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Magnetization Reversal in Template-Grown [NiFe/Cu] x n Multilayered Nanowires

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Abstract – [$Ni_{80}Fe_{20}$(20-50nm)/Cu(5-20nm)] x n multilayered nanowires were electrodeposited by switching between the deposition potentials of the two constituents (respectively -1.4 V and -0.3 V for NiFe and Cu deposition). The MR ratio can reach values of 2-2.5%, depending on the thickness of the non-magnetic Cu layer. The presence of non-magnetic Cu layers produces a decrease of the axial magnetic anisotropy in the multilayered nanowires, and consequently the magnetic permeability increases at the surface of the nanowires leading to the enhancement of the d.c. magnetic field effect over the MI response, which can go up to 100%.

Nowadays, there is an increasing demand for new types of materials with different structures and improved physical properties to be used in miniaturized devices. Recently, the nanowire arrays have been studied extensively because of their specific physical properties, with huge potential for multiple applications [1]. A special emphasis is laid on the nanowires prepared by electrochemical deposition in the nanopores of different templates, due to the efficiency of this preparation method. Additionally, the magnetotransport properties (both d.c. and a.c.) are behaving in a very specific manner in the multilayered nanowires structures, recommending them for applications in spintronic.

[$Ni_{80}Fe_{20}$(20-50nm)/Cu(5-20nm)]xn multilayered nanowires were electrodeposited into the nanopores of aluminium anodized (AAO) templates by switching between the deposition potentials of the two constituents (respectively -1.4 V and -0.3 V for $Ni_{80}Fe_{20}$ and Cu deposition). The nanowires have nominal diameters of 35 nm and variable lengths. With a single nanowire contacted by the nanoindentation procedure [2], we performed magnetoresistance and magnetoimpedance measurements. The MR curve is symmetrically anhysteretic, independent of the thickness of the non-magnetic Cu layer. The MR ratio can reach values of 2-2.5%, depending on the thickness of the non-magnetic Cu layer. The MR ratio can by modified by tailoring the thickness of the non-magnetic Cu layer between the exchange interaction length and the spin-diffusion length. A supplementary current passing through the nanowire produces a spin torque which excites the spin waves and for sufficient current strengths reverses the direction of the magnetization. In all measurements there is one step from antiparallel to parallel orientation of the magnetization in the ferromagnetic layers (NiFe) which appears as an abrupt decrement of the resistance, and one from parallel to antiparrallel orientation which appears as an abrupt increment of the resistance. For a step current of 1000 μA there are two distinct steps: one for a positive current of 11 mA and one for a negative current of 13 mA.

The presence of non-magnetic Cu layers produces a decrease of the axial magnetic anisotropy in the multilayered nanowires, and consequently the magnetic permeability increases at the surface of the nanowires leading to the enhancement of the d.c. magnetic field effect over the MI response, which can go up to 100%. The maximum GMI response is achieved at frequencies around 10 GHz and for d.c. applied magnetic fields of 300 Oe. The GMI response is very small for frequencies below 8 GHz and above 12 GHz. The variation of the frequency affects both the magnitude of the GMI response and the value of the d.c. magnetic field at which the maximum impedance response is achieved. The direction of the d.c. magnetic field relative to the layers composing the multilayered structure influences strongly the GMI response, too. A supplementary current passing through the nanowire produces a spin torque which excites the spin waves and for sufficient current strengths reverses the direction of the magnetization. The results reported in the present work open up the possibility of realization of nanosensors arrays with enhanced sensitivity in a narrow range of frequencies.

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