Surface and Interface

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Interfacial electronic structure at the resistance switching heterojunction between Al and $La_{0.7}Ca_{0.3}MnO_3$

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Introduction

Recently, electric-field-induced resistance switching (RS) at metal-insulator-metal (MIM) structures has attracted considerable interest for its potential applications to a new nonvolatile memory device, resistance random access memory (ReRAM). However, the mechanisms of RS have not been fully understood yet, and this has largely hindered development of future ReRAM. For MIM structures based on perovskite manganite, it was reported that RS characteristics significantly depends on the metal species of electrodes [1]. Thus, it has been suggested that the interface between metals and manganites plays an important role in RS.

In this study, we employed photoemission spectroscopy (PES) to study the difference of interfacial electronic states between Al/$La_{0.7}Ca_{0.3}MnO_3$ (LCMO) with RS behaviours and Ag/LCMO without RS.

Experimental

LCMO thin films were grown on Nb-doped $SrTiO_3$(001) by laser molecular beam epitaxy. Substrate temperature and oxygen pressure were kept at 1050 ºC and 1×10^{-4} Torr during LCMO deposition. Surface morphology was characterized by atomic force microscopy, confirming the atomically flat surface of the LCMO. After the growth of LCMO films, Al or Ag metals were deposited on LCMO by a radio frequency sputtering method at room temperature. PES measurements were performed at undulator beamline BL-2C. These growth and characterization cycles were carried out *in situ*.

Result and Discussion

Figure 1 shows electrode (Al and Ag) thickness dependence of Mn 2*p* core-level spectra for (a) Al/LCMO and (b) Ag/LCMO. The Mn 2*p* core-level spectra of LCMO films indicate that Mn valency of the LCMO surface is a mixture of +3 and +4. As can be seen in Fig. 1(a), a satellite peak denoted by opened triangle appears around 647.5 eV after Al deposition [2], suggesting the existence of Mn^{2+} ions at the interface due to reduction of Mn ions. With a further increase of Al thickness above 0.5 nm, sharp peaks appear at lower binding energy (indicated by closed triangle). These peaks are assigned to the metallic Mn due to further reduction from Mn^{2+}. In addition, it was revealed from Al 2*p* spectra for Al/LCMO that Al metal was oxidized along with the reduction of Mn ions (not shown). These results indicate that redox reaction occurred at the interface between Al and LCMO [3]. In sharp contrast, we do not observe any indication of redox reaction at the Ag/LCMO interface as shown in Fig. 1(b). Thus, redox reaction occurred at the interface of metal/LCMO showing RS, but did not occur at the interface not showing RS. These results indicate that the redox reactions at the electrode/LCMO interface are responsible for the RS behavior.

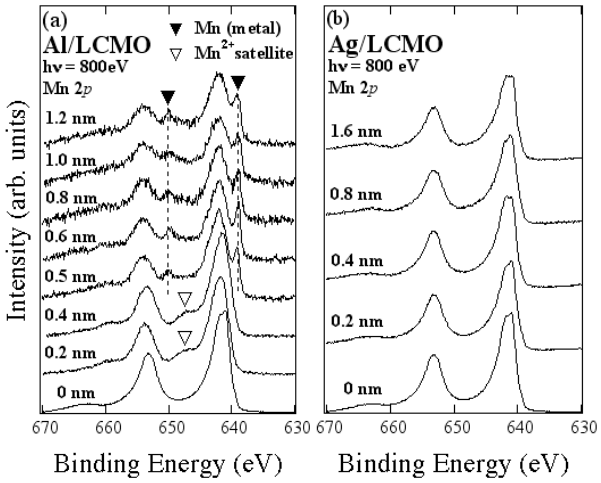

Fig 1: The dependence of Mn 2*p* core-level spectra on Al and Ag electrode thickness for (a) Al/LCMO and (b) Ag/LCMO, respectively.

References

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