Magnetism, structure and reactivity of exchanged-coupled Co/Hematite interfaces.

O. Bezencenet[1], S.Stanescu[2], M.-J. Guittet[1], P. Ohresser[2], A. Barbier[1] and R. Belkhou[2]

[1]CEA- Saclay, DSM/DRECAM/SPCSI, 91191 Gif sur Yvette, France.
[2]SOLEIL, L'Orme des Merisiers Saint Aubin, BP 48, F-91192 Gif sur Yvette, France.

Modern applications for thin film magnets involve unique requirements for the control and design of specific magnetic properties. The exchange bias (EB) phenomenon in Ferromagnet/Antiferromagnetic (F/AF) bilayers appears to be a useful feature for controlling relevant parameters as the coercive and the exchange field. This effect has been extensively used these last decades for the development of modern magnetic devices as magnetic sensors, non-volatile magnetic memory… It is well established that the EB effect is the results of an interfacial interaction between F/AF and is related to the details of the spin arrangement at the interface. Therefore and in order to give a full description of the role of the interface on the EB phenomena, we have focused our study on the Co/α-Fe_2O_3 interface which may be considered as a model system for exchange bias as well as for metal/oxide interaction.

We present first, recent results obtained using X-PEEM and magnetic X-ray dichroism experiments to determine the onset and structure of the magnetic AFM domain structure of hematite at a sub-micron scale. This study is believed to be a mandatory step toward a complete description of the exchange bias phenomenon in such systems. To avoid the typical charge build-up occurring in oxide single crystals all epitaxial hematite films have been deposited on single crystalline Pt(111). Five different hematite thicknesses have been investigated ranging from 3.5 nm to 20 nm, in order to fully characterise the behaviour of the antiferromagnetism with hematite thickness. The X-PEEM experiments reveal very rich and complex AFM domain structures made by large domains (10-30 μm) mainly delimited by dislocation lines which are associated with the morphological features. Within each large domain the AFM domains adopt a dendritic fine structure (1-5 μm width). Thanks to the implementation of a variable linear light polarization, allowing identifying the orientation of the magnetic anisotropy in the AFM, we could show that up to 15 nm hematite thickness the AF structure is not bulk like and the anisotropy is not, as intuitively expected, in the basal plane. This genuine feature may explain the unusual properties of thin hematite films with respect to exchange coupling.

Further, we have considered the first stage of the in-situ growth of a Co/hematite. In the Co/α-Fe_2O_3 system the Co layer adjacent to the hematite layer is partially oxidized, whereas the α-Fe_2O_3 is reduced. Interestingly, this reaction occurs at – and seems limited to - the very beginning of the growth. Quantitative analysis shows that the amount of cobalt oxidized and hematite reduced are independent of the thickness of the metal layer. This chemical reaction at the interface drives the magnetic exchange between the antiferromagnetic oxide and the ferromagnetic Co as evidenced by X-PEEM images.