EE Department Seminar

October 12, Friday, 14:00
Yorgo Istefanopulos Meeting Lounge (KB 217)

Exchange Bias Systems studied by High Resolution Quantitative Magnetic Force Microscopy

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It is generally believed that exchange bias (EB) implies the presence of pinned uncompensated moments pin-UCS in the antiferromagnet (AF) layer that are coupled to the ferromagnet (F) layer. An obstacle to understanding the EB effect is that only a subset of the UCS (those pinned and coupled to the F) are responsible for the EB-effect. The materials used, but also the experimental method and preparation may affect these subsets of UCS in distinct ways [1], and an interpretation of UCS measurements must take this into account. Moreover, the materials morphology, texture, defect density and nature of grain boundaries influence the density and spatial distribution of the pin-UCS. Experimental methods that measure the pin-UCS density distribution with spatial resolution comparable to the materials' grain size are needed.

Here we study F/AF heterostructure-samples by VSM and quantitative, high resolution MFM. MFM works in magnetic fields (up to several T) but is not element specific. Analyzing data acquired with the F-layer in the saturated state and with different magnetization states of the tip allows the separation of the different sources of MFM contrast. Using quantitative MFM we measure the local areal density of pinned uncompensated moments (pin-UCS) in the antiferromagnetic (AF) CoO layer and correlate the F-domain structure in a perpendicular anisotropy CoPt multilayer with the pin-UCS density [2]. Larger applied fields drive the receding domains to areas of proportionally higher pin-UCS aligned antiparallel to F-moments. This confirms our prior results [1] that these antiparallel pin-UCS are responsible for the EB-effect, while parallel UCS coexist. The data confirm that the evolution of the F-domains is determined by the pin-UCS in the AF-layer, and also present examples of frustration in the system. This frustration and the inhomogeneous spatial distribution of the pin-UCS also have a major effect on the coercivity of the EB-systems that has not yet been acounted for. Moreover, grain-boundary engineering can be used to decouple the AF grains leading to a stronger EB-effect but a smaller coercivity.

New approaches with rare-earth-ferrimagnet/ferromagnet bilayers to increase unidirectional anisotropy provided by the EB-effect will be discussed.

[1] I. Schmid, P. Kappenberger, S. Romer, M. A. Marionni, and H. J. Hug. The role of uncompensated spin in exchange biasing. Europhys. Lett., 81:17 001, 2008.

[2] I. Schmid, M. A. Marionni, and H. J. Hug. Exchange Bias and Domain Evolution at 10 nm Scales. Phys. Rev. Lett., 105:197201, 2010.

Dr. Sevil Ozer took a position as a postdoctoral researcher of BioAFM Lab. at the Electronic Department of Bogazici University. She received her Ph.D. degree in 2012 from Basel University, the MS degree in 2006 from Bilkent University and the BS degree from METU, respectively, all in Physics.