Surface electronic structures of terminating-layer-controlled La0.6Sr0.4MnO3 thin films studied by in-situ photoemission spectroscopy

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Introduction
The half-metallic nature in hole-doped perovskite manganese oxides¹ makes these materials intriguing for potential application to the magnetoelectronic devices.²-⁴ However, in spite of 100% spin polarization of their conduction carriers, the performance of thin film tunneling magnetoresistance is far below what is expected.²-⁴ The fact suggests the importance of the surfaces and interfaces; since perovskite oxides represented by the formula ABO₃ consist of AO (A-site plane) and BO₂ (B-site plane) atomic layers, alternatively stacked along the c-axis direction, it is important to investigate the difference of surface electronic structures between two different terminating-layers. In this study, we have investigated the surface electronic structures of A(LaₐSr₀.₄O)- and B(MnO₂)-site terminated LSMO (LSMO/STO) films at two different terminating-layers. In this study, we have investigated the surface electronic structures of A(LaₐSr₀.₄O)- and B(MnO₂)-site terminated LSMO/SrO/STO films grown epitaxially on SrTiO₃(001) substrates by laser molecular beam epitaxy (laser-MBE) in terms of in-situ synchrotron-radiation photoemission spectroscopy.

Experimental
The termination-layer-controlled LSMO thin films were grown in a laser-MBE chamber connected to a synchrotron radiation photoemission system at BL1C of the Photon Factory.³ The terminating layer of the La₀.₆Sr₀.₄MnO₃ films was changed from B to A site by inserting one atomic layer of SrO between the La₀.₆Sr₀.₄MnO₃ film and a wet-etched TiO₂-terminated SrTiO₃(001) substrate.⁶ The successful control of the terminating layer was confirmed by measuring the angular dependence of core-level spectra.⁷ The film was transferred to the photoemission chamber under vacuum of 10⁻¹⁰ Torr. The PES spectra were taken at 150 K with the total energy resolution of about 300 meV at the photon energy of 270 eV.

Results and Discussion
Figure 1 shows Sr 3d core-level PES spectra for A-site terminated LSMO (LSMO/SrO/STO) and B-site terminated LSMO (LSMO/STO) films at two different emission angles θ = 0° and 60°. The Sr 3d spectra show noticeable and quantitative difference between two films, reflecting their electronic structures in the surface region. More detailed information on these Sr 3d spectra can be obtained by curve fitting, as shown in Fig. 1. It is clear that the Sr 3d core level consists of three components labeled B₆, S₆, and S'₆ for LSMO/SrO/STO while only two major components, B₇ and S₇, are visible in the spectra of LSMO/STO. The reduced intensities of the B₆ and S₇ components under surface-sensitive conditions (θ = 60°) indicate that these components originate from the Sr atoms in a La/SrO layer below a MnO₂ plane. On the other hand, the opposite angular behavior of other components (S₆, S'₆, and S₇) indicates their surface origin.

By taking into account the different terminating layers of the two films, we assign the second doublet S₆ with the chemical shift (CS) values of 0.68±0.01 eV in LSMO/SrO/STO to Sr atoms in the uppermost La/SrO layer on the MnO₂ terminating layer. The presence of Sr atoms may originate from the thermodynamic surface-segregation and/or residual Sr atoms migrating at the surface during deposition.

References

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