EVOLUTION OF THE MAGNETIC MOMENT DISTRIBUTION OF ARRAYS OF NANOWIRES STUDIED BY MFM

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The development of high-density magnetic storage media based on magnetic nanostructures is currently attracting a great interest. The self-organization techniques reveal as one of the most efficient methods to obtain nanostructures in a large scale. Among these techniques (growth of islands, ion irradiation, particles assembly, etc) we have used the selective electrodeposition of metals to fabricate highly ordered arrays of magnetic nanowires embedded in porous alumina [1,2].

The results presented in this work correspond to arrays of 30-nm-diameter Ni nanowires. The hexagonal symmetry lattice parameter of the array is 150 nm and the length of the wires is about 1 micron. From the hysteresis loops performed by VSM we can conclude that the array presents axial easy axis mainly due the shape anisotropy [3], and it is also noticeable that the coercitive field (about 1000 Oe) is larger than in the Ni thin films. As a first approximation, individual nanowires can be taken as nearly single-domain with given magnetic poles distributions at their ends, however, the whole array behavior differs from a bistable system as a consequence of the magnetostatic interactions between individual nanowires [4].

The study of the magnetic moment distribution allows us to extract important information about the anisotropy and magnetization mechanisms of the samples. In this sense, the MFM (Magnetic Force Microscopy) is a useful technique that gives us the magnetic domain structure with a resolution better than 20nm. It is well known that the thin films with high uniaxial perpendicular anisotropy present stripe domains [5]. The size and shape of the domains depend on the anisotropy of the material, the thickness and the magnetic history [6,7].

MFM studies in arrays of nanowires allows one to determine the local magnetic state of individual nanowires which offers a complementary information to that of the whole array obtained by VSM. Even if the array of nanowires does not correspond to a continuous film, we have observed similar effects. The distribution of nanowires with magnetic moment in up or down directions depends on the previous magnetic history as shown in figure 1 and figure 2. MFM technique finally enables us to obtain detailed information of the fine domain structure at the very ends of the nanowires and determine the strength of magnetostatic interactions among them.

References:

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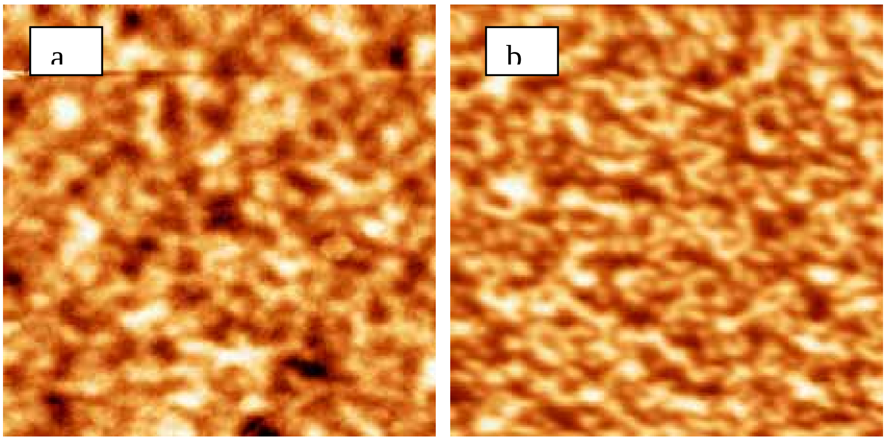
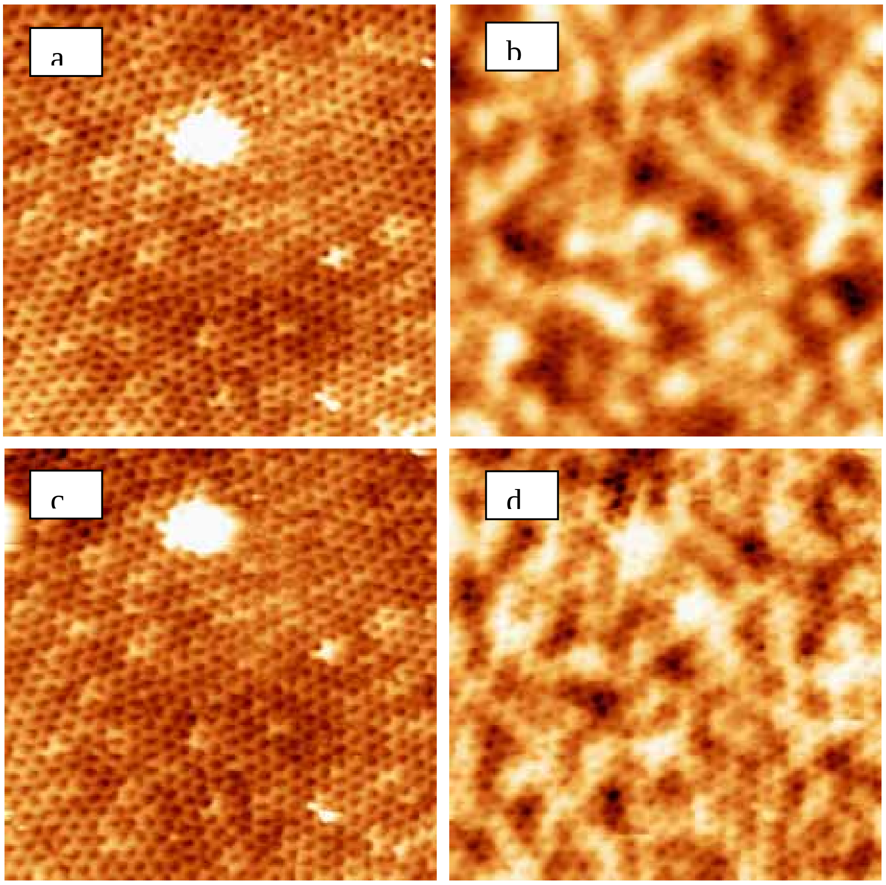
Figure 1:



MFM images of a nanowires array after (a) demagnetization loops (b) saturation in the direction perpendicular to the nanowires.
Images size: 6µm×6µm

Figure 2



(a) and (c) topographic images of a nanowires array, MFM images after (b) demagnetization loops (b) applying 200 Oe parallel to the nanowires.
Images size: 3µm×3µm