Growth of Hexagonal Iron Nanodot Arrays on Self-Assembled Diblock-Copolymer Templates

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To overcome the limitations of conventional top-down methods for nanopatterning, novel approaches based on self-assembly are being explored. We employ the microphase separation in PS-b-PMMA films to produce island-like nanodomains, which are very uniform in size and shape.
By annealing M-plane sapphire we prepare a facetted substrate [1] to provide a preferential direction for the self-assembly of the diblock-copolymer (Fig. 1a). Thereby we induce a long-range hexagonal arrangement of island-like PS nanodomains in a PMMA matrix [2] (Fig. 1b). Iron, when sputter deposited onto the self-assembled block-copolymer template, is selectively wetting the PS domains [3]. Thus, island-like iron nanostructures are formed, adopting the size and hexagonal lateral arrangement predefined by the chemical structure of the diblock-copolymer template (Fig. 1c). In this quick, facile, and inexpensive way we can produce hexagonal arrays of magnetic nanostructures with large-scale lateral order using templates of self-assembled block-copolymer films.

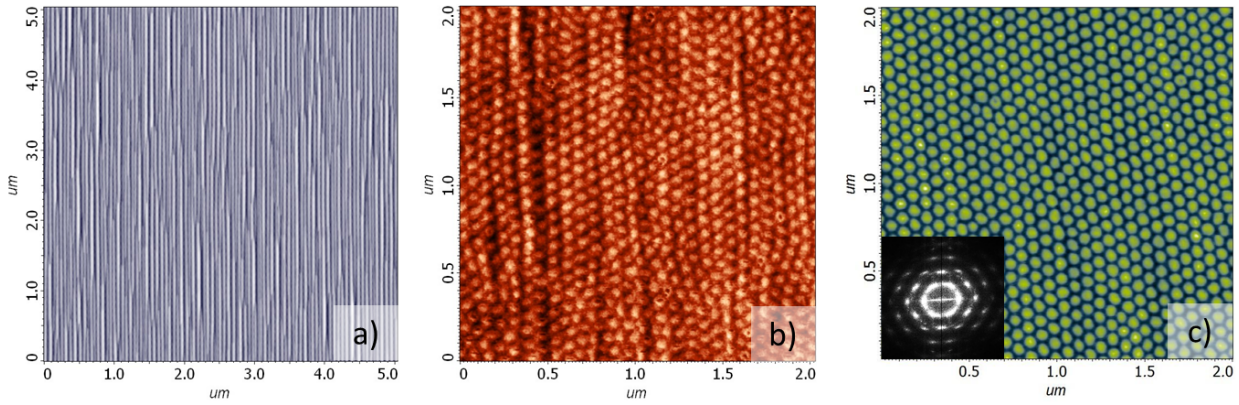

Figure 1: AFM micrographs of a) a facetted sapphire substrate, b) a PS-b-PMMA template, c) iron nanodots fabricated by sputter deposition onto the template (inset: FFT of the height image).

We have recently begun to investigate the evolvement of the structural and magnetic characteristics in such ^{57}Fe nanostructure arrays during growth at different sample temperatures by in-situ nuclear resonant and non-resonant scattering techniques at the beamline P01 at PETRA III. During sequential sputter deposition processes at different temperatures we recorded GISAXS patterns, NFS time spectra, and NRXR curves after deposition steps of nominally 1 ML of ^{57}Fe each. The combination of information from NFS time spectra and GISAXS scattering patterns enables us to relate different states in the magnetization dynamics of the iron nanostructures with the according stages of growth. Preliminary results obtained from simulation of the GISAXS data using IsGISAXS [4] indicate a flat conical shape of the iron nanostructures growing at room temperature (Fig. 2a), with a height of 6.5 nm and a diameter of 65 nm after deposition of nominally 5 ML. At 200°C the selectivity of wetting of iron on the diblock-copolymer template is enhanced and the iron nanostructures assume a more cylindrical shape (Fig. 2b), with a height of 10 nm and a radius of 40 nm after deposition of nominally 5 ML. For both growing conditions we find the size, distance and lateral arrangement of the iron nanostructures to have extremely small distributions. NRXR

data evidence clearly that no intermixing takes place at the interface between the iron nanostructures and the diblock-copolymer template. For detailed information on magnetic characteristics please refer to the contribution "*Structural Growth and Magnetic Birth of a Self-Assembled Array of Superferromagnetic Nanoislands*" by Kai Schlage.

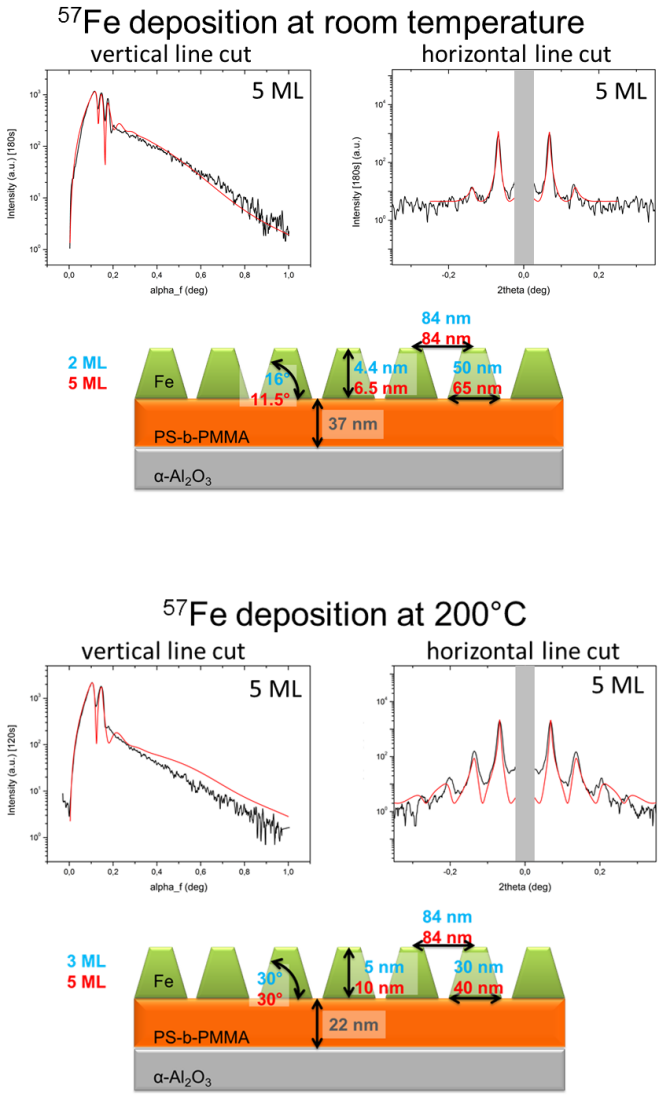

Figure 2: Results of GISAXS measurements and IsGISAXS simulations: Experimental data (line cuts through GISAXS patterns) are shown as black curves, simulated intensity distributions as red curves. Preliminarily derived geometrical parameters are presented in modeled sample cross sections. IsGISAXS does not allow for input of the substrate facets or chemical structure of the diblock-copolymer template.

References

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