

Temperature dependence of the magnetization depth profile at manganite/titanate interface probed by X-ray resonant magnetic scattering

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Transition metal manganites are from a theoretical point of view the ideal materials for the production of spintronic devices due to their intrinsic half-metallic behavior. Nevertheless, their performances as sources and collectors of spin-polarized currents are strongly weakened by the reduced magnetization they present at the interface with non-magnetic material, the so called magnetic “dead layer” [1]. A detailed understanding of this detrimental mechanism, and of the strategies to exclude it, requires an accurate measurement of magnetization gradients with a spatial (vertical) resolution of a single mono-layer. X-ray resonant magnetic scattering (XRMS) in specular condition is the most innovative and promising technique to this aim [2]. We have performed a XRMS study of atomically-engineered $\text{La}_{1-x}\text{Sr}_x\text{MnO}_3/\text{SrTiO}_3$ interfaces that gives evidence of an unexpected temperature dependence to the thickness of the magnetically dead layer. Upon cooling from 300K to 100K, the dead layer thickness decreases from ~ 4 unit cells (16 Å) to ~ 2 unit cells, and the bulk magnetization increases. Upon further cooling, however, the dead layer thickness unexpectedly increases and the bulk magnetization decreases. The regrowth of the dead layer at low temperature can be eliminated by application of a small (~ 350 Oe) field. Crucial to the XRMS analysis is the use of code to model the magneto-optic properties of anisotropic materials that permits the extraction of the magnetization profile of a dead layer at a surface or buried interface with unit cell resolution by fitting the XRMS spectra as a function of photon energy and incidence angle. The regrowth of the dead layer at low T could be explained by the nucleation of a competing phase at the interface with a different ground state, while the reduction in the measured bulk magnetization can be attributed to magnetocrystalline effects in these materials that orient the magnetic moments in a direction that is tilted with respect to the scattering plane.

References

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