Influence of the deposition conditions on the properties of Co and Ni nanowires

Elena Matei[1], Victor Kuncser[1], Nicoleta Preda[1], Maria Eugenia Toimil Molares[2], Jean Philippe Ansermet[3], Ionut Enculescu[1]

[1]National Institute of Materials Physics, Atomistilor 103 bis, Magurele, Romania;[2]GSI Darmstadt, Germany; [3]EPFL, Lausanne
elena.matei@infim.ro

Magnetic nanowires are extremely interesting at this moment due to the potential applications in data storage or in other fields of information technology or communications. A large number of methods for preparing such metallic nanostructures were developed during the last decade. These methods are based on a variety of techniques, both physical and chemical.

Electrochemical deposition in nanoporous membranes, the so called template method, represents a convenient method to prepare such nanowires with desired characteristics [1]. One can use membranes with pores with desired shape and dimensions. By this approach one can tune the properties of the deposited material such as composition, structure, optical, magnetic or electric characteristics. Moreover, one can prepare complex structures such as multilayers and multisegment nanowires by pulsed or by sequential deposition [2,3]. The most employed porous membranes used as templates are anodic alumina and ion track polymer membranes. The polymer membranes obtained by swift heavy ion irradiation and subsequent etching contain pore densities ranging from 1 pore sample to 10^9 pores per square centimeter. The characteristics of these templates are quite adequate for studies of magnetic nanowires since one can tune the pore density i.e. the density of nanowires and their dimensions independently.

In the present paper we report our results regarding the influence of the templates and of the deposition conditions on the structural, morphological and magnetic properties of Ni and Co arrays of nanowires prepared by template replication by electrodeposition.

Polycarbonate foils, 30 micrometer thick, were irradiated with swift heavy ions (e.g. Au with 11.4 MeV/nucleon) in GSI's UNILAC accelerator. Further, this defect track is selectively etched by submersing the samples into an aqueous solution of 5M NaOH and 10% vol methanol at 50°C. In these conditions cylindrical pores are obtained, the etching rate being in this case 2 micrometers / hour. The electrochemical deposition was performed from baths containing the metal ions. Thus Ni electrodeposition was performed from a Watts bath containing Ni sulfate and Ni chloride and boric acid. To this "classical" composition we added polyvinylpyrrolidone (PVP) in order to increase the pore wetting and in this way to increase the pore filling efficiency. A similar bath was used for the deposition of Co, namely containing Co sulfate as source of Co ions, boric acid and PVP.

The electrochemical deposition process was performed on samples containing pores with different diameters and with different surface densities. In figure 1 the scanning electron microscopy image of arrays of nickel and cobalt wires deposited in membranes with different pore diameters and at different deposition potentials are presented.

X ray diffraction measurements show that the structural properties of the deposited nanowire arrays depend on the deposition potential. An analysis of the texture coefficient for both Ni and Co show different growth planes for low and high rate deposition of the nanowires.

Magnetic measurements were performed for the nanowire arrays in two geometries namely with the applied field perpendicular and parallel to the nanowire. The measurements evidence the strong shape anisotropy of the magnetic quasi-one-dimensional structures, the interaction of nanowires in an array and the influence of the growth parameters through the structure i.e. crystalline magnetic anisotropy.

References

[1] Enculescu, I.; Matei, E.; Sima, M.; Neumann, R.; Granville, S.; Ansermet, J. – Ph.; IEEE Trans. On Magn. (2008), **44**, 2678-2680
[2] Enculescu I.; Toimil-Molares M.E.; Zet C.; Daub M.; Westerberg L.; Neumann R.; Spohr R. Appl. Phys. A, (2007), **86**, 43 – 47.
[3] Matei E., Ion L., Antohe S., Neumann R., Enculescu I., Nanotechnology, (2010), **21**, 105202

Figures

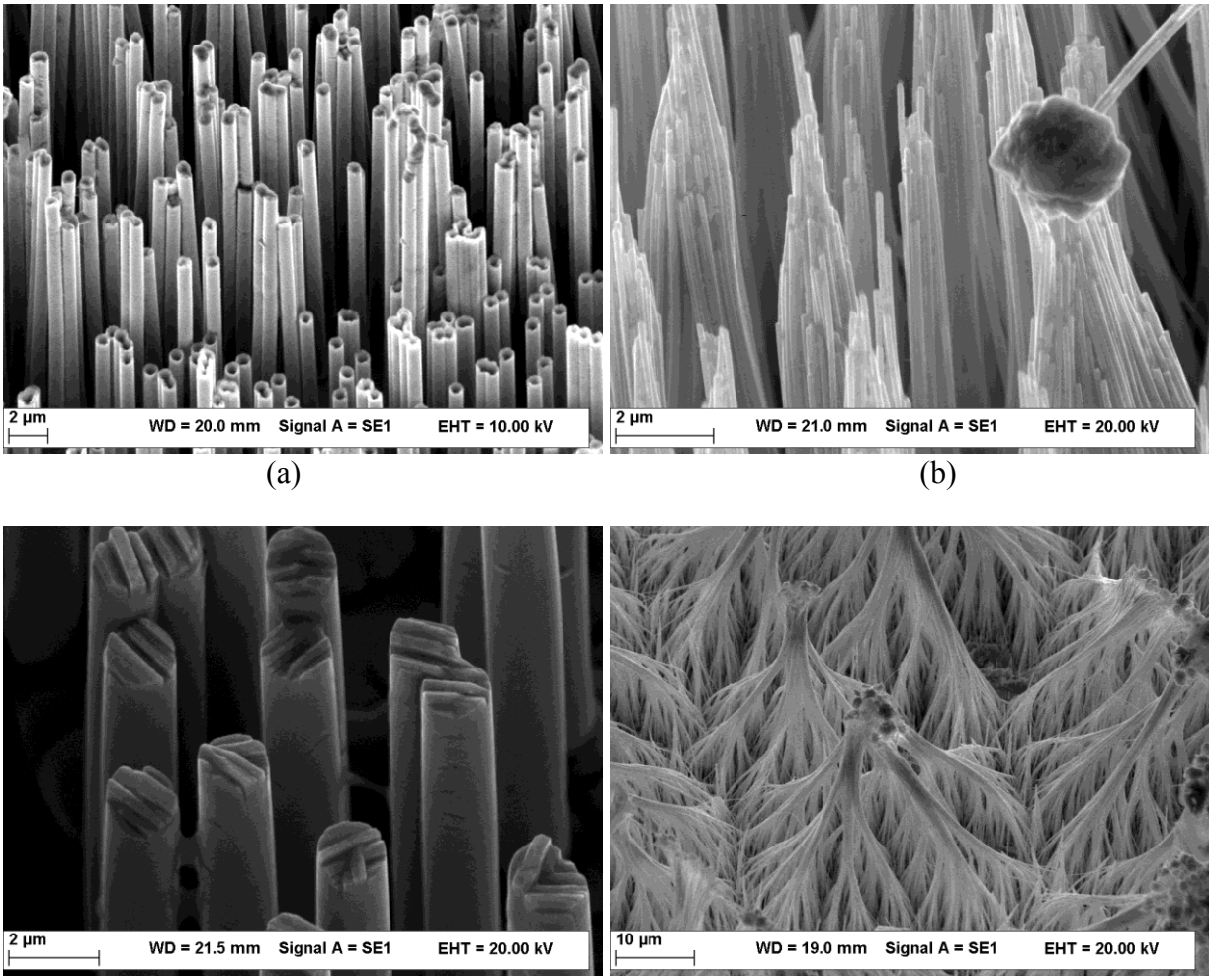

Figure caption: Arrays of metallic nanowires with magnetic properties deposited in membranes with different pore size: (a) Ni wires with 800 nm diameter, (b) Ni wires with 100 nm diameter; (c) cobalt wires 800 nm in diameter; (d) Co nanowires 100 nm diameter.