Surface and Interface

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Orientation dependence of Schottky barrier height for $La_{0.6}Sr_{0.4}MnO_3$/Nb:$SrTiO_3$ heterojunctions

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Introduction

The height of the Schottky barrier (SBH) that forms at a metal/insulator junction is an essential and fundamental parameter that dominates the performance of the electronic devices. Recently, it has been reported that "interface dipole" forms at the Schottky junction based on (100)-oriented perovskite oxides $La_{0.6}Sr_{0.4}MnO_3$/Nb:$SrTiO_3$ (LSMO/Nb:STO) heterojunction [1] and $La_{1-x}Ca_xMnO_3$/Nb:STO heterojunction [2].

Although the origin of the interface dipole is not clear, the formation may be correlated with the charge transfer induced by charge discontinuity or the ion replacement induced by lattice mismatch at heterointerfaces.

In this study, we performed *in situ* photoemissin studies on LSMO/Nb:STO to investigate the orientation dependence of its SBH. In contrast to (100) oriented heterojunctions, (110) oriented one has no charge discontinuity at the interface as shown in the inset of Fig.1. Comparing the results of the LSMO/Nb:STO(110) with (100), we discuss the origin of the interface dipole.

Experimental

LSMO thin films were grown on Nb:STO(100) and (110) substrates in a laser MBE chamber connected to a synchrotron-radiation photoemission system at BL-2C. During LSMO depositions, the substrate temperatures were kept at 1050 ℃ and the ambient oxygen pressures were 1×10^{-4} Torr. The film thicknesses were controlled on an atomic scale by monitoring the intensity oscillations of the reflection high-energy electron diffraction (RHEED) specular spot during growth. The PES spectra were taken *in situ* a total energy resolution of 150 meV in the energy range of 600 to 800 eV.

Results and discussion

Figure 1 shows the plot of the energy shift of the Ti 2*p* core-level peaks as a function of LSMO(100) and LSMO(110) over-layer thickness. Judging from the saturation level of the peak shift, the energy shifts due to band bending can be estimated to be 1.2±0.1 and 1.1±0.1 eV for LSMO/Nb:STO(100) and LSMO/Nb:STO(110) junctions, respectively. Since a flatband is formed at the surface of Nb:STO, these energy shifts correspond to the built-in potentials of the Schottky junctions [1]. Since there is the negligibly small energy difference between the Fermi level and the conduction band minimum owing to a degenerate semiconductor nature of Nb:STO, the SBHs of the LSMO/Nb:STO(100) and the (110) junctions are evaluated to be 1.2±0.1 and 1.1±0.1 eV, respectively. Irrespective of the absence of the charge discontinuity in the (110) junctions, the SBHs of such (110) junction show almost the same value as that of the (100) junction. Therefore, these results suggest that the charge discontinuity hardly contributes to the dipole formation at the interface

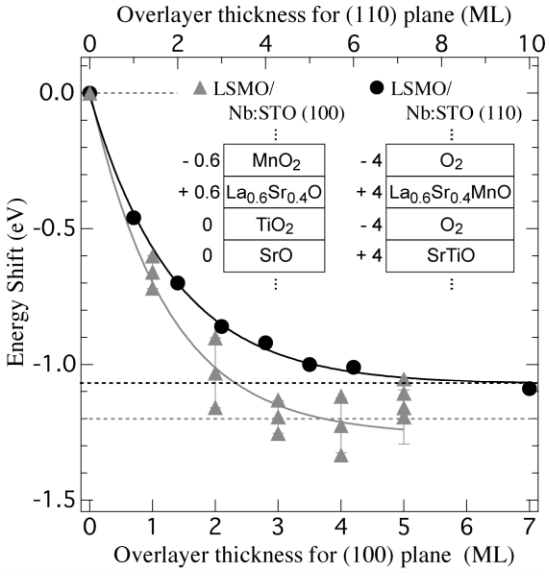

Fig.1 : The plot of the energy shift of the Ti 2*p* core-level peaks as a function of LSMO(100) (triangle) and LSMO(110) (circle) over-layer thickness. The lines are guides for the eye.

References

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