# ELECTROCHEMICAL DEPOSITION OF FeGa/NiFe AND FeGa/CoFeB MAGNETIC MULTILAYERED FILMS AND NANOWIRE ARRAYS

N. Lupu*, H. Chiriac, P. Pascariu
National Institute of Research and Development for Technical Physics, Iasi, Romania

Recently, hybrid structures consisting of a combination of magnetostrictive alloys and soft magnetic materials have been proposed [1]. The multilayered thin films, prepared by conventional sputtering methods, were designed on the basis of "exchange spring" magnets, which consist of two materials with different magnetic properties, exchange coupled in a multilayer system. This behavior is called "exchange magnetostriction" and depends strongly on the thickness of the different layers forming the multilayered structure [2].
This work focuses on our new results concerning the preparation and characterization of electrochemically deposited $[Fe_{1-x}Ga_x/Fe_{1-y}Ni_y]_n$ (x = 0.1÷0.3 at. %; y = 0.4÷0.8 at. %) and $[Fe_{1-x}Ga_x/Co_{60}Fe_{20}B_{20}]_n$ (x = 0.1÷0.3) multilayered films and nanowires arrays. Multilayered films 3-4 μm thick have been obtained by electrodepositing 50 consecutive sequences of amorphous Co-Fe-B or crystalline permalloy (Ni-Fe) (20 nm, 50 nm or 60 nm) and Fe-Ga (60, 50 nm or 20 nm) successive layers. 200 to 300 sequences multilayered nanowires were electrodeposited into commercially available Anodisc® and Synkera® nanoporous alumina membranes with pore diameters ranging from 35 to 250 nm, and lengths of 50-60 μm. The layers have been deposited successively by changing the electrodeposition potential in the range from 0.75 to 1.9 V. The composition and thickness of the different layers were tailored by optimizing the deposition parameters, such as the buffer additives and applied voltage.
The combination of $Fe_{1-x}Ga_x$ magnetostrictive material and crystalline $Fe_{1-y}Ni_y$ or $Co_{60}Fe_{20}B_{20}$ amorphous soft magnetic material shows good magnetic softness ($H_c$ does not exceed 60 Gs for permalloy and 20 Gs for the amorphous alloy) and gives novel magnetostrictive behavior caused by the formation of twisted spin structures. The best magnetic properties have been obtained for multilayered structures with the nominal compositions $Fe_{80}Ga_{20}/Fe_{20}Ni_{80}$ and respectively $Fe_{80}Ga_{20}/Co_{60}Fe_{20}B_{20}$ as indicated by the XRD patterns and thermomagnetic curves. The coercive field values for the multilayered structures containing layers of Co-Fe-B are smaller than those obtained for permalloy containing multilayers and than the ones reported previously for Fe-Ga single nanowires [3]. The reason for keeping such reduced coercivities might be the softness of amorphous Co-Fe-B layer, which allows the rotation of the magnetic moment much faster than if using other interface layers. All these aspects will be discussed in detail, considering also the magnetic and structural coupling between layers and the surface/interface phenomena.

[1] E. Quandt, A. Ludwig, J. Betz, K. Mackay, D. Givord, J. Appl. Phys. **81**, 5420 (1997).
[2] T. Shima, H. Takahashi, K. Takanashi, H. Fujimori, Sensors and Actuators A **91**, 210 (2001).
[3] P.D. McGary and B.J.H. Stadler, J. Appl. Phys. **97**, 10R503 (2005).

*Corresponding author. E-mail: nicole@phys-iasi.ro. Tel: +40-232-430680. Fax: +40-232-430680.