Synthesis and magnetic properties of FePd hexagonally ordered nanohole arrays

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Highly ordered nanoporous magnetic films, which have been obtained as replicas of ceramic nanoporous alumina templates, have recently attracted great scientific attention, both from basic and applied research points of view, due to their potential applications in sensors, ultra-high-density data storage media, magneto-electronic devices and micromagnetic systems[1].

These periodic spacing antidot arrays can be obtained by different techniques. Among them, the fabrication process based on the use of templates is the most inexpensive and highly efficient method [2]. Nanoporous anodic alumina membranes (NAAMs) can be successfully used as functional templates for the fabrication of ordered nanomaterials with hexagonal symmetry [3]. On top of this, iron-palladium alloys are also very interesting materials because they can exhibit outstanding properties, such as magnetic shape memory behaviour [4]. Specifically, these alloys with tuneable nanostructure are suitable for their use in rapid actuation microsensors used for actuators due to the improvement in their response speed.

In this work we report on the fabrication process, morphological and magnetic properties of novel antidot films made of $Fe_{1-x}Pd_x$ alloys (x = 0, 24) as a function of the film thickness. Nanoporous alumina templates were produced by following a two step anodization procedure in oxalic acid, as reported elsewhere [5]. Highly ordered arrays of Fe and FePd antidot films were prepared by the vacuum thermal evaporation method employing NAAMs as templates. Morphological characteristics were studied by a Scanning Electron Microscope (SEM) equipped with an Energy Dispersive X-ray (EDX) spectrometer and their topography was also locally confirmed by Atomic Force Microscopy (AFM) measurements. The antidots are grown spatially arranged on the magnetic film surface by following an hexagonally centred spatial distribution, having as main geometrical features an antidot diameter of about 40±5 nm, a periodic interspacing distance of 105±5 nm and a magnetic film thickness varying from 20 up to 50 nm. SEM and AFM images show that the as-deposited Fe-rich films replicate, rather well, the well-ordered patterned nanostructure of the nanoporous anodic alumina templates. The magnetic properties of the different FePd antidot films have been studied by means of Magnetic Force Microscopy (MFM) and Superconducting Quantum Interference Device (SQUID) magnetometry and they were compared with the magnetic properties of an FePd continuous film. Examination of the hysteresis loops in Fig. 1 shows that the easy axis of magnetization lies on the film plane for all the samples whenever the applied magnetic field is confined to such a plane, whereas the perpendicular direction to the film plane is a hard magnetization axis. Also, it can be observed in Fig. 2 that, from comparison with continuous magnetic film, the presence of holes modifies the shape and the magnetic properties of the hysteresis loops, which results have been summarized in table 1.

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Figures:

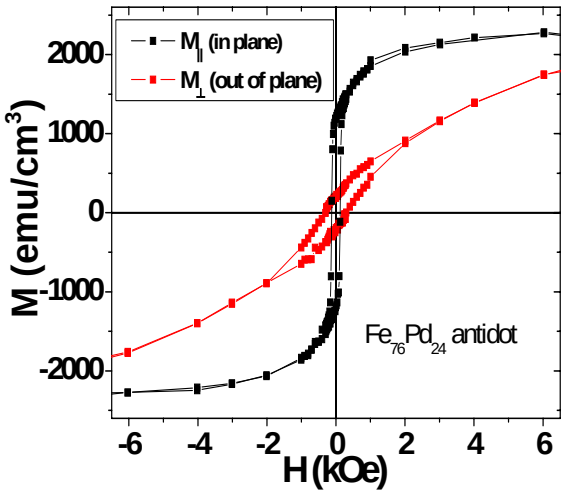

Figure 1. In-plane (parallel) and out-of-plane (perpendicular) room temperature hysteresis loops of 49 nm thickness $Fe_{76}Pd_{24}$ antidots film .

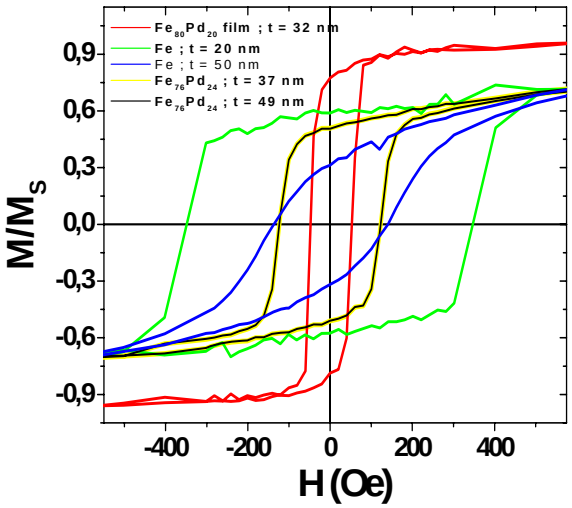

Figure 2. In plane room temperature hysteresis loops of all the studied samples.

Composition	Thickness (nm)	$H_{c\,\parallel}$(Oe)	$m_{r\,\parallel} = M_r/M_s$
$Fe_{80}Pd_{20}$ film	32	50	0.77
Fe	20	350	0.59
Fe	50	140	0.31
$Fe_{76}Pd_{24}$	37	125	0.51
$Fe_{76}Pd_{24}$	49	125	0.51

Table 1. $H_{c\,\parallel}$, and reduced remanence (M_r/M_s) values as obtained from in plane hysteresis loops, for the different Fe-rich antidot arrays with varying the film thickness.

TOPICS: Nanomagnetism