Magnetization process and magnetoresistance in tailored arrays of CoNi nanowires

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Dense arrays of magnetic nanowires prepared using suitable templates (i.e., electrochemical route) are receiving lately remarkable attention due to their unique physical and chemical properties which lead to a wide range of technological applications including various families of sensors, biomedical applications after suitable functionalization and high-density magnetic storage media[1]. Usually, due to the dominant shape anisotropy, magnetic nanowires are mainly magnetized along their axis. However, in particular cases, as for Co nanowires, magnetization can lie in a transverse orientation induced by their large magnetocrystalline anisotropy[2].

Electrochemical conditions of preparation of arrays of nanowires inside anodic alumina templates play a decisive role to determine the magnetization easy axis. In this work, besides of the usual procedure of changing the nanowire physical dimensions, we chose to modify the CoNi-alloy composition introducing small amounts of Ni. In this way, we can control effectively the easy axis magnetization orientation and thus its magnetic properties.

Cylindrical pores in the anodic alumina template exhibit a self-organized hexagonal arrangement, which geometrical features are in the present case: 35 nm in diameter, 105 nm of interpore distance, and typically 1 μm deep. CoNi nanowire arrays were electrodeposited into the anodic alumina templates, using suitable electrolytic baths[3]. Ni and Co nanowires were also deposited as reference samples. A thorough characterization of samples morphology and composition was performed using SEM (inset bottom) and XRD (inset up-right) techniques.

Hysteresis loops (M vs. H) measurements have been performed in a VSM magnetometer, and a detailed study of the M(H) curves dependence on the direction of the applied magnetic field (relative to the nanowires axis) is presented. In addition, magnetoresistance measurements (MR vs. H) were also performed as a function of the orientation of the applied field to determine its anisotropic behaviour (inset up-left). In this case, as top and bottom electrodes we used Au, thus enabling improved quality electrical contacts.

The results are discussed in terms of two distinct magnetization reversal mechanisms: coherent rotation and curling[4], as can be derived from the angular dependence of the switching field. As the Ni content in CoNi alloy increases, from the angular dependence of the switching field we deduce a change in the reversal mechanism from curling to coherent rotation. This is further confirmed by the magnetoresistance (MR) measurements, where the bell-shape MR curve is ascribed to rotation mechanisms.

References:

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Figure:

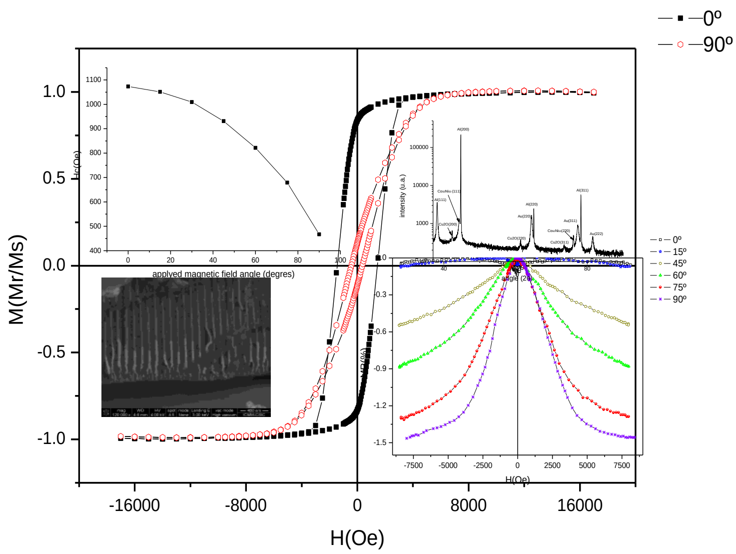

Fig 1: In-plane (0º) and out-of-plane (90º) hysteresis loops of CoNi nanowire arrays. Insets show coercivity variation with applied magnetic fiel angle (up-left), XRD pattern (up-right), SEM image (bottom –left) and MR curves (bottom-right).