

## Electronically sharp Ruddlesden-Popper type oxide heterointerfaces

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### Introduction

Strong coupling between adjacent material layers is often observed at perovskite heterointerfaces, leading to significant changes in the interface electronic structure due to the formation of accumulation/depletion layers that are usually at least a few unit cells thick. In the Ruddlesden-Popper (RP) structure, adjacent perovskite-type sub-units are separated in the *c*-axis direction by an electrically insulating (AO)<sub>2</sub> rock-salt layer, breaking the metal-oxygen-metal chains that normally electronically link neighbouring perovskite-type sub-units. It is therefore expected that RP-type interface would be inherently resistant against charge transfer often changing local carrier density. Integration of a RP-type interface between perovskite oxides can therefore be a simple technique for fabricating planar junction-type oxide devices based on structurally and electronically sharp oxide heterointerfaces.

### Experiment

In this work we study the interfacial electronic structure of (La<sub>0.6</sub>Sr<sub>0.4</sub>)FeO<sub>3</sub>/(La<sub>0.6</sub>Sr<sub>0.4</sub>)MnO<sub>3</sub> (LSFO/LSMO) heterostructures incorporating both traditional perovskite and RP-type interfaces grown on Nb-doped SrTiO<sub>3</sub> (100) substrates in a laser molecular-beam epitaxy chamber connected to a synchrotron radiation photoemission system at BL 2C. A traditional perovskite-type (La<sub>0.6</sub>Sr<sub>0.4</sub>)FeO<sub>3</sub>/(La<sub>0.6</sub>Sr<sub>0.4</sub>)MnO<sub>3</sub> interface was used as a reference case where charge transfer is known to occur over the interface. Two samples with RP-type interfaces were prepared with the LSMO and LSFO layers separated by 2 atomic layers of a binary oxide, (La<sub>0.6</sub>Sr<sub>0.4</sub>)O, resulting in a layer order of (La<sub>0.6</sub>Sr<sub>0.4</sub>)FeO<sub>3</sub>/(La<sub>0.6</sub>Sr<sub>0.4</sub>)O/(La<sub>0.6</sub>Sr<sub>0.4</sub>)MnO<sub>3</sub> (LSFO/LSO/LSMO) at the interface. Finally, a (La<sub>0.6</sub>Sr<sub>0.4</sub>)O/(La<sub>0.6</sub>Sr<sub>0.4</sub>)MnO<sub>3</sub> (LSO/LSMO) sample was grown as a reference where no charge transfer cannot occur due to the lack of the LSFO layer.

The electronic structure of obtained interfaces was characterized with Mn 2*p*-3*d* resonant PES (RPES) measurements using Scienta SES-2002 electron energy analyzer and with Mn 2*p* X-ray Absorption Spectroscopy (XAS) measurements performed in total electron yield mode.

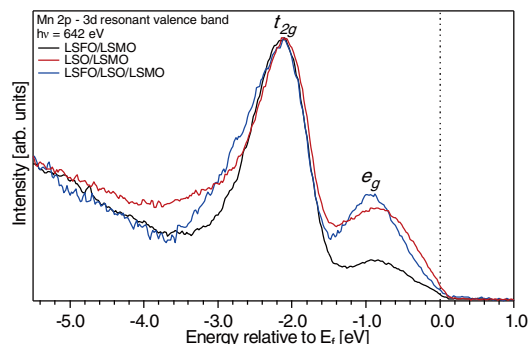


Figure 1: 2*p*-3*d* resonant valence band for charge transfer reference, no charge transfer reference and samples with RP-type interfaces.

### Results and Discussion

Figure 1 shows the RPES spectra for all samples. Whereas the no charge transfer reference sample (LSO/LSMO) exhibits significant intensity of Mn 3*d* *e<sub>g</sub>* states as expected due to the absence of the LSFO layer, the intensity of the *e<sub>g</sub>* peak is strongly depressed for the charge transfer reference sample (LSFO/LSMO), confirming the transfer of electrons from LSMO to LSFO and consequently an increase at hole-doping level of LSMO layers close to the heterointerface.

In contrast, the population at *e<sub>g</sub>* states for the sample with RP-type interface is roughly equal to that of the no charge transfer reference sample entirely lacking the LSFO capping layer. This clearly indicates that the presence of the RP-type interface between LSMO and LSFO layers prevents the charge transfer and thus the unwanted modulation in the hole-doping level of the LSMO layers adjacent to the interface. This conclusion is supported by the Mn 2*p* XAS measurements (not shown here), where the shape of the Mn 2*p*<sub>3/2</sub> multiplet of the sample with RP-type interface is similar to that of the LSO/LSMO no charge transfer reference sample, whereas LSFO/LSMO charge transfer reference exhibits clear separation of additional shoulder on the low energy side of the multiplet.

In conclusion the charge transfer results in the loss of electrons from LSMO layers close to a simple perovskite-type interface, whereas the LSMO layers adjacent to a RP-type interface remain unaffected and retain a bulk-like hole-doping level.

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