

Electron transfer in $\text{LaFeO}_3/\text{LaTiO}_3$ sandwich structures as probed by hard x-ray photoelectron spectroscopy

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Since the discovery of a two-dimensional electron gas at the interface between the two perovskite oxides LaAlO_3 and SrTiO_3 , a lot of effort has been spent on the search of other heterostructures, exhibiting new physical properties different from their single material constituents. Given the large variety of physical properties in transition metal oxides and the small lattice mismatch of oxide perovskites, one can think of essentially unlimited combinations to create novel functionalities in this kind of heterostructures.

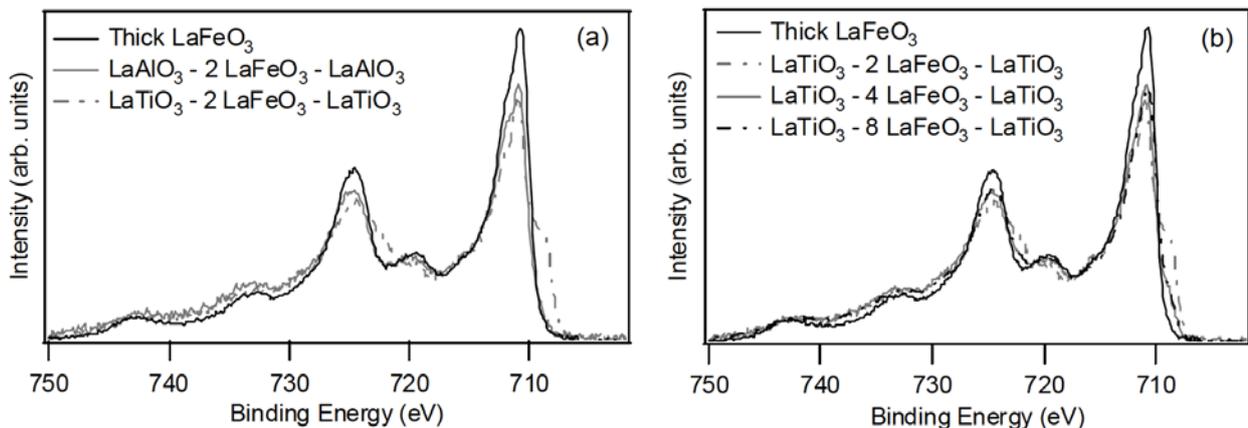


Figure 1. (a) Fe spectra of a $\text{LaTiO}_3\text{-LaFeO}_3$ heterostructure as well as two reference samples. A clear shoulder at lower binding energy is present in the $\text{LaTiO}_3\text{-LaFeO}_3$ heterostructure. (b) Various $\text{LaTiO}_3\text{-LaFeO}_3$ heterostructures with different thicknesses of the sandwiched LaFeO_3 layer.

We have fabricated thin film $\text{LaTiO}_3\text{-LaFeO}_3$ heterostructures by pulsed laser deposition, where the thicknesses of individual layers were varied from 2 monolayers ($< 1\text{ nm}$) to 30 monolayers ($> 10\text{ nm}$). While LaFeO_3 is a charge transfer insulator and LaTiO_3 a Mott-Hubbard insulator, both materials have a multi-valent element on the B-site position. When making a heterostructure of these two insulators, electron transfer from Ti^{3+} to Fe^{3+} is expected due to the specific band alignment at the interface. As a result, Fe would become partially $2+$ and Ti partially $4+$. This should lead to a chemical shift in the photoemission spectra. With the larger information depth when using hard x-rays in photoemission spectroscopy one should be able to observe the changes in valency at the buried interface between the two materials.

During the beamtime at BW2, various $\text{LaTiO}_3\text{-LaFeO}_3$ heterostructures were analysed by angle dependent measurements. The thickness of the sandwiched LaFeO_3 layer was varied to see whether a critical behavior can be observed. In addition, reference samples were measured.

Clear mixed valent Fe was observed for $\text{LaTiO}_3\text{-LaFeO}_3$ heterostructures. On the other hand, the reference samples (thick LaFeO_3 and $\text{LaFeO}_3\text{-LaAlO}_3$) showed only Fe^{3+} . This indicates that indeed Fe is reduced due to the presence of LaTiO_3 . This is shown in Figure 1a.

By varying the thickness of the sandwiched LaFeO_3 layer, the amount of Fe^{2+} could be controlled. This is shown in Figure 1b which strengthens the charge transfer hypothesis.

Mixed valence in the Ti spectra was less pronounced and has to be studied in more detail. Moreover, a more detailed study on the valence band spectra (charge transfer band versus Mott-Hubbard band) has to be conducted.