Orientation and Thickness Dependence of Magnetization at the Interfaces of Highly Spin Polarized Manganite Thin Films.

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Experiments probing the magnetization at the surface and interfaces of certain highly spin-polarized materials suggest that the surface magnetization is suppressed compared to the bulk. These materials include complex transition metal oxides such as $La_{0.7}Sr_{0.3}MnO_3$ (LSMO) and Fe_3O_4. For example, Park *et al.* showed that in (001)-oriented LSMO thin films, the surface magnetization as measured by spin-polarized photoemission or soft x-ray absorption spectroscopy falls much more rapidly than bulk as a function of temperature.[1]

However, the spin polarization of LSMO epitaxial thin films is not intrinsically suppressed at all surfaces and interfaces equally, but is highly sensitive to both the epitaxial strain state as well as the substrate orientation. Through the use of element-specific and surface sensitive soft x-ray absorption spectroscopy, the magnetic properties of (001), (110) and (111)-oriented LSMO/$SrTiO_3$ interfaces have been investigated and compared to bulk magnetometry and resistivity measurements. The samples under study were 5-40 nm thick LSMO wedge samples with a 1nm $SrTiO_3$ cap layer as well as uniformly thick LSMO layers. The magnetization of (110) and (111)-oriented LSMO/$SrTiO_3$ interfaces are robust as a function of thickness whereas the magnetization at the (001)-oriented LSMO/$SrTiO_3$ interface is suppressed significantly below a layer thickness of 20 nm.

Such findings can be correlated with the biaxial strain state of the $La_{0.7}Sr_{0.3}MnO_3$ films as determined from x-ray diffraction reciprocal space mapping; for a given film thickness it is the tetragonal distortion of (001) $La_{0.7}Sr_{0.3}MnO_3$ that severely impacts the magnetization, whereas the trigonal distortion for (111)-oriented films and monoclinic distortion for (110)-oriented films have less of an impact when compared to bulk properties. Changes in Mn-O bond angle due to the different symmetries of unit cell distortion result in variation of the double exchange transfer integral. This directly affect both electronic transport as well as magnetization properties. Our observations provide evidence that interface magnetization and thus spin polarization depends strongly on the crystal surface orientation as well as epitaxial strain.

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[1] J. H. Park, E. Vescovo, H. J. Kim, C. Kwon, R. Ramesh, and T. Venkatesan, Physical Review Letters **81**, 1953 (1998).