GISAXS and magnetic properties of (Co/Pt)$_n$ dot arrays produced by ion etching

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Controlling the structure of matter at the nanometer scale and assemble nanoparticles into arrays and networks in a controlled manner is the key to new technologies. The application of magnetic nanostructure arrays as storage medium is a big issue for years [1]. Magnetic nanostructure arrays are created using diblock copolymer micelles with SiO$_2$ loaded cores. The filled micelles are deposited on a Co/Pt-multilayer film. After removal of the organic shell by oxygen etching, free standing silica particles remain on the multilayer. The structure of the cores is transferred to the film via ion milling under normal incidence. With this method we are able to generate magnetic dot arrays with perpendicular easy magnetization direction [2] on the limit of current patterning methods. The dots were made of (Co/Pt)$_2$-multilayers. The magnetic properties of such dot-arrays depending on their size and distance were investigated by means of MOKE.

Figure 1: GISAXS of different preparation steps of a nanopatterned (Co/Pt)$_n$-multilayer films by ion milling of silica masks

By using different diblock copolymers, we are able to control dot diameters and mean distances [3]. This opens the possibility to study the size and distance dependence of magnetic properties of produced dots. Figure 1 shows GISAXS patterns of different stages of an array while bombardment with Ar$^+$ ions. As one can see, the scattering events get more pronounced, due to material erosion and increasing scattering contrast of the revealed structures. The scattering maximum, induced by the critical angle of the sample (Yoneda peak), moves during this process to lower $q_z$. The scattering maximum along $q_z$ is directly proportional to the electron density of the material. This enables us to determine the optimal sputtering conditions for the production of the free-standing particles on top of the underlying silicon substrate.

After ion bombardment, the remains of the Co/Pt multilayer stay ferromagnetic on sputtering. First investigations show, that coercitivity depends strongly on the size of the produced dots, but is independent on their interparticle distance. Figure 2 shows MOKE investigations and the corresponding lateral GISAXS
curves. Further systematic experiments and calculations are in progress to fully understand the magnetic properties of such dot arrays.

Figure 2: MOKE loops of remaining magnetic dot arrays after Ar$^+$ sputtering. The Kerr rotation $\theta$ as a function of the perpendicular magnetic field was taken for different dot distances (130 – 50 nm) at constant dot diameters (26nm). Corresponding GISAXS curves show the decrease of the interparticle distances.

References