Electronic Structure of the $SrTiO_3/LaAlO_3$ Interface Revealed by Resonant Soft X-ray Scattering

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The interfaces of hetero-junctions composed of transition-metal oxides have recently attracted great interest. Among them, the interface between two band insulators $SrTiO_3$ (STO) and $LaAlO_3$ (LAO) is especially interesting due to the metallic conductivity [1] and even superconductivity [2]. There has been intense debate on the origin of this metalicity, that is, whether it is due to oxygen vacancies ("extrinsic") or due to the polar nature of the LAO structure ("electronic reconstruction"). In this study we investigated the electronic structure of the STO-LAO superlattice by resonant soft x-ray scattering [3], which has recently been used to study $SrMnO_3$-$LaMnO_3$ superlattices [4].

The superlattice sample consisted of seven periods of 12 unit cells (uc) of STO and 6 uc of LAO. The present samples was grown on a STO (001) substrate by the pulsed laser deposition technique at an oxygen pressure of 1.0×10^{-5} Torr and a substrate temperature of 800 °C. A schematic view of the fabricated superlattice is shown in Fig. 1. The resonant soft x-ray scattering experiments were performed in NSRRC EPU BL 5. The spectra were taken at 80 K. The incident light was polarized in the scattering plane (π polarization) with the detector integrating over both final polarizations, i.e., both the $\pi\rightarrow\sigma$ and $\pi\rightarrow\pi$ scattering channels.

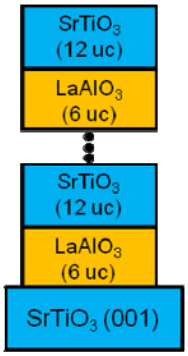

Figure 1. Schematic view of the $SrTiO_3/LaAlO_3$ superlattice sample.

Figure 2 shows the photon-energy dependence of the (003) peak at the Ti 2*p* edge. The structure factor for this (003) peak is proportional to ($f_{TiO2,\,int}$ - f_{TiO2} + $f_{AlO2,\,int}$ - f_{AlO2}), where f_{TiO2} and f_{AlO2} are the scattering factors of the TiO_2 and AlO_2 planes of the STO and LAO layers, respectively, and the subscript "int" means the scattering factor for the interface. The (003) reflection is forbidden by symmetry as long as the interface form factor is the same as the bulk. The existence of this peak in Fig. 2 therefore means that some kind of reconstruction occurs at the interface.

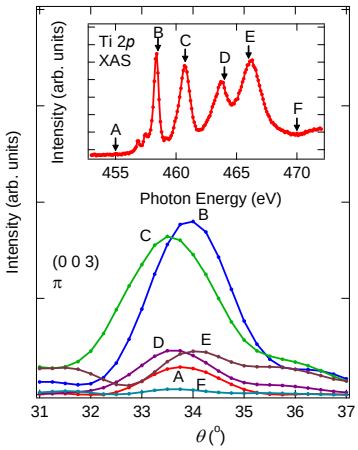

Figure 2. Photon-energy dependence of the (003) peak at the Ti 2*p* edge. The inset shows the Ti 2p absorption spectra and the arrows show the photon energy at these measurements.

Figure 3 shows the energy dependence of the (003) peak position at the Ti 2*p* edge and its comparison with the simple multilayer model of just the repetition of STO and LAO. The overall agreement is fairly good, but there are some discrepancies. The discrepancies are considered to come from the electronic reconstruction at the interface. At the La 3*d* edge, we obtained good agreement between experiment and calculation, which may be connected to the atomic sharpness at the interface.

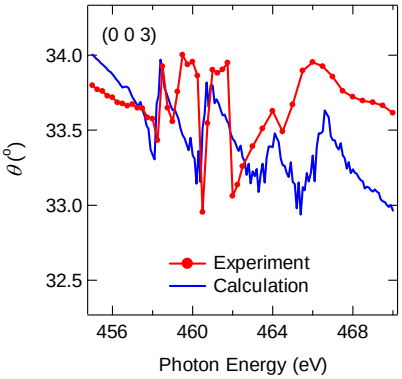

Figure 3. Photon-energy dependence of the (003) peak position at the Ti 2*p* edge and its comparison with the calculation.

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