Diameter influence on local and global in-plane magnetization of FePd antidot array

F. Béron[(1)*], K.R. Pirota[(1)], V. Vega[(2, 3)], A. Fernández[(2)], V.M. Prida[(2)], B. Hernando[(2)] and M. Knobel[(1)]

(1) Instituto de Física Gleb Wataghin (IFGW), Universidade Estadual de Campinas (UNICAMP), CP. 6165, Campinas, 13083-970, SP, Brazil, e-mail: fberon@ifi.unicamp.br
(2) Depto. Física, Universidad de Oviedo, Calvo Sotelo s/n, 33007, Oviedo, Asturias, Spain.
(3) SCTs, Universidad de Oviedo, Edificio Severo Ochoa, 33006, Oviedo, Asturias, Spain.
* Corresponding author.

Abstract – We compared the in-plane magnetic behavior of 50 nm thick FePd thin films vacuum thermal evaporated on hexagonal ordered nanoporous anodic aluminum oxide templates (diameter = 35 and 70 nm, interhole distance = 105 nm). The global magnetostatic properties (coercivity, remanence, and susceptibility) vary upon the applied field direction, differently depending upon the geometry. However, both do not exhibit a six-fold symmetry, despite the hexagonal holes ordering. On the other side, the local behavior, which was probed by the first-order reversal curve method, remains more or less constant in the plane for smaller diameter while following the global behavior for larger diameter.

Ferromagnetic antidot arrays (thin films patterned with holes) have been suggested for high-density information storage due to the specific magnetization domain structure that they exhibit [1]. Based on this idea, nanoporous anodic aluminum oxide (AAO) templates represent an efficient way for producing large area of antidot array in the nanometer scale. However, the cost for getting rid of lithography is the lack of long range order (ordered domains of typically few microns square) and the influence of a non-uniform surface for the thin film deposit.

In this work, we investigated the consequences of these two effects on the in-plane magnetic behavior, both locally and globally. We thermally evaporated in a vacuum chamber 50 nm thick FePd thin films on the top surface of nanoporous AAO templates [2], which were previously made by the two steps anodization process, with further varying the hole diameter (35 and 70 nm). Microscopy image confirms that the small diameters used seem to favor the growth of nanopillars that connect together as the deposition continues. Major hysteresis curves and first-order reversal curves (FORC) were measured along different directions in the plane, in order to probe the global and local behaviors.

The AAO hole diameter considerably modifies the in-plane magnetization behavior (see figure). In both cases, the global magnetostatic properties (coercivity, remanence, and susceptibility) show an angular dependence, which is mainly an uniaxial anisotropy. Effectively, the lack of long range order in the antidot arrays is though to prevent to obtain a six-fold symmetry, as the hexagonal order should create. The overall complex behaviors were successfully fitted with periodical expressions of 2, 4, 6 and 8θ periods. For 35 nm diameter, the FORC results show that the local coercivity remains constant regardless of the applied field direction, except along 90°, because there is always a region aligned in the easy axis direction. FORC results suggest that there are two reversal processes in competition. One becomes preponderant around 90°, thus modifying the magnetostatic behavior in this region. When increasing the hole diameter, the local coercivity now follows the global coercivity. We think that the magnetization reversal might begins on the domains border and/or inside a well ordered domain, and that the competition between these two processes is greatly altered by the geometry. This hypothesis will be investigated with micromagnetic simulations performed on a several microns square area of the antidot geometry, obtained by microscopy.

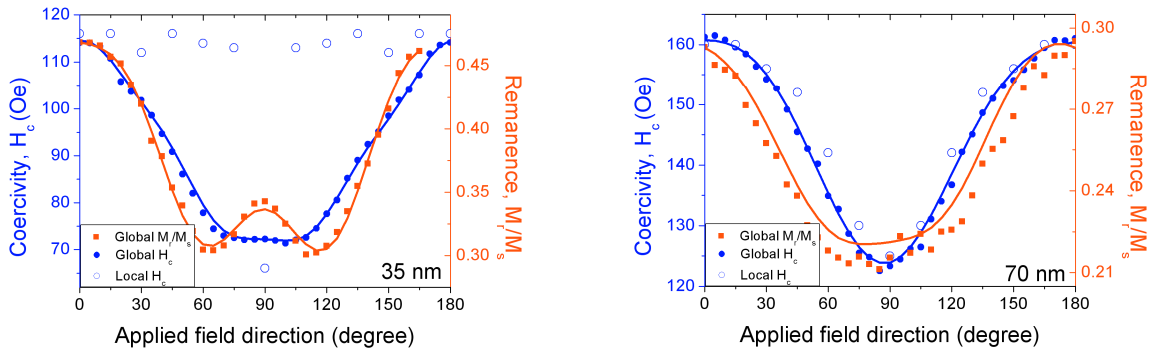

Figure: In-plane angular coercivity and remanence dependence for different hole diameters (dots = experimental, solid lines = fit).

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