

Composition dependence of surface electronic structures in $\text{La}_{1-x}\text{Sr}_x\text{MnO}_3$ thin films

Yoko FURUKAWA¹, Makoto MINOHARA², Kohei YOSHIMATSU¹,
Hiroshi KUMIGASHIRA^{1,3,4} and Masaharu OSHIMA¹⁻⁴

¹Department of Applied Chemistry, The University of Tokyo, Tokyo 113-8656, Japan

²Graduate School of Arts and Sciences, The University of Tokyo, Tokyo 153-8902, Japan

³JST CREST, Tokyo 113-8656, Japan

⁴Synchrotron Radiation Research Organization, The University of Tokyo, Tokyo, 113-8656, Japan

Introduction

A-site doped perovskite manganites have attracted much attention for their spectacular electromagnetic properties. In particular, $\text{La}_{1-x}\text{Sr}_x\text{MnO}_3$ (LSMO) is a very promising material in that it shows half metallic nature. In fact, the application of heterojunctions made with SrTiO_3 (STO) to high performance tunnel magnetoresistance devices are one of the most highly anticipated. However, in such cases, the interface/surface electronic states of LSMO are crucial to performance. Therefore it is essential to understand the LSMO surface electronic structures. In this study, photoemission spectroscopy (PES) measurements are made to investigate LSMO surface states, and obtain information guiding us to design more ideal interface/surface structures.

Experiments

MnO_2 -terminated LSMO ($x = 0.1$ – 0.5) thin films, with film thicknesses of about 100 monolayers, were grown on atomically flat (001)-oriented 0.05 wt% Nb-doped STO substrates, using a laser molecular beam epitaxy chamber connected to a synchrotron radiation PES system at BL2C [1]. Films of all compositions were deposited at substrate temperature $T = 1000$ °C and oxygen partial pressure $P_{\text{O}_2} = 1 \times 10^{-4}$ Torr, and were subsequently post-annealed at around $T = 450$ °C and $P_{\text{O}_2} = 760$ Torr. Surface morphology was characterized by *in situ* reflection high-energy electron diffraction and *ex situ* atomic force microscopy, confirming atomically flat terrace structures with (001) unit-cell steps. The PES spectra were taken *in situ* with a total energy resolution of about 115 meV and 300 meV at $h\nu = 300$ eV and 800 eV, respectively. Photoelectron emission angles in the range of 0° (=normal to the surface) to 60° were used, for enhancing surface sensitivity.

Results and Discussions

The inset of Fig. 1 shows the Sr 3d core level spectra of LSMO ($x = 0.4$) and their decompositions. It is evident that as the emission angle increases (surface sensitivity

increases), a component with chemical shift of ~ 1.2 eV (S) increases in intensity, indicating its surface nature. Judging from the energy shift amount and full width at half maximum, this component is assigned to rock-salt type SrO, which segregated to the LSMO surface [2]. In order to study the origin of this segregation, the composition dependence of SrO surface coverage was determined by PES results. As shown in Fig. 1, 10–20% coverage of SrO was found on all thin film surfaces.

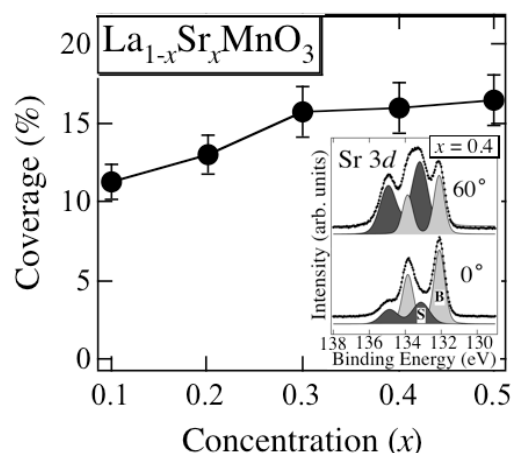


Fig. 1: Coverage of SrO segregation on LSMO thin film surfaces. The inset shows the peak fitted Sr 3d core level spectra of LSMO ($x = 0.4$).

Furthermore, the coverage did not depend on film thickness, suggesting that epitaxial strain relaxation is not a dominating factor for the segregation. These results suggest that the SrO segregation stabilized the surface energy of LSMO.

References

- [1] K. Horiba *et al.*, Rev. Sci. Instrum. **74**, 3406 (2003).
- [2] H. Kumigashira *et al.*, Appl. Phys. Lett. **82**, 3430 (2003).

* furukawa@sr.t.u-tokyo.ac.jp