Analysis of the magnetic interactions in arrays of FeNi nanowires by means of angular hysteresis loops and FORC measurements

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Compositional variation in magnetic nanowires (NWs) through controlled growth conditions allows to tailor their magnetic properties [1], which are affected by different factors such as geometry, composition or magnetic interactions between NWs. Herein, arrays of FeNi NWs have been electrodeposited into anodized aluminium oxide (AAO) membranes (Fig. 1a). Chemical composition analysis of the NWs showed anmolaous co-deposition, where Fe deposits in ratios higher than its electrolyte molar fractions under different trends. These effects were explained within a modified Bocris-Drazic-Despic (BDD) model [2].
Coercivities (H_c) ranging from 0.2 kOe to 1.0 kOe were obtained (Fig. 1b), observing an increase in H_c for a diminished Fe concentration. The angular hysteresis loops measurements allowed to determine that the magnetization reversal mechanisms is dominated by transverse domain wall reversal, and indicated the decrease in the magnetostatic interactions between NWs as the source of the rise in H_c. First-order reversal curve (FORC) analysis highlighted the limited role of the magnetic interactions in the arrays (Fig. 1c), except for $Fe_{0.80}Ni_{0.20}$ NWs which showed the typical FORC diagram for magnetically interacting NWs. FORC diagrams showed higher intensity at around H_c = 1 kOe, with weakening intensity for an increased Fe content due to the enhanced interactions.
This work shows the possibility of tailoring the magnetic properties of FeNi NWs by tuning the electrochemical parameters and, thus, their composition and crystallographic structure. This approach is of interest in applications such as magnetic recording and sensing devices, and opens the path to exploring the formation of ordered phases with outstanding permanent magnet properties (e.g. $L1_0$-FeNi phase [3]).

References

[1] Palmero, E. M. *et al.*, J. Appl. Phys. **116** (2014) 033908.
[2] Dragos, O. *et al.*, J. Electrochem. Soc. **163** (2015) 83-94.
[3] Lewis, L. H. *et al.*, J. Phys.: Condens. Matter Matter **26** (2014) 064213.

Figures

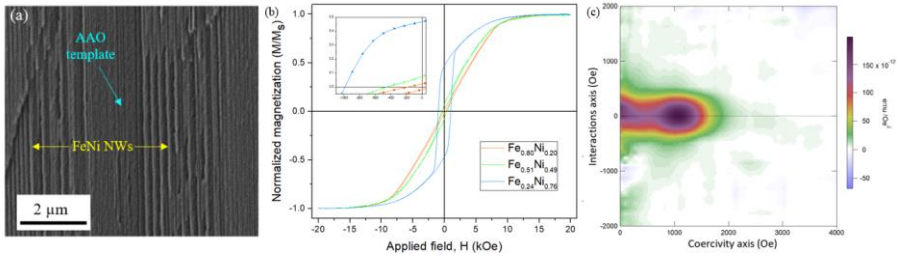

Figure 1: (a) FeNi NWs in an AAO template; (b) room temperature hysteresis loops measured for arrays of FeNi NWs with different compositions; and (c) FORC diagram obtained for an array of $Fe_{0.51}Ni_{0.49}$ NWs.

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