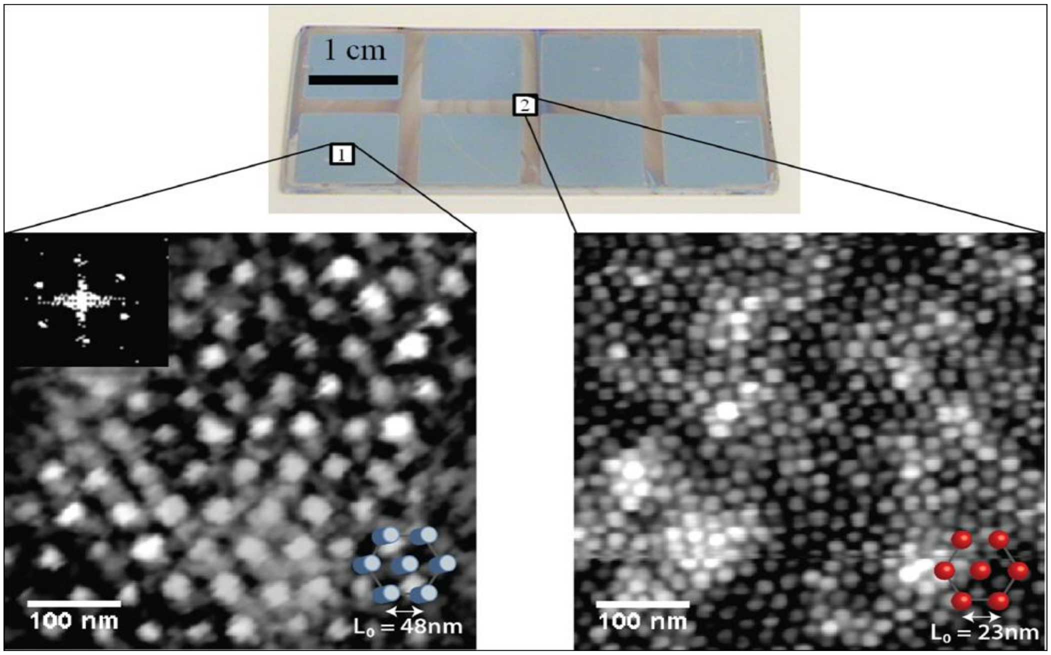

Figure 2: *Results*: The left AFM image shows a cylinder morphology block copolymer with pitch of 48nm while the right AFM shows a block copolymer with pitch of 23nm with spherical morphology.