Py ANTIDOT THIN FILMS: A TRANSPORT AND MAGNETIC CHARACTERIZATION AS A FUNCTION OF TEMPERATURE

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Nanopatterned media, and in particular arrays of magnetic dots and antidots, have gained increased attention in the last years. Antidots are particularly interesting because, since there is no isolated magnetic volume, the superparamagnetic limit below which thermal fluctuations erase the average magnetization [1], does not occur. In this way, they are strong candidates to be used as ultra-high density recording media. However, to achieve the desired submicron features, expensive, time consuming lithographic techniques, like e-beam or focused ion beam lithographies are usually required. An alternative route to obtain antidots is the use of easily fabricated nanoporous alumina as templates for the subsequent growth of a thin magnetic layer on top [1]. These templates present enormous advantages such as the possibility to build a net of aligned and ordered nanostructures and the ability to control their dimensions as desired.

Nanoporous alumina films were obtained by electrochemical oxidation of high-purity (>99.997%) aluminum foils. Prior to anodization, samples were cleaned in acetone and degreased in etanol. For surface improvement, samples were also electropolished at 20V for 3min in an Etanol (75%) : Perchloric Acid (25%) solution. With this procedure a mirror surface was obtained, setting the necessary conditions for a well organized porous structure to be obtained. In this work, the first anodizations were performed at a constant voltage of 40 V for 2 hours, with a 0.3 M oxalic acid solution (used as electrolyte) at a temperature between 2-6ºC. Afterwards, the resulting porous-oxide layer was then etched in 0.5 M Phosphoric Acid : 0.2 M Chromic Acid mixture at 60ºC for 2 hours. A standard two-step anodization procedure, first introduced by Masuda [2], is used in order to achieve some organization of the pore structure. So, a second anodization of the aluminum, using the engraved hole structure as *pre-pattern*, was then carried out using the same conditions as the first one. These anodization conditions resulted in nanoporous alumina substrates with average pore diameter of approximately 35 nm and separation of about 100 nm.

Permalloy thin films were then deposited on top of nanoporous alumina substrates with an Ion Beam Deposition (IBD) system. This system presents a base pressure less than 10^{-7} Torr. The Py films were deposited using a flow of Ar atoms in the deposition gun of 5.5 sccm, giving a work pressure in the chamber of about 2×10^{-4} Torr during the deposition process.A beam voltage of 1000V was applied giving a beam current of about 10.0 mA. With these condition a deposition rate of 0.35 A/s for Py target was obtained. A magnetic field of 250 Oe was applied to the substrate, during the deposition, in order to induce an uniaxial anisotropy. The morphology of the nanoporous alumina films and Permalloy thin films on the alumina -templates was characterized using FEI Quanta 400FEG SEM.

Thus the size of the magnetic antidots is related to the stability of the written bits, we have fabricated antidots of various sizes, but keeping the same density controlling the thicknesses of the deposited Permalloy films (3 nm to 100 nm). We were able to established a quasi-linear dependence of the pore diameter on the film thickness: for low thicknesses, the magnetic film starts by retaining the shape and size of the underneath nanopores, but, with increasing thickness, the size of the holes is reduced, until they close and a continuous film is formed.

As expected, antidot matrices exhibit properties very different from those of continuous films. The holes introduce shape anisotropies and act as major nucleation sites for magnetic domains. Other important consequence of the presence of these holes are the changes in the macroscopic magnetic properties such as magnetic anisotropy, coercive field and magnetoresistance. We will also present a detailed study of temperature dependence of electrical resistivity and magnetoresistance as a function of pore diameter.

References:

[1] Z. L. Xiao et al., *Appl. Phys. Lett.*, **81,** (2002) pp. 2869-2871.
[2] H. Masuda et al. , *Science*, **268**, (1995) pp. 1466-1468.

Figures:

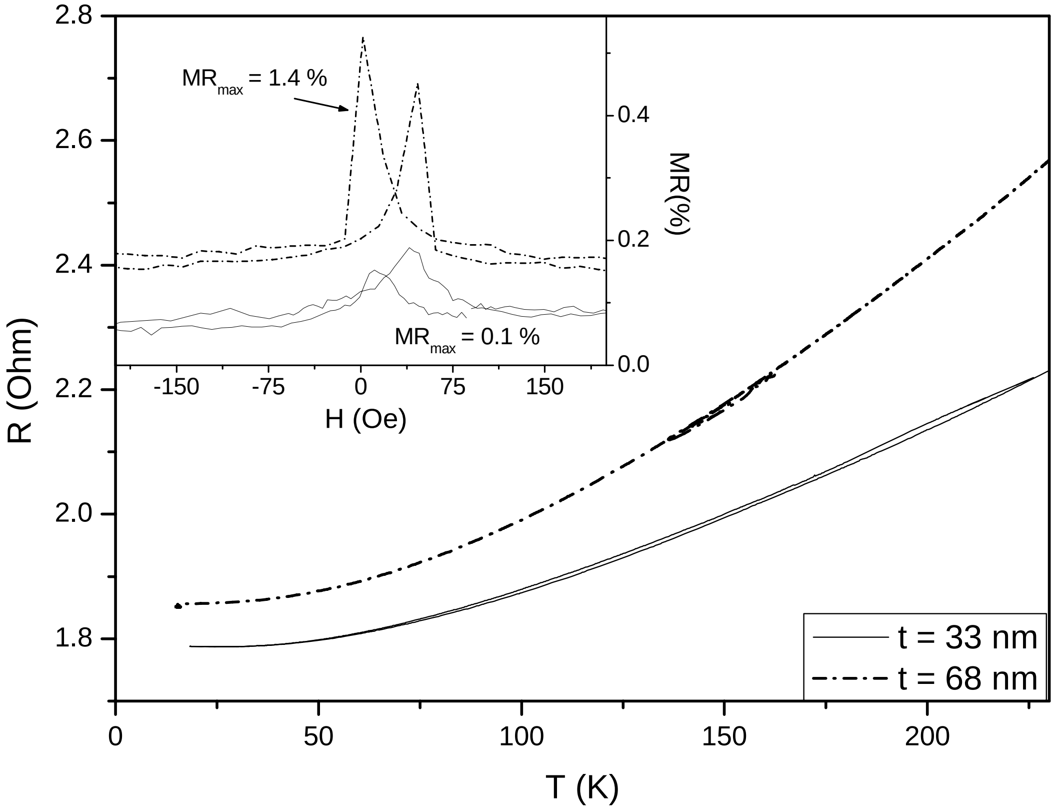

Fig. 1: R(T) for Py (33nm) and Py (68nm) over nanoporous alumina. Inset: MR(T=100K) for the same samples.