BL-2A/2013S2-002

Band diagram of a *p-n* junction between Mott-insulator $LaMnO_3$ and band-insulator Nb:$SrTiO_3$ determined by X-ray photoemission spectroscopy

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1 Introduction

Heterointerfaces of transition metal oxides have attracted considerable interest because of their unusual electronic and/or magnetic properties. One interesting aspect of these heterointerfaces, from the point of view of fundamental studies and device applications is the modulation of ferromagnetism [1] and the appearance of new optical transitions between interface states [2] in superlattices consisting of a "*p*-type" Mott-insulator $LaMnO_3$ (LMO) and *n*-type semiconductor $SrTiO_3$ (STO) . For understanding these novel phenomena, it is indispensable to elucidate the band diagram of the interface. In this study, we have investigated the band profile of LMO/Nb-doped STO (Nb:STO) *p-n* junctions at different donor concentrations using X-ray photoemission spectroscopy.

2 Experiment

Epitaxial LMO films with various thicknesses were grown on 0.05 wt. % and 0.5 wt. % Nb-doped STO substrates by laser molecular beam epitaxy. After thin film growth, samples were transferred to an XPS chamber without air exposure and XPS measurements were performed using a VG-Scienta R3000 analyzer with a monochromatized Al K_α X-ray source ($h\nu$ = 1486.6 eV).

3 Results and Discussion

Figure 1 shows Ti 2*p* core level spectra of Nb:STO covered by a LMO overlayer. The positions of the Ti 2*p* core levels shift to lower binding energies with increasing LMO overlayer thickness for both junctions, irrespective of the Nb doping concentration. These energy shifts correspond to the built-in potentials formed in Nb:STO due to band bending. Notably, the energy shifts change depending on the donor concentration, being 0.55 ± 0.05 eV for Nb: 0.05 wt. % and 0.25 ± 0.05 eV for Nb: 0.5 wt. %. Based on the *p-n* junction model of conventional semiconductors, the total built-in potential of a LMO/Nb:STO junction was estimated to be 0.63 eV and the hole density in the LMO film was 6.0×10^{20} cm^{-3}. These values are consistent with previous results obtained from transport properties [3,4]. The results indicate that the junction properties of a LMO/Nb:STO heterointerface can be accurately described in the framework of the *p-n* junction model.

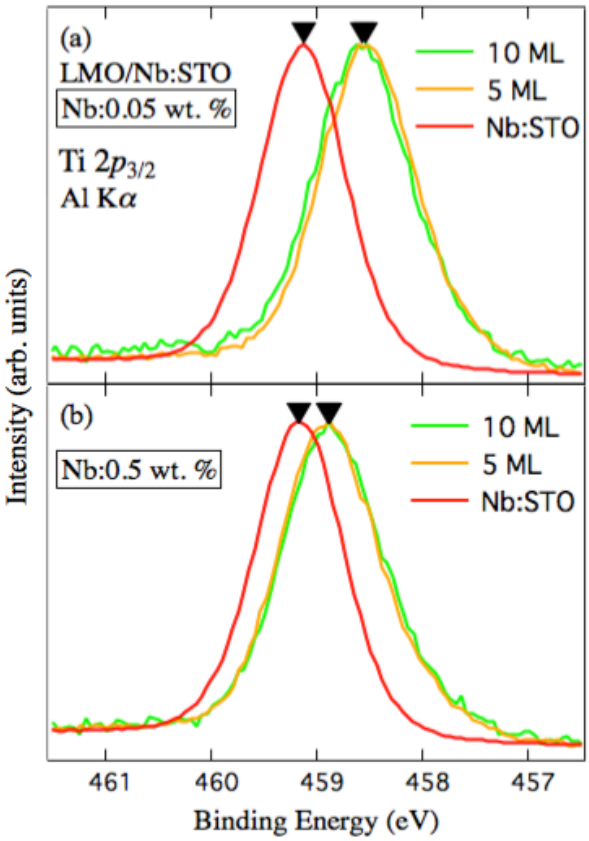

Fig. 1 Ti 2*p* core-level photoemission spectra of LMO/Nb:STO heterointerface. (a) Nb: 0.05 wt. %, (b) Nb: 0.5 wt. %

References

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