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Electronic structures of $(SrTiO_3)_{1-x}(La_{0.6}Sr_{0.4}MnO_3)_x$ mixed-crystal films studied by synchrotron-radiation photoemission spectroscopy

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Introduction

The perovskite manganese oxide $La_{0.6}Sr_{0.4}MnO_3$ (LSMO) is one of the most promising materials for spin tunnel junction because of its half metallic nature. However, the performance of tunnelling magnetoresistance (TMR) devices based on LSMO/$SrTiO_3$ (STO)/LSMO tunnelling junction is much lower than expected one. This suggests the "dead layer" formation at heterointerfaces between LSMO and STO [1]. We investigated the electronic structure of LSMO/STO heterointerfaces by means of photoemission spectroscopy (PES) previously. It is revealed that the electronic structure of their heterointerfaces cannot be reproduced simply by the linear combination of valence bands for LSMO and STO, suggesting that interfacial electronic structure exhibits mixed-crystal-like behaviour. Therefore, it is worthwhile to compare the electronic structures of LSMO/STO heterointerfaces with these of LSMO-STO mixed crystal. In this study, we have performed the PES measurements of $(STO)_{1-x}(LSMO)_x$ films.

Experimental

$(STO)_{1-x}(LSMO)_x$ (LSMT) (x = 0.1, 0.25, 0.5) epitaxial films were grown in a laser MBE chamber connected to a synchrotron radiation PES system at BL2C of the Photon Factory [2]. During deposition, the substrate temperature was kept at 1000 °C and the oxygen pressure was 1×10^{-4} Torr. The film thickness was estimated to be 40 nm by monitoring the intensity of the specular spot in reflection high-energy electron diffraction (RHEED) patterns. The PES spectra were taken *in situ* with a total energy resolution of 150 meV.

Results and discussion

Figure 1 shows the valence band spectra of LSMT films (dots). LSMO and STO spectra are also shown for references. The valence band spectra of LSMT films consist of Mn 3*d* band (1-3 eV) and O 2*p* band (3-8 eV), and change systematically with increasing composition ratio x. The energy positions of Mn 3*d* states (e_g and t_{2g} states) were precisely determined by Mn 2*p*-3*d* resonant PES.

In order to address the nature of the electronic structures in LSMT films, we try to reproduce the spectra by linear combination of LSMO and STO spectra. The results are superimposed on the experimental data in Fig. 1 as solid lines. The linear combination well reproduces the O 2*p* derived structure, while there are considerable differences in Mn 3*d* derived structure near the Fermi level: the Mn 3*d* states in LSMT are located at higher binding energy than the simulation based on the linear combination. Furthermore, we found that the energy separation between O 2*p* and Mn 3*d* states becomes larger with increasing the composition ratio x. This result suggests that the Mn-O hybridization strength decreases with decreasing x.

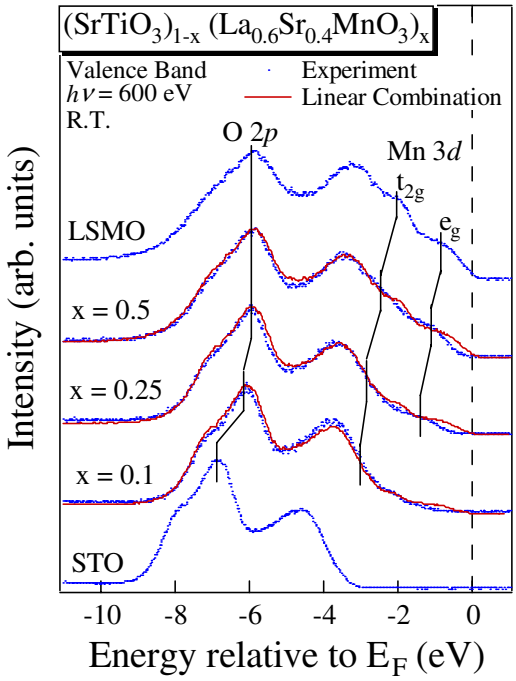

Fig. 1 : The valence band spectra of LSMT films (dots) and simulation (solid lines) based on linear combination of LSMO and STO

References

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