TAILORING MAGNETIC DOMAINS BY PERIODIC ANTIDOTS ON THE NANOSCALE

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Tailoring of magnetic domains is one key for new or strongly improved applications of magnetic thin films ranging from data storage or sensor applications to spin-waveguides in spintronics. The preparation of homogeneously distributed defect structures allows adjustment of the microscopic domain formation in magnetic films due to pinning and nucleation at the defect sites. We prepared periodic antidots, i.e. holes, in Fe, Co, and FeNi films. Self-assembled and isotropically etched polystyrene (PS) nanospheres serve as template for the subsequent deposition of magnetic thin films [1]. After removal of the mask, we obtain films with hexagonally ordered antidots, which can be fine-tuned with respect to their diameters and distances. We investigated the influence of the samples' geometrical parameters on their magnetic properties using both, integral and microscopic techniques. SQUID magnetometry reveals a monotonous increase of the coercive field with the antidot diameter for constant film thickness and antidot periodicity. Magnetic force microscopy reveals that the periodic arrangement of antidots forms characteristic, periodic domain patterns. Depending on the antidot diameter, we identified two types of these patterns. The result for larger antidot diameters stands out, as the observed pattern shows many characteristics of 2D artificial spin-ice systems [2]. This analogy is studied by micromagnetic simulations in more detail [3].

Furthermore, we studied the magnetization reversal mechanisms in antidot arrays by anisotropic magnetorestistance (AMR). We constrict the AMR measurements to a highly ordered area of the antidot array (about $2 \times 15\ \mu m^2$) by applying focused ion beam (FIB) cutting. This constriction allows for a well defined orientation of the external magnetic field with respect to the antidot lattice. The study showed that the hexagonal arrangement of antidots results in a 6-fold anisotropy of the magnetization reversal. Simulated AMR-loops show very good agreement with the experiments. In a scanning transmission x-ray microscopy (STXM) study we found clear indication that the antidots act as domain wall pinning sites. The domain walls created in the course of the reversal process align always with the nearest neighbor direction of the antidot lattice. As a result, the smallest observed domain width directly corresponds to the antidot lattice constant.

References

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