XXXII Panhellenic Conference on Solid State Physics and Materials Science
Conference Center "Carolos Papoulias", 18-21 September 2016, Ioannina, Greece

Modeling domain wall velocity in bi-magnetic nanowires

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We study the magnetic properties of exchange biased cylindrical nanowires (NW) composed of a ferromagnetic core and an antiferromagnetic shell, using atomistic modeling (Fig.1a) and the Metropolis Monte Carlo simulation algorithm. Emphasis is given to the interplay between magnetostatics and exchange biasing. The magnetic structure is described within a classical Heisenberg Hamiltonian on a simple cubic lattice with uniaxial anisotropy (K_{FM}, K_{AF}) and dipolar interactions (g). Our findings demonstrate that core-shell FM-AF nanowires exhibit an increase the coercivity (H_c) with length, reaching a saturation value (H_{c0}) that depends on the dipolar strength. The bias field (H_b) increases with wire length and reaches a saturation value (H_{b0}) whose behaviour depends on the competition between dipolar strength and anisotropy (K_{FM}). In particular, in nanowires with a hard FM core ($K_{FM}/g > 10$) the saturation value of H_{b0} increases with dipolar strength, while the opposite trend is observed when the FM core is soft ($K_{FM}/g \sim 1$). A systematic study of the time evolution of the magnetization profile demonstrated that magnetization reversal of FM-AF NWs proceeds by nucleation of a pair of domain walls (DW) at the opposite ends of the wire, propagation of the DWs towards the centre of the wire with constant and opposite velocities (Fig.1b) and eventually, their merge. The DW velocity is shown to decrease with increasing dipolar strength. Interestingly, the presence of the AF shell modifies the DW dynamics in two aspects: First, the DW nucleation process is delayed and the coherent rotation mechanism is restored for NWs with moderate dipolar strengths (anisotropic FM). Second, at a given reversing field, the DW velocity is higher in the FM-AF nanowire than their FM counterpart. The implications of our results to potential applications of magnetic nanowires are discussed.

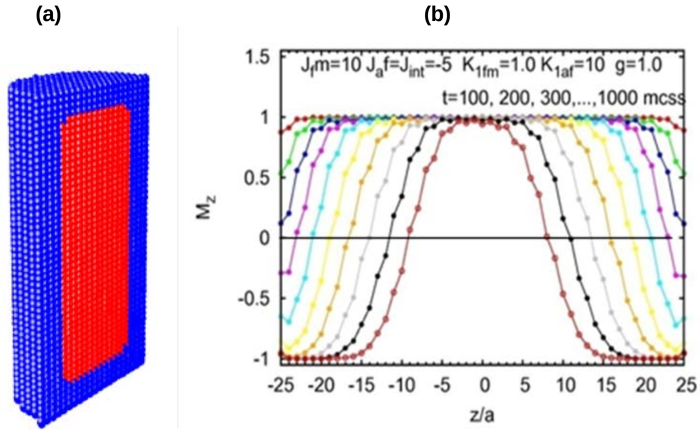

Figure 1 (a) Atomistic description of a cylindrical bi-magnetic nanowire with FM core – AF shell morphology. (b) Typical time evolution of the magnetization profile along the axis a bi-magnetic nanowire (L_{FM}=50a, t_{AF}=3a) shows nucleation and propagation of a pair of domain walls with constant velocity towards the center of the nanowire.

Acknowledgment. One of us (DK) acknowledges financial support by the Special Account for Research of ASPETE through project "Strengthening of research of faculty members of ASPETE"