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MS-3-O-2652 Oxygen Octahedral Tilts: The Origin of Ferromagnetism at Insulating $LaMnO_3$ and $SrTiO_3$ Interfaces.

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Complex oxide superlattices exhibit many unusual and interesting properties, such as the 2D electron gas found at insulating $LaAlO_3/SrTiO_3$ interfaces, and it is usually hard to foretell their macroscopic behavior based only on their constituents properties[1]. One fact that is well known is that the strong electron-lattice coupling that exists in ABO_3 perovskite-type materials results in lattice distortions that play a very important role in the physical properties[2]. The stress promoted by the lattice mismatch in epitaxial heterostructures can be used to tune the structure near the interfaces, such as the oxygen octahedral rotations, which can provoke important changes in the electronic properties[3].

Here we report the presence of an insulating ferromagnetic interface between paramagnetic $SrTiO_3$ (STO) and antiferromagnetic $LaMnO_3$ (LMO) in superlattices grown by pulsed-laser-deposition. In our samples, SQUID magnetometry and polarized neutron reflectometry measurements show that LMO exhibits a ferromagnetic ordering, with the local magnetization enhanced near the interfaces within a region approximately three unit cells thick. In order to analyze the structure, chemistry and electronic properties of these interfaces, we have carried out a study in an aberration corrected STEM, combining annular bright field (ABF) imaging[4] with EELS and theoretical calculations.

EELS show the absence of significant charge transfer between neighboring Mn and Ti ions across the interface. ABF images are used to locate oxygen columns and hence, investigation of oxygen octahedral tilts. Fig. 1 shows an ABF image of the whole LMO thin film sandwiched in between STO layers acquired in a Nion UltraSTEM200 operated at 200 kV. Fig. 1 shows the result of Fourier filtering (FFT) the image in 1. In the inset of Fig. 1 an enlarged view of the filtered ABF image is shown. The O columns and the octahedral tilts across the LMO layer can be clearly observed. In order to quantify these tilts, we measure the difference in vertical coordinates between adjacent O columns. The geometry of octahedral rotations in the middle of the LMO layers is consistent with the octahedral tilts reported in the LMO bulk. However, near the interfaces, these rotations are suppressed. We will discuss these findings and relate them to the macroscopic properties of the layers. Density-functional calculations will be used to establish the connection between structural distortions and the enhanced magnetism measured.

References:

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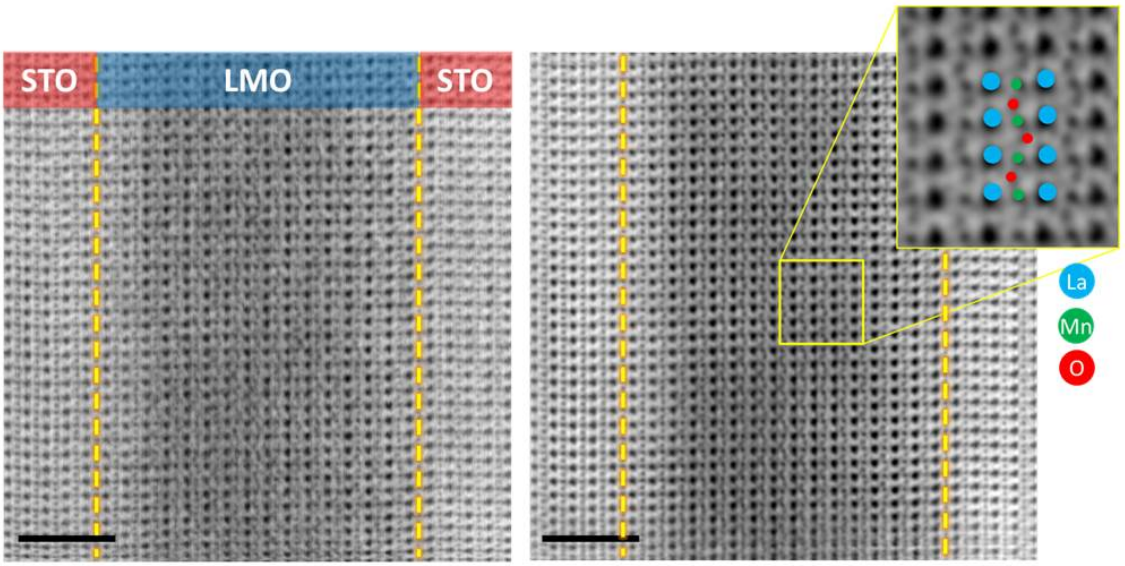

Fig. 1: High-resolution (left) raw ABF and (right) FFT filtered images of a LMO thin film sandwiched in between STO layers. The interfaces are marked with yellow dashed lines. A green arrow marks the growth direction. The scale bars are 2 nm.