Towards an all-track process for DSA

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Directed self-assembly (DSA) of block copolymers (BCPs) is identified as a potential lithography solution at 16nm node and below in ITRS.[1] The integration of DSA with the existing lithography may provide sub-lithographic features,[2-4] improved pattern quality, [5, 6] and lower processing complexity than some double patterning techniques.[7] However, as of commercialization of DSA is considered, many manufacturing-related challenges need to be addressed. Examples of these challenges include, processing time/throughput and solvent compatibility. Although a previous work demonstrated that the assembly of BCPs can be done in a timeframe that is suitable for manufacturing,[8] the kinetics of other annealing steps involved has not been studied thoroughly yet, especially for the recently reported chemical pattern fabrication method[9] which provides 193i lithography compatibility[4] and accurate control in the chemistry and geometry.

Here we propose an improved DSA process with new specialized materials based on our previous work[9] and seek to address the challenges of DSA commercialization. In this study we demonstrate that all the critical steps, including the deposition of the imaging layer, the deposition of the brush layer, and the assembly of block copolymers can be done in minutes on a hot plate in an N2 atmosphere, which simulates the processing environment of a lithography track module. The proposed process started with the spin-coating and cross-linking of a thin imaging layer followed by the patterning and the etching steps. After the resist was removed by solvents, a polymer brush was then grafted onto the exposed region and resulted in a well-controlled chemical pattern. A thin film of BCPs having a natural period of 25 nm can then be directed to assemble on the chemical pattern having a period of 100 nm (4x density multiplication.) We intentionally chose one high (250^{o}C) processing temperature for every annealing step to streamline tool arrangement and promote the temperature-dependent rate-limiting steps. The kinetics of each step was studied using several different indices, such as film thickness or Au nanoparticle adsorption (Fig. 1). A very large area of perfect assembly (Fig. 2) suggested that DSA with density multiplication can be achieved under the processing environment of a track module. The proposed process presents a viable solution to some of the anticipated throughput-related challenges to DSA commercialization and thus, brings integration of DSA within reach of the semiconductor manufacturing industry.

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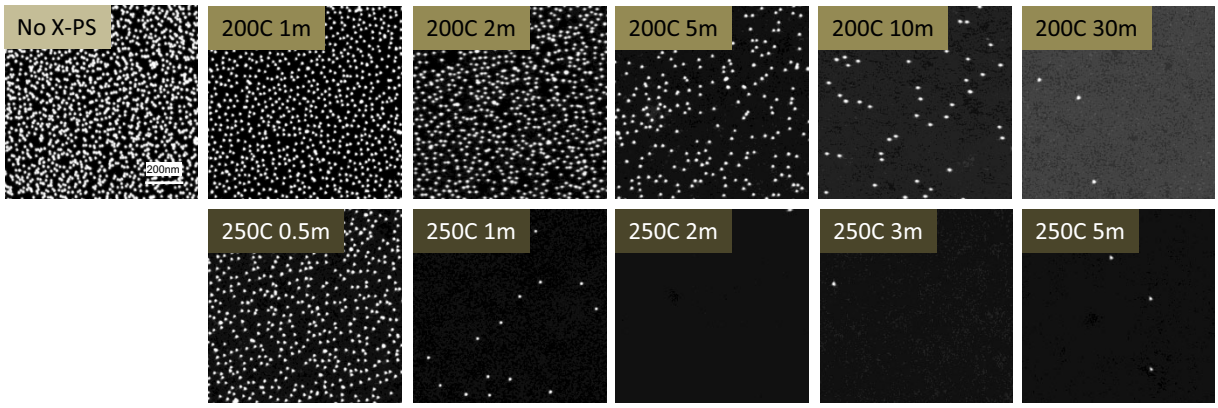

Fig. 1: Adsorption of Au nano-particles on P2VP-OH grafted X-PS surfaces serves as an indicator for the degree of completion of the cross-linking reaction.

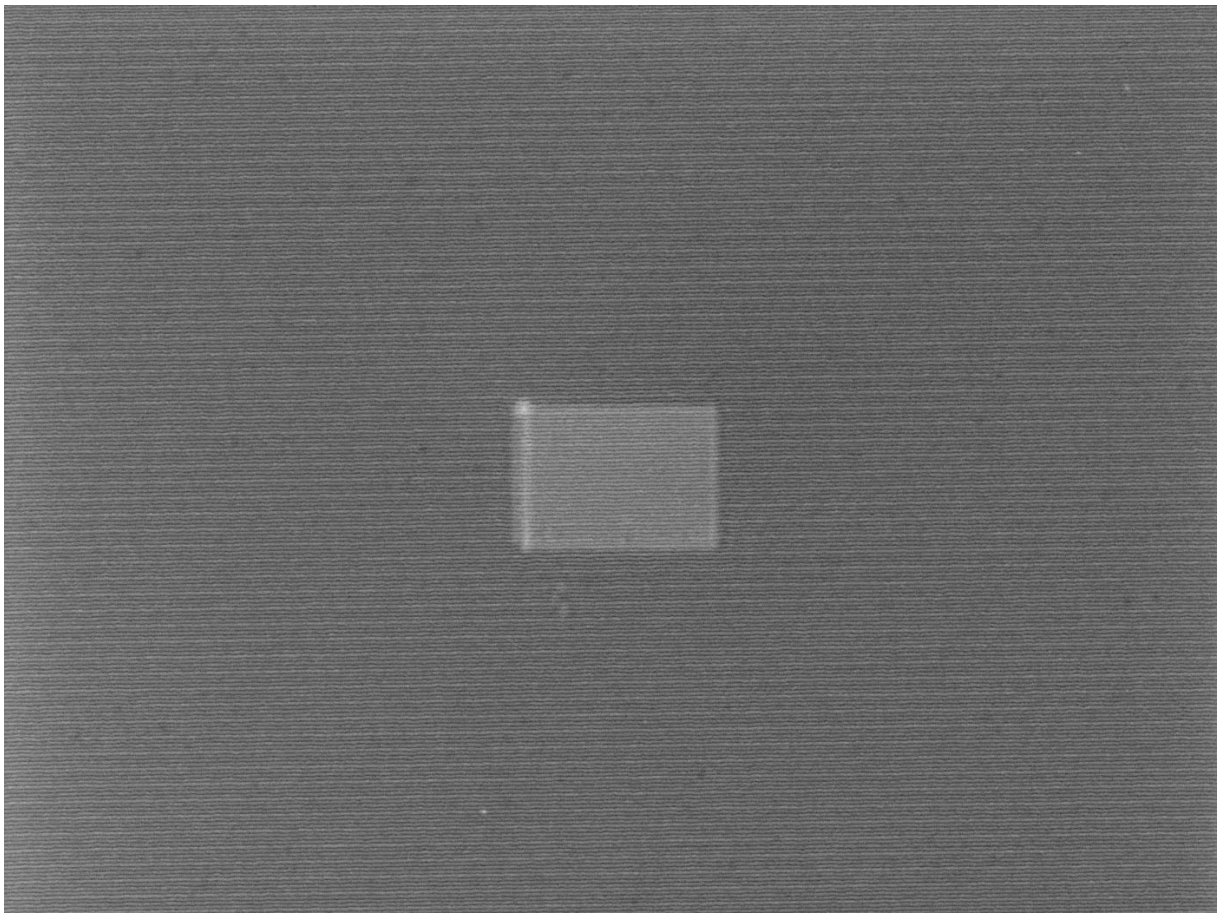

Fig. 2: Large area of perfection was achieved using the process proposed in this work.

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