Characterization of Ni membranes with controlled highly ordered nanohole arrays by Magnetic Force Microscopy.

A. Asenjo[1], M. Jaafar[1],D. Navas[1], M. Hernández-Vélez[2], J.B. González[3], A. García-Martín[3], J.M. García-Martín[3], G. Armelles[3] and M. Vázquez[1]
[1]Instituto de Ciencia de Materiales, CSIC. 28049 Madrid, Spain
[2]Departamento de Física Aplicada, Universidad Autónoma de Madrid, 28049, Spain
[3]Instituto de Microelectrónica de Madrid, IMM-CSIC, 28760 Tres Cantos, Spain
aasenjo@icmm.csic.es

During the last years a large variety of different nanostructures have been prepared using anodic nanoporous alumina membranes (NAM). Such highly-ordered arrays of nanostructures with hexagonal symmetry can be then obtained by self-organization during the anodization process [1,2]. These NAMs have been widely employed as templates for the fabrication of nanowires or nanotubes arrays and membranes with semiconductor, metallic or polymeric character. Our present work has been focused on the fabrication and characterization of magnetic metallic membranes with well ordered nanoholes. This nanostructures has been achieved by controlled replica/antireplica processes starting from highly ordered nanoporous alumina membranes [1,3,4].

In particular, the objective of this work has been to study the magnetization process of Ni nanohole membranes where we can control the pore diameter and the hexagonal symmetry lattice constant. Samples with an interpore distance of 105 nm and pore diameters between 35 and 70 nm have been prepared (see figure 1).

Hysteresis loops (see figure 2a) have been measured in a vibrating sample magnetometer, VSM, at room temperature, for different orientations of the applied field with regards to the plane of the membrane. From them, the easy magnetization direction can be derived to be inside the plane of the membrane. Moreover, anisotropy and coercive fields are experimentally obtained as a function of the pore diameters, keeping the geometrical hexagonal symmetry constant, and both are compared with the values corresponding to continuous Ni film.

Topography and magnetic characterizations at the surface of the samples have been additionally performed by a combination of AFM and MFM images. The existence of three magnetic privileged directions that coincide with those which join the first neighbours (typical from the centre hexagonally structure) are confirmed. The shape of the magnetic pseudodomain is triangular where each vertex corresponds to a pore (see fig.2b). The domain wall pinning in the pores could be the origin of the magnetic moment distribution measured by MFM. These experimental results are analysed with the help of micromagnetic simulations.

The magnetization process is analysed by macroscopic VSM loops, Kerr magnetometry (hysteresis loops) and Kerr spectroscopy (magneto-optic properties). The magneto-optic measurements have been compared with the results obtained by the simulations.

In summary, this work relates with the design and preparation of Ni membranes with controlled nanohole arrays and with further study of the magnetization process by different combined techniques.

References:

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Figures:

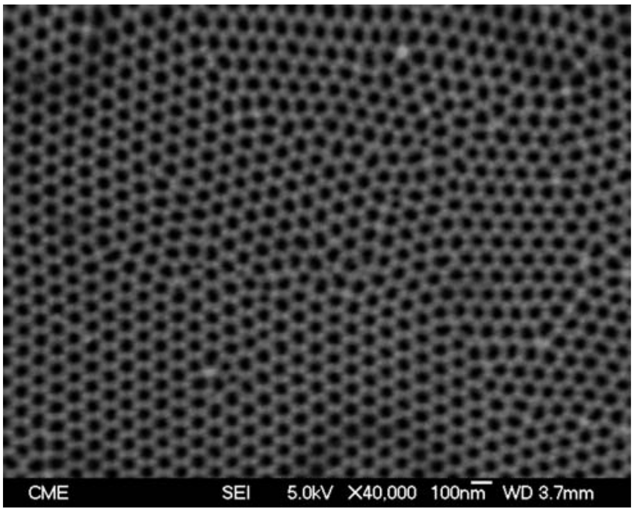

Figure 1.- HRSEM image of a Ni nanohole array with an interpore distance of 105 nm and 60 nm for pore diameter.

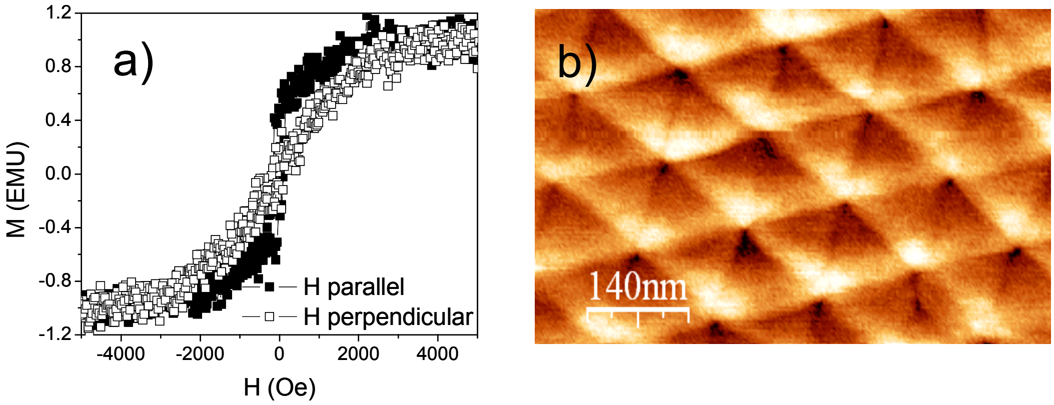

Figure 2.- (a) Hysteresis loops with the magnetic field applied parallel (■) and perpendicular (□) to the membrane plane of a Ni nanohole array with an interpore distance of 105 nm and 60 nm pore diameter and MFM image (b) in remanence state.