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Interface Magnetism in $LaMnO_3$ / $SrTiO_3$ Superlattices: Influence of Oxygen Octahedral Tilts

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Complex oxides exhibit a remarkable variation in physical properties, ranging from high Tc superconductivity to colossal magnetoresistance. Thus oxide based heterostructures offer an extremely flexible platform to study interactions between different phenomena. In many cases, however, it is difficult to predict *a priori* the macroscopic response based on the properties of their constituents and so complex oxide superlattices have been the subject of many investigations [1]. In particular, the strong electron-lattice coupling in transition metal oxides with ABO_3 perovskite-type structure means that lattice distortions play a very important role in the physical properties [2]. In thin epitaxial films the stress induced by lattice mismatch to the substrate therefore constitutes a very effective tool to tune the electron-lattice coupling [2]. In particular, O octahedral rotations can be affected by epitaxial strain, and these rotations lead to changes in the electronic properties at the interface [3]. An example can be found in $LaMnO_3$/$SrTiO_3$ (LMO/STO) superlattices. STO is a cubic insulator in bulk, while LMO is an antiferromagnet. However, when these materials are combined in superlattices, a clear ferromagnetic signal is obtained. In our samples grown by Pulsed Laser Deposition (PLD), we find magnetism enhanced in a region of several unit cells from the interface, while the structures remain insulating [4]. Magnetism in other LMO/STO superlattices has been explained in terms of interfacial charge transfer [5], but the role of interfacial octahedral tilts is still unclear.

In this work, we examine the role of these tilts on the magnetic properties of PLD-grown LMO/STO superlattices in the aberration corrected scanning transmission electron microscope (STEM) by means of annular bright field (ABF) imaging [6]. The ABF imaging mode offers an improvement in resolution over conventional bright field imaging. It also allows reliable imaging of both light and heavy columns over a range of thickness and defocus values [7]. We use ABF imaging to quantify the rotations of the octahedra formed by oxygen atoms as a function of the distance from the interface.

Figure 1 shows the raw and Fourier filtered ABF images of a single LMO layer sandwiched between STO layers, viewed down the [110] projection. The O columns can be clearly observed in both materials. The ripple of the O columns (defined as the height difference between alternating O columns, and thus a measure of the tangent of the tilt angle) is plotted in Figure 2. The values have been averaged laterally in the direction parallel to the interface. As expected, in the STO layers there are no vertical displacements of the O atoms (no ripple). Within the LMO layer there is a noticeable ripple which approximately averages to 0.5±0.1Å between the two extreme positions, in agreement with the value of 0.49 Å we measured in bulk crystal. Near both interfaces there is a transition layer, around 3-4 unit cells thick, where the oxygen atom displacements show intermediate values. In these interface regions the Mn-O-Mn angle gets closer to 180º. By means of density-functional theory we will explore the role of these structural distortions on interface magnetism.

References:

[1] E. Dagotto, and Y. Tokura, MRS Bulletin. **33** (2008), p. 1037.
[2] A. Vailionis *et al*, Physical Review Letter **83** (2011), 064101.
[3] A.Y.Borisevich *et al*, Physical Review Letter **105** (2010), 087204.
[4] H.M. Christen, D.H. Kim, and C.M. Rouleau, Applied Physics A **93** (2008), p. 807.
[5] J. Garcia-Barriocanal *et al*, Advanced Materials **22** (2009), p. 627.
[6] S. D. Findlay *et al*, Applied Physics Express **3** (2010), 116603.
[7] S. D. Findlay *et al*, Ultramicroscopy **110** (2010), p. 903.
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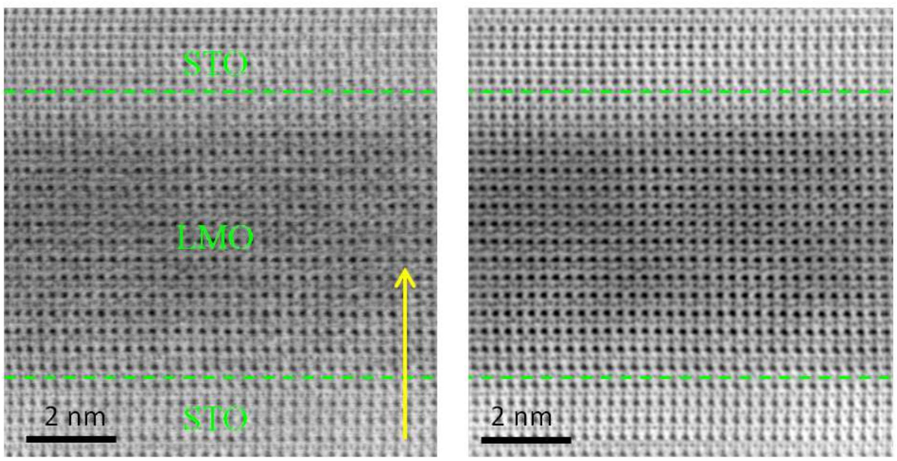

Figure 1. (Left) Raw ABF and (right) FFT filtered images of a thin film sandwiched in between STO layers (bright). The interfaces are marked with dashed lines. A yellow arrow marks the growth direction.

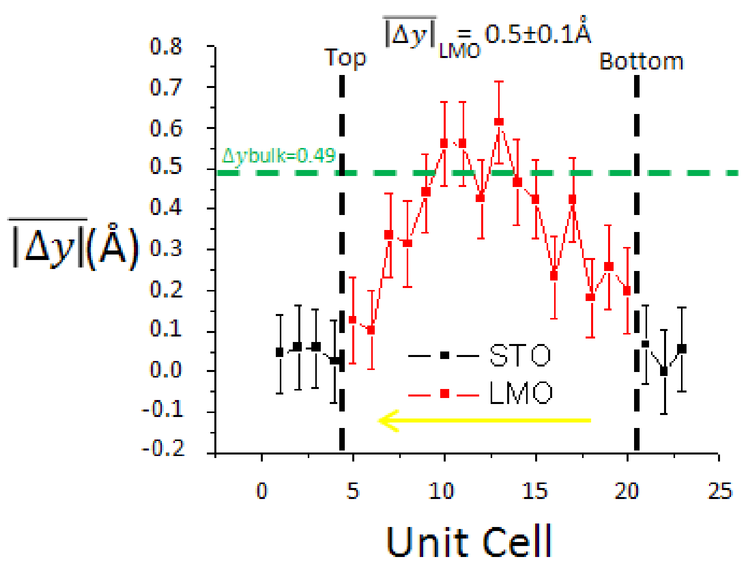

Figure 2. Absolute values of the oxygen atomic column vertical displacements, averaged laterally for the LMO layer. A yellow arrow marks the growth direction.

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