Directed self-assembly of block co-polymers: chemical guiding patterns and advanced nanometer-scale characterization

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Directed self-assembly (DSA) of block co-polymers allows the generation of high-resolution patterns at wafer scale level [1]. The characteristic feature size of the final pattern is dictated by the molecular weight of the block co-polymer, while its orientation is prompted by the pre-definition of guiding patterns on the surface. DSA is considered by the semiconductor industry as one of the best candidates as lithography method for the next technological nodes, as it combines high resolution (< 10 nm half pitch) and high throughput, together with more simplicity and lower cost in comparison with extreme UV optical lithography.

In chemical epitaxy DSA, the guiding patterns that fix the orientation and position of the block co-polymer self-assembled features are defined as areas of the surface of varied chemical strength (affinity) with the blocks forming the co-polymer. In the first part of the talk, we will show different examples of creating high resolution chemical guiding patterns for chemical epitaxy DSA: functionalization by selective oxygen plasma exposure [2], direct chemical modification by atomic force nanolithography [3]; and electron beam exposure [4]. By properly tuning of the interface energies, it is possible to generate patterns of dense arrays of line/spaces using wide guiding stripes, relaxing the requirements of the lithography method for the guiding pattern generation.

In addition, we will show our recent advances in the characterization of thin polymer layers of self-assembled block co-polymers by Atomic Force Microscopy (AFM). There is an increasing need for new metrology approaches when the critical dimension of the patterns approaches or it is below 10 nm. We use peak force tapping to probe the nanomechanical properties of the block co-polymers, including the change in elasticity of the block co-polymer phases, allowing to determine the optimal conditions for their imaging [5].

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[1] R. Ruiz et al. *Density multiplication and improved lithography by directed block copolymer assembly* . Science 321 (2008) 936-939

[2] L. Oria et al. *Polystyrene as a Brush Layer for Directed Self-Assembly of Block Co-Polymers.* Microelectron.Eng. 110 (2013) 234-240

[3] M. Fernández-Regúlez et al. *Sub-10 Nm Resistless Nanolithography for Directed Self-Assembly of Block Copolymers*. Appl.Matter.Interfaces 6 (2014) 21596-21602

[4] L. Evangelio et al. *Creation of guiding patterns for directed self-assembly of block copolymers by resistless direct e-beam exposure.* J. Micro/Nanolith. MEMS MOEMS. 14 (2015) 033511

[5] M. Lorenzoni et al. *Nanomechanical Properties of Solvent Cast PS and PMMA Polymer Blends and Block Co-Polymers.* J. Micro/Nanolith. MEMS MOEMS. 14 (2015) 033509