1C, 2C/2002S2-002

Spectral evidence for inherent “dead layer “ formation at $La_{1-y}Sr_yFeO_3/La_{1-x}Sr_xMnO_3$ heterointerface

Ryuji HASHIMOTO[1], Akira CHIKAMATSU[1], Hiroshi KUMIGASHIRA[1*], Masaharu OSHIMA[1], Naoyuki NAKAGAWA[2], Tsuyoshi OHNISHI[2], Mikk LIPPMAA[2], Hiroki WADATI[3], Atsushi FUJIMORI[3], Kanta ONO[4], Masashi KAWASAKI[5], and Hideomi KOINUMA[6]

[1]Department of Applied Chemistry, The University of Tokyo, Tokyo 113-8656, Japan
[2]Institute for Solid State Physics, The University of Tokyo, Kashiwa 277-8581, Japan
[3]Department of Complexity Science and Engineering, The University of Tokyo, Kashiwa 277-8561,Japan
[4]Institute of Materials Structure Science, KEK-PF, 1-1 Oho, Tsukuba 305-0801, Japan
[5]Institute for Materials Research, Tohoku University, Sendai 980-8577, Japan
[6]Materials and Structures Laboratory, Tokyo Institute of Technology, Yokohama 226-8503, Japan

Introduction

Superlattices based on perovskite transition-metal oxides have attracted much attention because of the possibility of tuning the magnetic and electronic properties of a thin film in ways that would not be possible in single-phase bulk materials.[1] However, the lack of information on the electronic structure of the interfacial layers, especially the occurrence of charge transfer between constituent layers, does not allow us to fabricate superlattices with predetermined properties. In this study, we report *in situ* Mn 2*p*-3*d* resonant photoemission (PES) characterization of $La_{0.6}Sr_{0.4}MnO_3$ (LSMO) layers that have been covered with a thin $La_{0.6}Sr_{0.4}FeO_3$ (LSFO) overlayer to investigate the occurrence of charge transfer between transition metals across the heterointerface.

Experimental

The LSFO/LSMO superlattices as well as LSMO thin films were fabricated onto TiO_2-terminated $SrTiO_3$ (STO) substrates 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 950 °C and the oxygen pressure was $1x10^{-4}$ Torr.[1] The side view of the fabricated film libraries are shown in the inset of Fig. 1. After cooling down below 100 °C, the samples were transferred into the PES chamber under the vacuum of 10^{-10} Torr. The PES spectra were taken with a total energy resolution of 150 meV in the photon energy range of 600-700 eV. The chemically abrupt interface between LSFO and LSMO was confirmed by analyzing the intensity of Mn 2*p* core level.[3]

Results and Discussion

Figure 1 shows the Mn 3*d* spectra near the Fermi level (E_F) of LSMO layers in the vicinity of an interface with the LSFO overlayers. Spectra of $La_{1-x}Sr_xMnO_3$ (x = 0.4 and 0.55) films are also shown as a reference. The spectra were obtained by subtracting the off-resonance spectra (no Mn 3*d* contribution) from the on-resonance spectra. The Mn 3*d* spectra consist of two prominent peaks at about 2.1 and 0.8 eV. These peaks are assigned to Mn 3*d* $t_{2g}\uparrow$ and $e_g\uparrow$ states, respectively. Figure 1 shows an interesting change in spectral intensity near E_F, reflecting the modulated electronic structure at the interface; the intensity of the $e_g\uparrow$ states drops dramatically as the LSFO overlayer thickness increases, while the $t_{2g}\uparrow$ states show no noticeable change. The observed changes in the valence band spectra are very similar to the relative changes in the peak intensities of the valence band photoemission spectra that have been observed in $La_{1-x}Sr_xMnO_3$ as a function of carrier concentration, where the intensity of the $e_g\uparrow$ states monotonically decreases with increasing hole concentration (x).[4] The spectra obtained from 20 ML-thick x = 0.4 and x = 0.55 LSMO films, also shown in Fig. 1, demonstrate this behavior. The reduction of spectral intensity of $e_g\uparrow$ states with increasing LSFO overlayer thickness therefore clearly indicates the occurrence of electron transfer from LSMO to LSFO layers in the interface region.

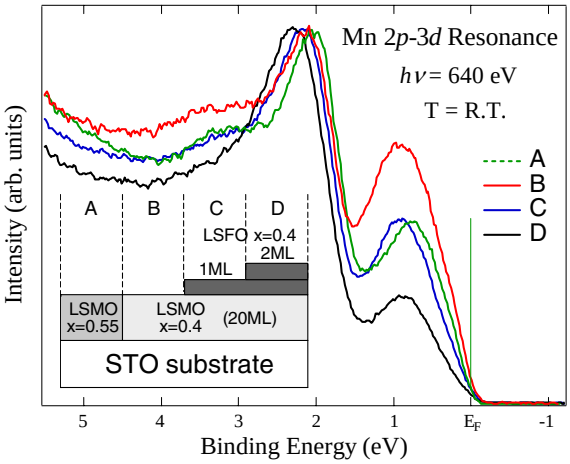

Fig. 1: Mn 3*d* spectra of LSMO layers in the vicinity of an interface with LSFO.

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