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Transport Properties of Magnetic Ni and Ni-alloy Nanowire Arrays

Diana C. Leitao[1], Laura G. Vivas[3],Celia T. Sousa[2],Andre M. Pereira[2],Manuel Vazquez[3], Joao Ventura[2]; Joao P.Araujo[2]

[1.] INESC-MN and IN, Lisboa, Portugal.; [2]. IFIMUP and IN, Porto, Portugal.; [3]. ICMM - CSIC, Madrid, Spain.

The knowledge of the electrical and magneto-transport properties of magnetic nanostructures is technologically crucial for advanced applications such as spintronic devices. In particular, the importance of characterizing magnetic nanowires (NWs) was recently boosted by increased research on domain-wall dynamics. To this end, most studies relied on e-beam fabricated NW-stripes and lithography-defined electrical contacts. In this work we study the transport properties [R(T)] of Ni, NiFe and NiCo NWs embedded in anodic aluminum oxide (AAO). The AAO provides a template to electrodeposit NWs, while the underneath Al foil works as the bottom electrode. The dendrites present at the bottom of the pores were filled with Cu to prevent their influence on the NWs magnetic properties.[1]An overall metallic-like behavior was observed for all NWs, with Ni displaying an almost linear trend above 50K, previously attributed to a suppression of electron-magnon scattering due to confinementeffects.[2] Fittings using a Bloch-Gruneisen dependence describing phonon-scattering give θ_D(Ni)~390 K[$\theta_D \sim 0.87\theta_D^{bulk}$]. This result is in close accordance with the calculated surface-to-volume ratio (~11%) and should be related with surface damping of lattice vibrations. Nevertheless, the bulk part of the NWs (~90%) should provide a considerable magnetic contribution to R(T). In fact, a magnetic contribution of 30% to the ideal resistivity was estimated at 300K in 20nm Ni thin films, where a similar R(T) linear character was observed.[3]Curve fittings suggest that the Cu dendrites may be playing an important role in R(T) behavior of our samples. On the other hand, the Ni-alloy NWs show more concave R(T) curves revealing an enhancement of the magnetic contribution. To further evaluate the relevant physical information contained in R(T), we used the temperature coefficient of the resistance (TCR) to eliminate the geometrical characteristics and highlight the dependence on the residual resistivity. Overall, our NWs show a lower TCR compared to similar samples reported in the literature, indicating the presence of a large number of scattering centers originating from surface and grain-boundaries.

References:

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