Revealing Magnetoelectric Coupling in Heterostructures by X-ray Magnetic Circular Dichroism

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Multiferroic materials that present magnetoelectric (ME) coupling are possible candidates for low energy consumption magnetic storage media [1], since the magnetic information can be switched by an electric field instead of an electric current. There are only a few materials that present ME coupling in one single system, so called intrinsic multiferroics [2]. The electric polarization in these systems is often very small and in many cases the ordering temperature is much below room temperature. That has led to the development of artificial systems in the attempt to achieve room temperature operation. In such systems, a heterostructure of, for example, ferroelectric and ferromagnet are combined and the magnetoelectric coupling occurs at the interface [3].

In this talk I will present our work on heterostructures exhibiting ME coupling and how X-ray dichroism can help in the characterization and understanding of these systems. In $La_{0.7}Sr_{0.3}MnO_3$/[Pb $(Mg_{1/3}Nb_{2/3})O_3]_{0.68}$-$[PbTiO_3]_{0.32}$ (011) (LSMO/PMN-PT) we have observed a shift on LSMO Curie temperature (Tc) of 10K close to room temperature by switching the ferroelectric polarization [4]. The shift in Tc is remanent in electric field. Simulations of the X-ray linear dichroism (XLD) spectra show good agreement with a structural modification in LSMO driven by the change in strain coming from the piezoelectric substrate. X-ray magnetic circular dichroism (XMCD) measurements along different directions point to an overall decrease in moment. Therefore, the shift in Tc likely originates from an increase (decrease) of electron hoping which benefits (hinders) the double exchange mechanism. In another system, the co-existence of two types of magnetoelectric coupling mechanisms at room temperature were unraveled by XMCD [5]. In a Co wedge deposited on PMN-PT (011) our XMCD measurements as a function of Co thickness point to the coexistence of a charge screening effect restricted to Co/PMN-PT interface together with a strain driven mechanism. Density Functional Theory calculates the contribution of each effect proposing a spiral state in the Co thin film created by the added effect of both coupling mechanisms.

References

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