300mm DSA process qualification and stability

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Directed Self-Assembly (DSA) is today a credible alternative lithographic technology for semiconductor industry[1]. In the coming years, DSA integration could be a standard complementary step with other lithographic techniques (193nm immersion, e-beam, extreme ultraviolet). The potential of DSA must next be confirmed viable for high volume manufacturing. Developments are especially necessary to transfer this technology on 300mm wafers in order to demonstrate semiconductor fab-compatibility. The challenges concern the stability, both uniformity and defectivity, of the entire process, including tools, Block Co-Polymers (BCP) and Neural Layer (NL) materials[2,3,4].

We focus this study on polystyrene-*block*-poly(methyl methacrylate) (PS-*b*-PMMA) BCP having a cylindrical morphology with a periodicity close to 35nm (Nanostrength® EO C35 supplied by Arkema) for contact hole patterning application. Unpatterned configuration (BCP self-assembly without guiding pattern) is initially used for entire 300mm process qualification. Process stability is firstly checked through a tight monitoring of some parameters (NL & BCP thicknesses, PMMA domains diameter, BCP period, defectivity…). We also consider process delay times effect on BCP material self-assembly defictivity during DSA i.e. the waiting time between DSA steps (for instance between NL grafting and BCP self-assembly) (Fig1). PMMA phase removal by ultraviolet irradiation (PMMA chains scission and PS matrix crosslinking) followed by a wet development is then qualified in terms of uniformity (Fig2). Acetic acid and isopropyl alcohol developers efficiencies are especially compared in order to remove properly PMMA nanodomains. Etching demonstration of BCP pattern into a hardmask is then presented. This process baseline is applied to patterned surface (graphoepitaxy) and an optimized process window of contact hole shrink process is defined. Finally, process stability (CD uniformity and defectivity related to BCP lithography) is investigated.

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[1] The International Technology Roadmap for Semiconductors, http://www.itrs.net/Links/2013ITRS/2013Chapters/2013Litho.pdf and http://www.itrs.net/Links/2013ITRS/2013Chapters/2013ERM.pdf (**2013**)
[2] R. Tiron et al., *Proc. SPIE*, 868012 (**2013**)
[3] M. Argoud et al., *Proc. of SPIE*, 9049-81 (**2014**)
[4] A. Gharbi et al.,Proc. of SPIE, 9049-58, (**2014**)

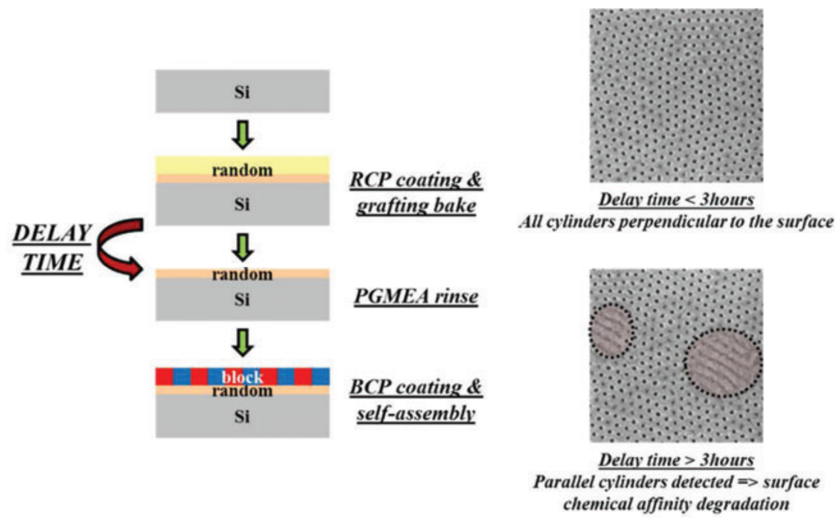

Figure 1: Illustration of long process delay time during DSA

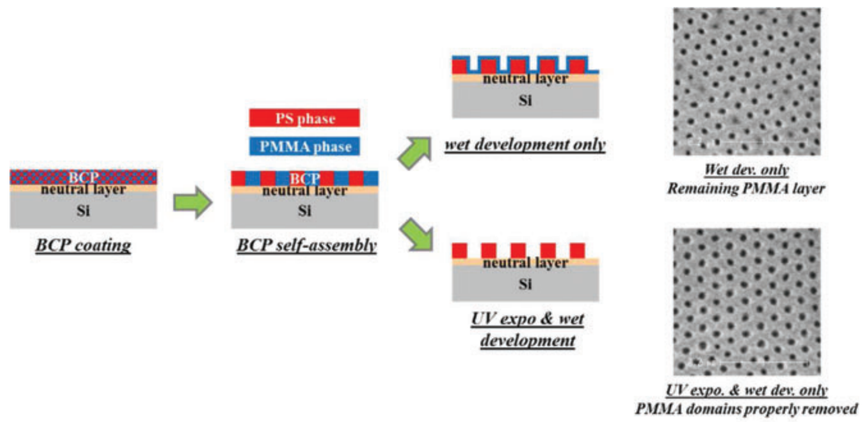

Figure 2: Ultraviolet irradiation used to remove properly PMMA domains.