Improved versatility of DSA topographic patterns through the use of UV-exposed grafted layers.

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Affordable, simple, versatile: Directed self-assembly of block-copolymers is still highly investigated as a sub-10nm features lithography technique for next generation node in the CMOS industry. While several integration are known possible, throughout literature chemoepitaxy seems the consensus with well-established process flow such as LiNe[1] or SMART[2]. The use of topographic grating to direct the assembly, known as graphoepitaxy, can also provide well defined structures with a variety of block copolymer materials and process environment. Such templates are simpler to create and less demanding in term of lithographic resolution : topographic gratings of four time the polymer period (L0) is usually sufficient whereas chemoepitaxy requires features close to one L0, with precise control on uniformity. Graphoepitaxy also provide a greater number of interface to better direct low defect self-assemblies; however, more interfaces demands more control over the spread of surface energies seen by the block-copolymer. Fully or partially functionalized surfaces with grafted layers of polymers is a well spread technique[3] that only solves half part of the problem: the former promotes bottom wetting layer impacting etching transfer; the latter inherently promotes variability in surface energies.

This work presents a simple, versatile and cost effective surface modification technique for precise control over the surface affinity of topographic gratings used for the 300mm graphoepitaxy of PS-*b*-PMMA lamellar block copolymer. Figure 1 shows how the method uses the property of various copolymers brushes to undergo UV-induced oxidation coupled with simulated intensity profiles inside a 3D grating structure as a mean to precisely select the free surface energy distribution. In this work, both homo-polystyrene and PS-*r*-PMMA thin films grafted to the surface of the grating are modified. The result is non-preferential wetting promoted at the bottom interface while sidewalls are left highly PMMA attractive as depicted in figure 2.

Topographic gratings for DSA combined with such modification technique could still provide tremendous versatility in the assembly and design of line/space features across a single wafer.

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1. Pathangi, H. et al. Journal of Micro/Nanolithography, MEMS, and MOEMS 14, 31204 (2015).
2. Kim, J. et al. Proceedings of SPIE Vol. 9423, 94230R (2015)
3. Minko, S. in Polymer surfaces and interfaces 215–234 (2008).

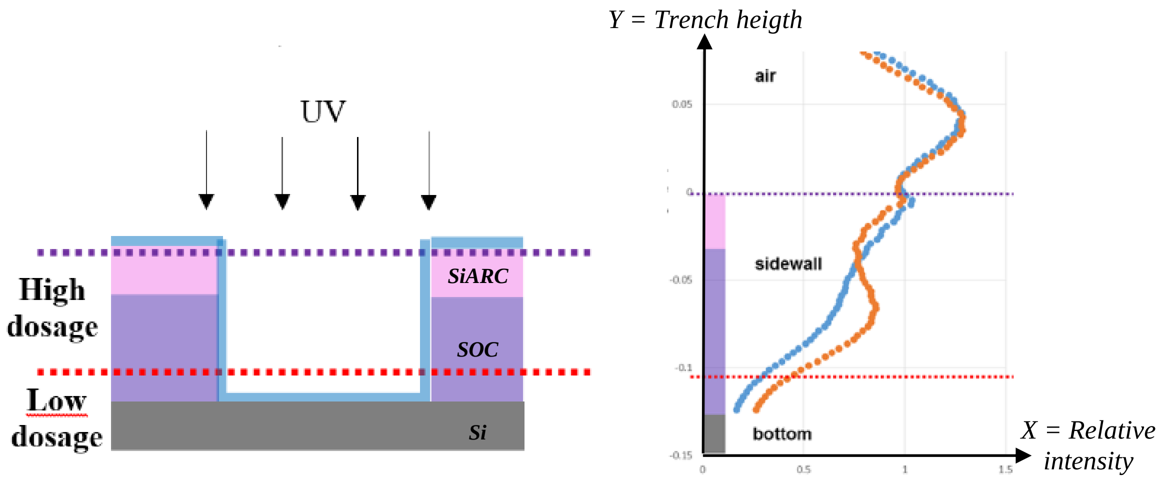

Figure 1: A/ Drawing of the concept: the UV exposure inside hard mask (light and dark purple: SiARC and SOC), high aspect-ratio gratings generate higher dosage on sidewalls than on the bottom interface. Thus, a two-tone photoactivated modification of a previously grafted underlayer occurs. B/ Simulated data of a 193nm wavelength light relative intensity dispersion inside DSA gratings of two different dimensions (orange is 180nm wide gratings, blue is 100nm wide). The differentiation can exists for a wide range of patterns.

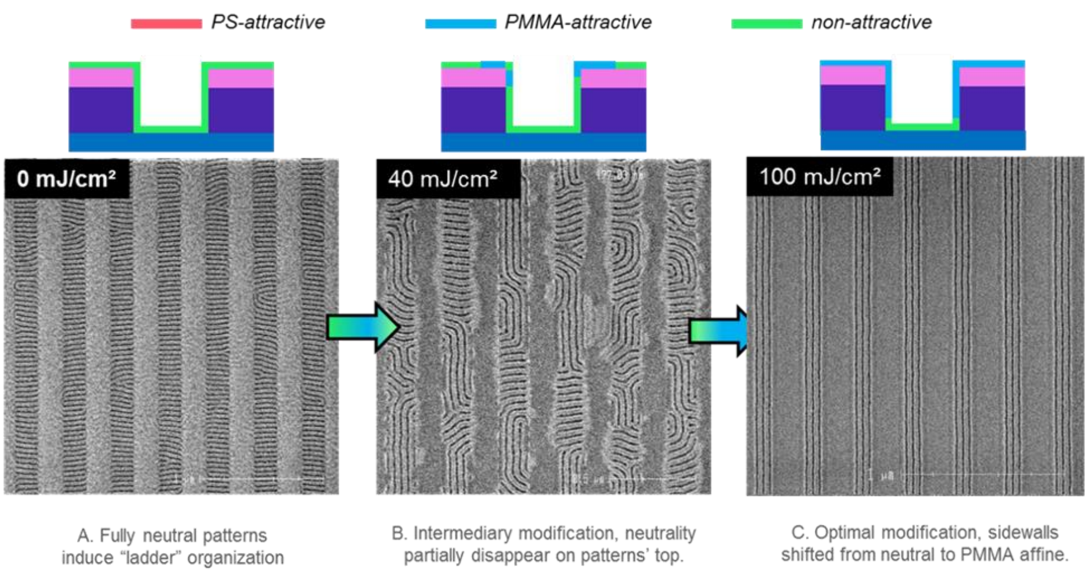

Figure 2: Top-down CDSEM review showing three states of gratings UV-modification. The schematic each represent the ideal cross-section of the gratings, with the proposed surface affinity of the grafted layer regarding the blocks of the 38nm period lamellar forming PS-b-PMMA. A/ Standard random brush with no modification promotes lamellae perpendicular to the gratings. B/ Significant UV dosage triggers partial modification the random layer, promoting both perpendicular and parallel lamellae. C/ The optimum UV dosage promotes lamellae fully parallel to the gratings while conserving a non-preferentiality at the buried interface.