The effect of the magnetoelastic anisotropy on the magnetization processes in rapidly quenched amorphous nanowires

Cristian Rotarescu, Sorin Corodeanu, Costică Hlenschi, Horia Chiriac, Nicoleta Lupu, and Tibor-Adrian Óvári

National Institute of Research and Development for Technical Physics, 47 Mangeron Boulevard, Iași, Romania

The recently prepared rapidly solidified ultrathin cylindrical amorphous wires exhibit a number of advantages [1] in comparison with other types of nanowires prepared by electrodeposition or by various lithography techniques: much longer wire length, more suitable shape for the fast and ultrafast domain wall propagation (vs. planar samples), they are obtained as single nanowires (vs. electrodeposited arrays of nanowires), and the presence of the amorphous state (i.e. the absence of the magnetocrystalline anisotropy). The last advantage allows us to further investigate the role played by the magnetoelastic anisotropy in their magnetic behavior.

We have performed a micromagnetic investigation of the highly magnetostrictive $Fe_{77.5}Si_{7.5}B_{15}$ amorphous nanowires, with the aim to achieve a suitable interpretation of the hysteresis loop measurements of these types of samples prepared in our institute. Experimental hysteresis loops have been obtained by means of an inductive method adapted for such small sample diameters (between 100 and 200 nm).

Here we have focused on the influence of magnetoelastic anisotropy on the magnetization reversal process within magnetostrictive amorphous nanowires having various diameters. Magnetoelastic anisotropy gives rise to important effects in rapidly solidified amorphous nanowires due to the coupling between magnetostriction and internal mechanical stresses inherent to their preparation process.

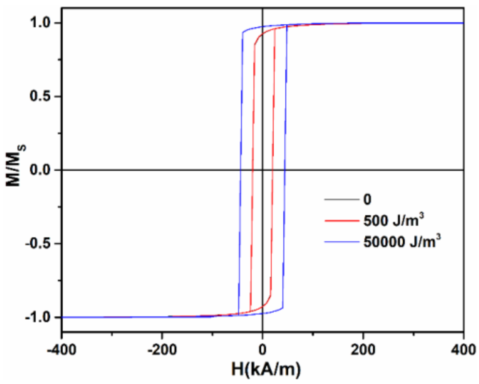

Figure 1: Simulated hysteresis loops for 2 µm long amorphous nanowire with 100 nm nucleus diameter (the effect of different values of magnetoelastic anisotropy).

We have found that values of the magnetoelastic anisotropy constants up to $5 \cdot 10^2$ J/m^3 do not significantly affect the value of the switching field, as shown in Figure 1. However, the increment of its value to $5 \cdot 10^4$ J/m^3 results in a strong increase of the switching field, emphasizing its importance in magnetization reversal process.

The modelling was made using MuMax3 [2] - a GPU-accelerated micromagnetic simulation program having low memory requirements, which open up the possibility to use it for simulations at a very large scale.

The results reveal the importance of factors such as dimensions (geometry) and magnetoelastic contribution in providing key information for the design of cylindrical amorphous nanowires for the future applications.

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References

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