Controlling Interfacial Phenomena in Hybrid $V_2O_3$/Co Bilayers

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INTRODUCTION

Interfacial exchange coupling and proximity effects in antiferromagnetic/ferromagnetic (AFM/FM) bilayers are the potential keys that control the exchange bias phenomena exploited in all spintronic devices. In both cases, the spin fluctuations in the AFM layer during the temperature-driven magnetic phase transition at Néel temperature ($T_N$) are commonly used to understand the magnitude of the exchange bias field ($H_B$), the inset of $H_C$, referred as Blocking temperature ($T_B$), as well as the enhancement of the coercive field ($H_C$).

Here we show that the magnetization reversal of the FM layer, in particular, its magnetic domain structure during reversal, not only has a strong influence on the mentioned effects but also control them. Temperature dependent measurements performed in a $V_2O_3$/Co bilayer after different field cooling (FC) procedures reveal that these effects depend strongly on the FC angle and are associated with a different domain structure of the FM layer that has a well-defined uniaxial magnetic anisotropy.

Remarkably, a wide temperature window for different domain structure of the FM layer is found. All experimental observations can be explained within the Random-Field Model for the interfacial exchange coupling in AFM/FM bilayers with a fixed ADM domain structure in contact with a variable (angle dependent) FM domain structure.

RT Magnetization

At 300 K the $V_2O_3$ is paramagnetic and the data reflect the intrinsic uniaxial magnetic anisotropy of the Co layer.

FM and AFM domain textures across MIT

Figure 3. Scheme of the FM and AFM domain textures. The relevant directions are indicated: uniaxial anisotropy of the FM layer ($K_{\parallel}$ solid yellow line)/interfacial unidirectional anisotropy ($K_{\perp}$ solid blue line); external inplane magnetic field ($H$, dashed green line). The bottom image is a high-resolution co-localized near-field v-MOKE microscopy images acquired during the temperature-driven magnetic phase transition at MIT.

Conclusions

- The magnetic domain texture of the FM layer during reversal has a strong influence in the interfacial exchange bias.
- Transport properties for the two anisotropy configurations do not differ.
- Our results provide a general microscopic view that can be extended to any AFM/FM system.
- The Key role of the FM texture during reversal could be used to design interfacial effects at will.

Temperature dependence

Figure 4. Temperature dependent v-MOKE hysteresis loops recorded after two selected positive FC procedures on the same sample. (a) collinear ($\beta_F = 0^\circ$) anisotropy configuration; (b) non-collinear ($\beta_F = 50^\circ$) configuration.

References