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Bulk and Interface Effects in Exchange Bias Systems

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Abstract –We present a series of experiments which differentiate the contributions of the AF bulk and interfacial effects to measured value of exchange bias (H_{EX}) on sputtered metallic systems. We show that H_{EX} is determined by the fraction of the AF grain volume distribution which can be set and remains thermally stable during measurement (Fig. 1). The measured value of H_{EX} is moderated by the order of the interfacial spins. Such order is temperature and field dependent which account for the weakened coupling between the layers, having a marked temperature dependence at low temperatures (Fig.2).

Exchange bias plays a crucial role in the performance of read sensors for magnetic recording. The effect of the AF spins on exchange bias has been studied extensively. However the mechanism of exchange bias still remains open [1]. Polycrystalline samples consisting of FeMn/NiFe and IrMn/CoFe were sputtered using a HiTUS system. Thermal activation measurements were carried out using a vibrating-sample magnetometer. Grain size analysis was measured by TEM. Samples showed to be not crystallographically ordered. This allows the application of an independent single domain AF grain model. Following this model we are able to account for bulk and interfacial effects, which allows explaining the increase and decrease of H_{EX} with the AF grain size, the layer thickness, and the variation of H_{EX} with the activation temperature of energy barriers to reversal and also with the temperature of measurement.

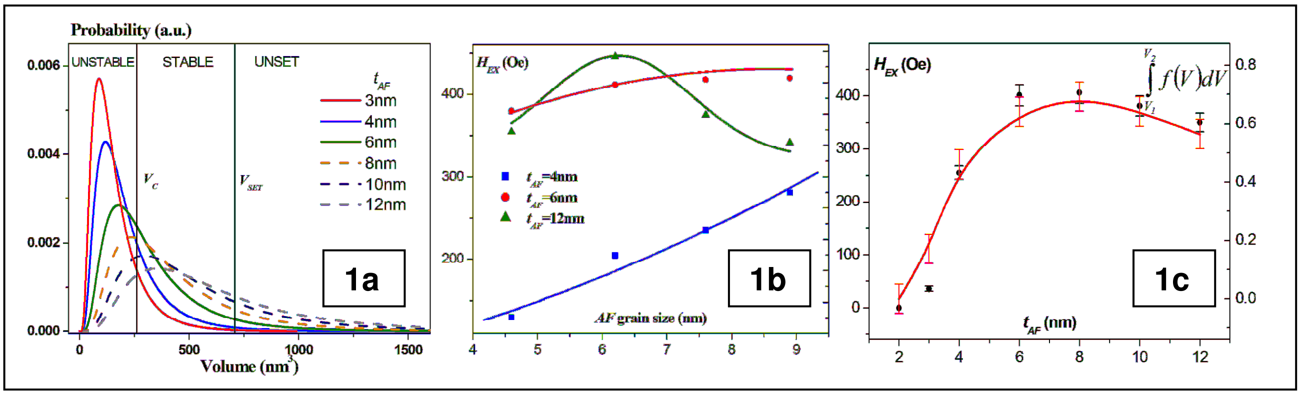

Figure 1: AF grain volume distributions. Volume varied via AF thickness. **b)** H_{EX} variation with AF grain size. **c)** H_{EX} variation with AF thickness. Solid lines in **1b)** and **1c)** are the measured integral of AF grain volume distribution for the set and stable region.

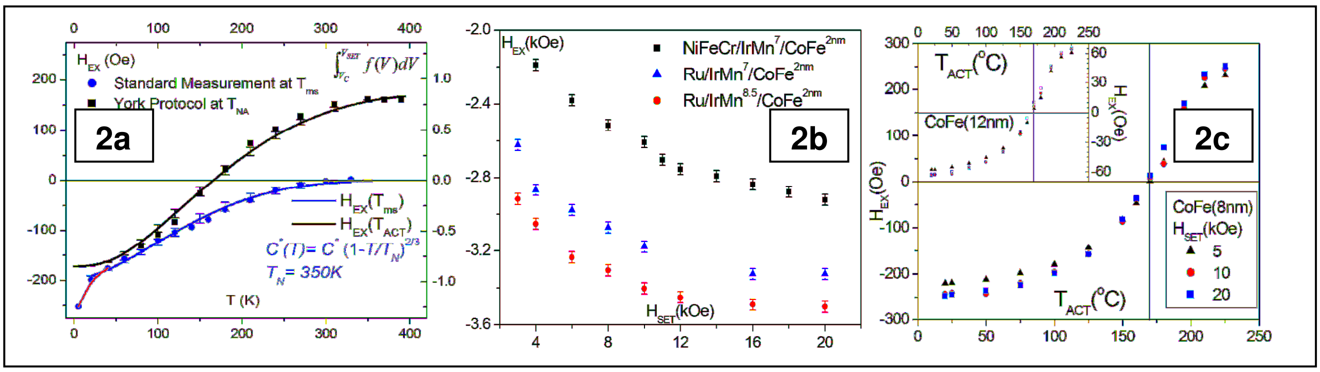

Figure 2: a) Fitting of $H_{EX}(T_{ms})$ measured after field cooling and fitting of $H_{EX}(T_{ACT})$ following the *AF* grain volume dependent model. FeMn(10)/NiFe(10) nm. **b)** Variation of H_{EX} with the setting field, H_{SET}. **c)** $H_{EX}(T_{ACT})$ after setting with different fields for a CoFe (12nm)/IrMn/CoFe(8nm) system. H_{SET} modifies H_{EX} but has no effect on the blocking temperature distribution.

References

[1] T.R. Gao et al. J. Appl. Phys. **105** 053913 (2009)