Block-copolymer thin film templates for nanoscale fabrication processes: Reactive Ion Etching, E-Beam deposition and Ion Beam Synthesis

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Block copolymer (BC) lithography is an emerging nano-lithographic process using self-assembled nanoscale morphologies of BCs to fabricate uniform and dense nanometer-scale features over wafer-scale areas[1,2]. Self-organizing BCs is fully compatible with standard semiconductor technology and represents a low-cost and efficient instrument for the creation of nanostructures with critical dimensions below the current photolithographic resolution limits.

In this talk we will show how this simple method can be used to fabricate spatially organized nano-objects such as silicon nanocrystals (NCs) into a thin SiO_2 film by three different elaboration methods, reactive ions etching, E-Beam deposition and Ultra Low Energy Ion Beam Synthesis (ULE-IBS). The BC nanostructure formed on a SiO_2 film is composed of a PS matrix including a hexagonally close-packed PMMA cylinder pattern, perpendicularly oriented with respect to the film. The diameter of the pores is about 17 nm and the pitch around 33 nm. The SiO_2 film is 15 nm thick, thermally grown on a (100) silicon wafer. The first method, selective reactive ion etching process, is performed with different duration from 15 second up to 1 minute. This method allows the transfer of the hexagonal BC pattern into the SiO_2 film with a control of the depth down to the silicon/SiO_2 interface. Using e-beam evaporation, Si or SiO is deposited in the BC openings. After lift-off and thermal annealing at high temperatures we obtain an array of organized silicon NCs rich nanopilars on a SiO_2 matrix. In the third method, ULE-IBS, a local implantation of Si^+ is realized at 1 keV and two fluence 0.5 and 1 x 10^{16} ions/cm^2. Then the remaining BC is removed by degradation in a piranha solution and the samples are annealed at 1050°C during 30 minutes to precipitate *an average of six Si NCs per nanopocket*. The different structures mainly characterized by TOF-SIMS, AFM, Photoluminescence and Energy Filtered Transmission Electron Microscopy (EFTEM) will be presented. The limits of these processes will be discussed.

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[1] W. Li, S. Yang J. Vac. Sci. Technol. B **25**, 1982 (2007).
[2] W.Chang, T.L. Lee, C.H. Wann, C.Y. Chang, H.-S.P. Wong IEEE's 2009 International Electron Devices Meeting in Baltimore.