



Contribution ID: 96

Type: Oral presentations

Near-surface magnetic moment of Co-doped magnetite (100)

Thursday, 18 June 2015 12:40 (20 minutes)

The widely varying magnetic and electrical properties of spinel ferrites make them promising materials for spintronics applications. In particular, the magnetite is electrically conducting with $\langle 111 \rangle$ as easy axis, while cobalt ferrite is an insulating hard ferrimagnet with a magnetocrystalline anisotropy over an order of magnitude larger than that of the magnetite and with $\langle 100 \rangle$ easy axis [1]. By modifying the Co:Fe ratio and the preparation method, the magnetic and electrical properties can be tuned between those of magnetite and those of cobalt ferrite [2]. However, the detailed magnetic properties are difficult to predict because of the many degrees of freedom involved, such as the inversion level and the flexible cation distribution. Additional mechanisms might enter into play when cobalt ferrites are reduced to nanometer thickness.

In this work, we focus on the study of the magnetic properties of the Co-doped magnetite surface. Co was deposited at room temperature on a well-characterized magnetite (001) surface, prepared by sputtering/annealing cycles. The surface was characterized in-situ by X-ray Photoelectron Spectroscopy (XPS), X-ray absorption (XAS) and X-ray Magnetic Circular Dichroism (XMCD) in Photoemission Electron Microscopy (PEEM) (Fig. 1) in order to obtain the composition, the magnetic domains distribution, and the near-surface orbital and spin magnetic moment of the individual cations [3]. The sample was subsequently annealed to increasing temperatures in order to promote the Co adatoms incorporation and/or diffusion into the crystal lattice. The results suggest the preferential Co incorporation as Co^{2+} , which is in good agreement with the results reported in the literature. The evolution of the Co incorporation into the crystal lattice as a function of the annealing temperature was investigated. Moreover, it was observed that the domains distribution on Co-doped magnetite surface exactly matches with those measured on pure magnetite surface (Fig. 2).

References

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- [2] J. A. Moyer et al., Controlling the electronic structure of $\text{Co}_{1-x}\text{Fe}_2+x\text{O}_4$ thin films through iron doping, Phys. Rev. B 83, 035121 (2011).
- [3] L. Martín-García et al, Spin and orbital magnetic moment of reconstructed $\sqrt{2} \times \sqrt{2} \times \sqrt{2} \times \sqrt{2}$ magnetite (001), Phys. Rev. B 91, 020408 (2015).

Caption (s) - Add figures as attached files (2 fig. max)

Fig. 1. Co L-edge XAS spectra measured with positive and negative helicity and XMCD calculated spectrum of the Co-doped magnetite surface (nominal Co coverage of 0.5 ML). Fig. 2. XMCD-PEEM images of the same zone of the Co-doped magnetite (100) sample measured at (left) the Fe L-edge and (right) the Co L-edge (50 μm of field of view).

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Session Classification: Session 7 - II ALBA User's Meeting 2015

Track Classification: II ALBA User's Meeting