Perpendicular exchange bias energy and dynamics of the magnetization switching mechanism in $[Pt/Co]_3/Pt/IrMn$ multilayers

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The multilayer stack of [2nm Pt/5nm Co]$_3$/10 nm IrMn exhibits perpendicular unidirectional anisotropy, due to interfacial exchange coupling between Co/Pt stack and antiferromagnetic layer, with a different switching mechanism for the backward and forward branch of the hysteresis loop as result [1]. This difference in switching mechanism was studied by magneto-optical Kerr effect (MOKE) for a series of samples with the ferromagnetic stack and the antiferromagnetic layer separated by an additional Pt spacer with a thickness varying from 0.1 to 1.2 nm. Three main measurements were performed for analysis of the dynamics of thermally activated switching from the metastable state: hysteresis loops taken at different field sweep rates, magnetization relaxation measurements and direct imaging of the magnetic domains. The energy barrier of the metastable state was calculated for both the forward and backward branches of the hysteresis loop. The difference of these energies, which are plotted in Fig.1, is proportional to the exchange bias field. The exchange bias energy reaches a maximum for a 0.1 nm thin Pt spacer and subsequently decreases exponentially for thicker Pt films. Different reversal mechanisms are observed: predominant nucleation for the forward branch and domain wall propagation for the backward branch. Model of spatial distribution of energy barrier dispersion, proposed by Bruno [2], was used to explain difference of switching mechanisms. Figure 2 shows that a high dispersion of the energy barrier correlates with a predominance of the nucleation mechanism, whereas low dispersion of the energy barrier reflects domain wall propagation. Samples with 0.1 nm Pt exhibit maximum exchange bias energy and maximum energy dispersion, both indicating a domain nucleation mechanism (Fig. 2)

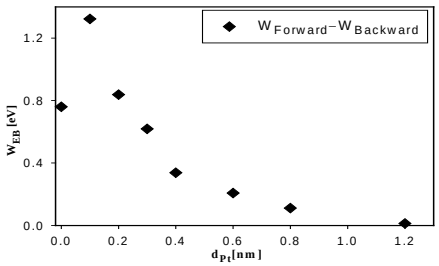

Fig. 1. Exchange bias energy vs. thickness of Pt spacer for $[Pt/Co]_3$-Pt-IrMn.

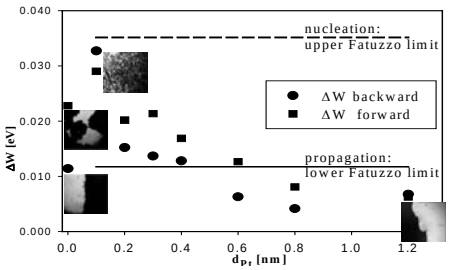

Fig. 2. Energy dispersion vs. thickness of Pt spacer and corresponding domain image.

[1] M.Czapkiewicz *et al.*, phys. stat. sol. (c) **3**(1) (2006) 48.
[2] P.Bruno *et al.*, J.Appl.Phys. **68** (11) (1990) 5763.

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