Title: Evolution of Critical Dimension and Line Edge Roughness during Block-Copolymer Nano-Patterning

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The lack of a proven optical solution for mass production of integrated circuits beyond the 22nm node threatens to slow the pace of feature density growth as defined by the ITRS roadmap. Directed block-copolymer assembly (DBCPA) is a promising nanofabrication technique that has been used for feature density multiplication and to improve line edge roughness (LER). To move beyond the 22nm node, we have developed an integrated lithographic approach using ArF immersion lithography, DBCPA, and nano-imprint lithography (n-IL), which leverages the strengths of one technique against the weaknesses of the others. To determine the feasibility of this technique for IC mass production, we characterize the evolution of 3σ LER and defect count during each lithographic processing step. Specifically, we use immersion interference lithography to fabricate line/space arrays at 80-100nm pitch, which are then used to form a chemical pattern via plasma trim-etch and back-fill processes. DBCPA onto these pre-patterned surfaces results in density multiplication of the arrays (two- to four-fold increases in spatial frequency). Following selective removal of one polymer block, the remaining line pattern acts as an etch mask to form a nano-imprint lithography (n-IL) master, which is then used to perform n-IL directly, or via a daughter mold. Patterned features are non-destructively characterized after critical process steps using a high resolution (sub-nm) SEM with electron deceleration capabilities followed by image analysis using MATLAB. Critical dimensions, 3σ LER, and defect density are tracked during the various processing steps to understand the challenges and limitations of this emerging integrated lithographic approach.

* A portion of this work was supported by the Laboratory Directed Research and Development program at Sandia National Laboratories. Sandia is a multiprogram laboratory operated by Sandia Corporation, a Lockheed Martin Company, for the United States Department of Energy's National Nuclear Security Administration under Contract DE-AC04-94AL85000.

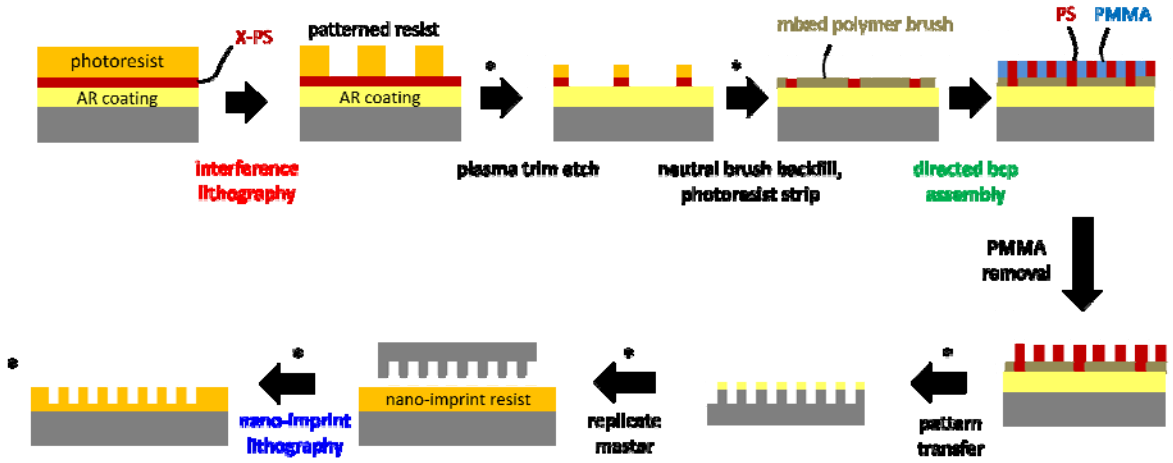

Figure 1. Process flow for integrated block copolymer lithographic approach. * denotes metrology steps for critical dimension, line edge roughness, and defect density analysis. Acronyms: crosslinked polystyrene (X-PS), anti-reflection (AR), block copolymer (bcp), polystyrene (PS), poly(methyl methacrylate) (PMMA).

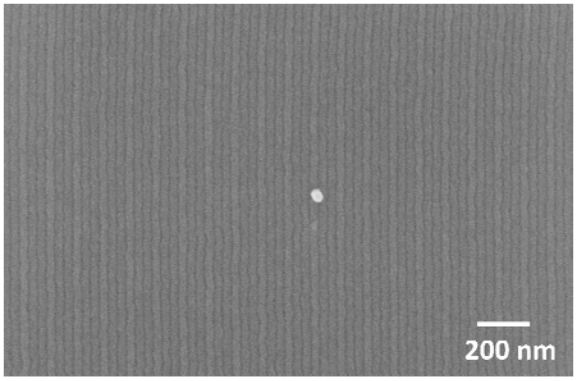

Figure 2. Block copolymer (PS-b-PMMA) assembled at 30 nm pitch on a 90 nm pitch chemical pre-pattern.

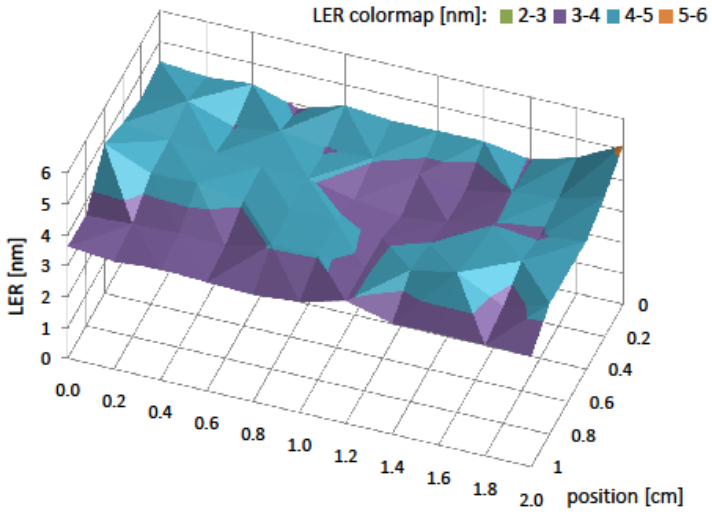

Figure 3. Example of line edge roughness data for 82nm pitch pre-pattern measured over a 2.0 cm^2 chip.