Implementation of Surface Energy Modification in Grapho-Epitaxy Directed Self-Assembly for Hole Multiplication

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Directed self-assembly (DSA) of block copolymers (BCP) has received a great deal of research attention as a potential patterning approach for future generation device fabrication. Specifically, a grapho-epitaxy process using perpendicularly oriented cylindrical phase BCPs (at imec known as templated DSA) may offer an efficient solution for patterning randomly distributed contact holes with sub-resolution pitches such as found in via and cut mask levels. The major merit of this method is the possibility of a reduction of cost and processing time compared to multiple patterning approaches by eliminating one or more masks.

In templated DSA, conventional lithography and dry etching is used to create a topographical pre-pattern consisting of trench-like shapes (templates) in which a cylindrical BCP is deposited and allowed to phase separate before the minority block is removed. This should result in one or multiple sub-resolution holes within each template. Before templated DSA can be implemented in device fabrication, a number of process-related challenges need to be resolved. The most important ones are profile control of the BCP cylinder, hole placement accuracy and transfer of the DSA pattern into an underlying stack.

Several computational simulation studies are available which describe the influence of the template surface energy on the morphology of the self-assembly [1,2]. In general, these predict that selective control of the surface energy at the bottom and sidewall of the template is crucial for achieving a cylinder that reaches all the way down to the bottom. Furthermore, changing the sidewall surface energy from minority to majority block affinitive allows the use of pre-pattern templates of half the dimensions (for the same BCP material), which is vital for design reasons.

This paper focuses on the experimental implementation of a dedicated surface energy modification step in imec's templated DSA process flow (given in Figure 1 and Figure 2). Our approach to achieve selective control over the surface energy of the bottom and sidewall of the template by using polymer brushes will be discussed. Afterwards, experimental findings are presented concerning the influence of surface energy on the cylinder profile, hole placement accuracy and transfer of the pattern into an underlying stack.

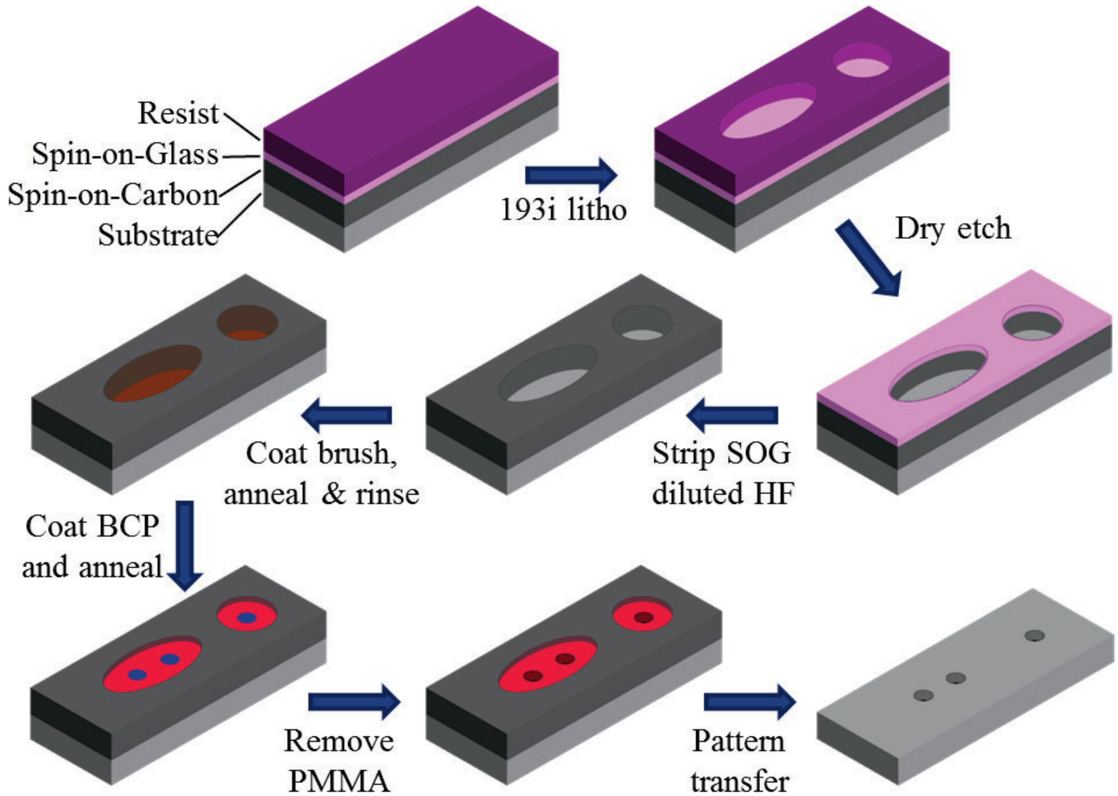

Figure 1. Schematic of the process flow for templated DSA at imec.

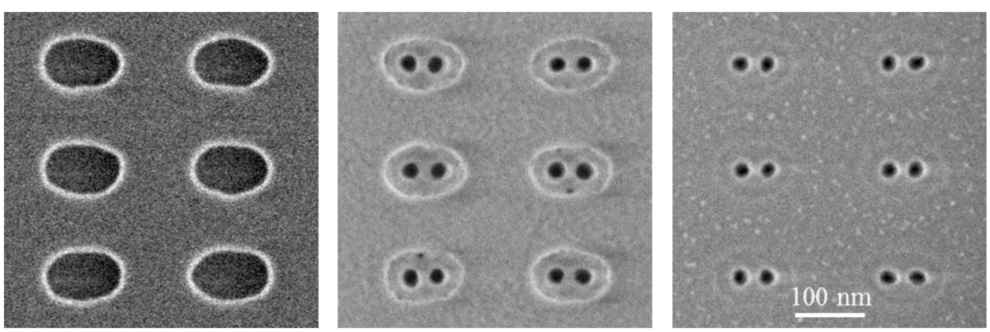

Figure 2. Top-down SEM images taken at different steps in the process flow: after dry etch (left), after PMMA removal (center) and after pattern transfer into the underlying substrate (right).

References:

[1] H. Yi, A. Latypov, and H.-S. P. Wong, Proc. SPIE **8680**, (2013).
[2] A. Latypov, Proc. SPIE **9049**, (2014).