PROCESS OPTIMIZATION AND IMPROVEMENT OF CONTACT HOLE CDU AND PATTERN PLACEMENT USING GRAPHO-EPITAXY DSA WITH EUV PATTERNED TEMPLATES

Carolien Boeckx[a,b], Jan Doise[a,b], Boon Teik Chan[b], Stefan De Gendt[a,b], Paulina Rincon Delgadillo[b]

[a] KU Leuven, Department of Chemistry, Celestijnenlaan 200F, B-3001, Heverlee Belgium
[b] IMEC, Kapeldreef 75, B-3001 Leuven, Belgium

Keywords: lithography, block-copolymers, self-assembly, grapho-epitaxy, placement error, CDU

Directed self-assembly (DSA) of cylindrical block copolymers (BCP) is a valuable candidate for frequency multiplication and hole shrink and repair for contact layer patterning. Conventional lithography techniques are used to generate pre-patterns that guide the phase separation of block co-polymers through the interaction with the sidewalls and the bottom of the templates. In these templates of defined dimensions and wetting properties, a cylinder forming polystyrene-*b*-methyl methacrylate (PS-*b*-PMMA) is deposited and annealed. After the annealing step, the inner PMMA block is subsequently removed (Figure 1). One of the main limitations for the implementation of grapho-epitaxy DSA in device fabrication is control over critical dimension uniformity (CDU) and placement errors. In the past, simulations have predicted that the variability during DSA can be controlled by using high resolution EUV printed pre-patterns that have improved template CDU and well-defined complex, shapes beyond the resolution of 193nm immersion lithography.

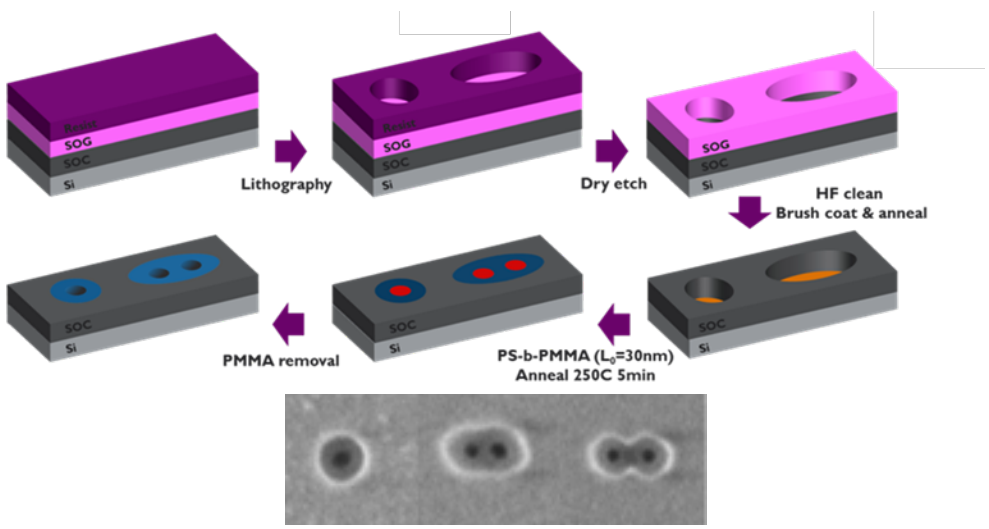

Figure 1: Schematic representation of the EUV templated DSA process flow for singlet, ellipse and peanut-shaped templates

In this study, we will demonstrate the impact of the template generation method and variations in the template shape on CDU and pattern placement of the DSA holes. (1) Our focus lies on the formation of singlet and doublet structures. First, the surface wetting of the Spin-on-carbon (SOC) sidewalls and Si bottom substrate were optimized using random copolymer brushes to obtain the desired perpendicular cylindrical morphology of the BCP inside the pre-pattern. Brush grafting on the SOC and Si surface was controlled by varying the anneal T and t. (2,3) Second, 193nm immersion lithography as a template generation method is compared to EUV lithography. Since the latter has an improved resolution it is expected to improve pre-pattern uniformity and result in lower variability. The impact of dose and pre-pattern size on the variability is determined for singlet and doublet structures. In addition, the ability of printing complex structures, such as the so called peanut shaped templates, will be explored as they are expected to enlarge the process window and reduce placement errors due to better confinement of the BCPs. To determine the impact of template shape on the final variability both elliptical and peanut shaped template shapes are considered for doublet structures.

1) J. Doise, J. Bekaert, B. T. Chan, R. Gronheid, Y. Cao, S. Hong, G. Lin, D. Fishman, Y. Chakk, and T. Marzook, "Implementation of surface energy modification in graphoepitaxy directed self-assembly for hole multiplication," *J. Vac. Sci. Technol. B, Nanotechnol. Microelectron. Mater. Process. Meas. Phenom.*, vol. 33, no. 6, p. 06F301, 2015.

2) P. Mansky, "Controlling Polymer-Surface Interactions with Random Copolymer Brushes," *Science (80-.).*, vol. 275, no. 5305, pp. 1458–1460, 1997.

3) S. Wuister, T. Druzhinina, D. Ambesi, B. Laenens, L. He Yi, and J. Finders, "Influence of litho patterning on DSA placement errors," *Proc. SPIE*, vol. 9049, p. 90491O, 2014.