DIMENSIONALITY EFFECTS AND DOMAIN WALL PROPAGATION ON PERPENDICULARLY EXCHANGE BIASED WIRES

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The phenomenon of exchange bias plays an important role in the development of spin electronic devices. Recently, the study of exchanged-biased systems with perpendicular anisotropy has attracted a lot of interest since the AF spin distribution at the interfaces can be probed. However only studies on non-patterned polycrystalline structures have been reported [1,2]. Here, a study of exchange bias experiments on patterned wires based on CoO(1nm)/Pt(0.5-1 nm)/Co(0.5 nm)/Pt(4nm)/Al_2O_3(0001) sputtered ultra thin films is presented.

Dynamics of magnetization reversal is studied between 10-300K by time resolved extraordinary Hall effect (EHE). At room temperature, the continuous films exhibit strong perpendicular anisotropy and magnetization reversal is dominated by easy domain wall propagation, following rare nucleation events. Below the blocking temperature of the CoO layer, the hysteresis loops (measured by EHE) present a strong asymmetry due to the perpendicular exchange bias between the ferromagnetic Co and the antiferromagnetic CoO layers, showing an exchange bias over 2000 Oe at 10K. The blocking temperature (TB) is found to be around 150K in the continuous films and it gets reduced up to 90K (30K) in patterned 5-µm (1-µm) width wires.

Also important (see figure 1), the extraordinary Hall effect shows an abrupt transition at TB in the continuous films that can be explained in terms of an increase in the total magnetization of the system over TB or a modification, below TB, of the asymmetric scattering process, at the origin of the EHE, due to the presence of an exchange bias. In the patterned films, there exists also an increase of the EHE signal around TB, but the transition is less abrupt than in the continuous structures.

Finally, the dynamics of magnetization reversal in micron size wires will be discussed. The propagation of a single 1D domain wall parallel or anti-parallel to the bias field was studied by measuring the EHE as a function of time in a constant field [3] in the creep regime. It has been found that the domain wall velocity is not sign-dependent over a critical applied field as shown in figure 2. However, below that critical field, the domain wall propagates at a smaller velocity when the applied field is opposite to the bias sign. This results suggests that the exchange bias adds an energy barrier to the domain wall propagation.

References:

[1] S. Maat et al, Phys. Rev. Lett. 87, 87202 (2001).
[2] F. Garcia et al, IEEE. Trans. Mag. 38, 2730 (2002).
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Figures:

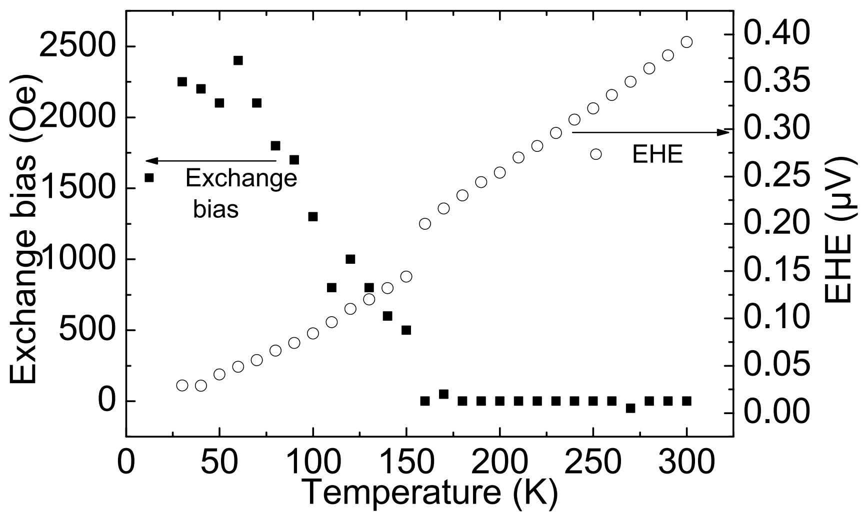

Figure 1.- Exchange bias (full squares) and EHE signal (open circles) as a function of the temperature in a continuous thin film.

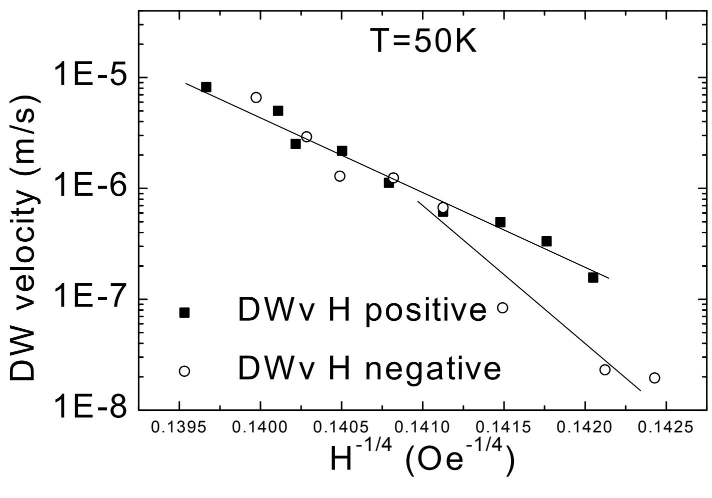

Figure 2.- Domain wall propagation velocity for positive (full squares) and negative (open circles) applied fields.