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Soft x-ray photoemission study of $La_{1-x}Sr_xTiO_3$ thin films

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Introduction

$La_{1-x}Sr_xTiO_3$ (LSTO), which has a perovskite-type structure, is a basic material for studying the mechanism of filling-controlled Mott transition (FC-MIT) [1]. With decreasing *x*, LSTO changes from a band insulator ($SrTiO_3$, Ti^{4+}, $3d^0$) to a paramagnetic metal, an antiferromagnetic metal, to an antiferromagnetic Mott-Hubbard insulator ($LaTiO_3$, Ti^{3+}, $3d^1$) [2,3]. In previous studies, critical behaviors of the electric structure have been observed in the vicinity of the metal-insulator transition [3,4]. For $0.05 < x < 0.9$, LSTO exhibits a Fermi–liquid-like behavior. On the other hand, around *x*=0.05, LSTO shows metal–to-Mott insulator transition (MIT) [2]. However, because of the large contribution of surface states to the incoherent part of the photoemission spectra, it has been difficult to quantitatively evaluate the spectral weight transfer from the coherent part to the incoherent part with *d*-band filling [4]. In this work, we have measured *in-situ* soft x-ray photoemission spectroscopy (SX-PES) spectra of epitaxially grown LSTO thin films (x=0.9, 0.8, 0.7) with clear step-and-terrace structure and well-ordered surfaces as a function of hole doping *x*.

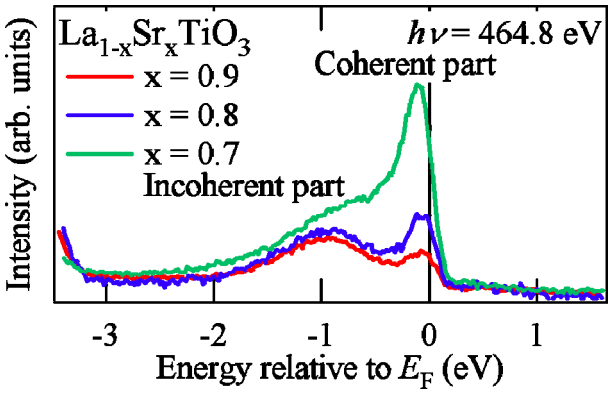
Experiment

LSTO thin films were fabricated eptiaxially on TiO_2-terminated $SrTiO_3$ (100) substrates at 950-1000 °C and in an oxygen pressure 1-5 × 10^{-6} Torr by laser Molecular Beam Epitaxy (MBE) method. The LSTO thin films were transferred to a synchrotron radiation photoemission chamber at BL-2C of Photon Factory under ultrahigh vacuum of about 10^{-10} Torr connected directly with a laser MBE chamber [5]. The thickness of the LSTO thin films is 100 monolayer (approximate 39.05 nm) and was examined by Reflection High Energy Electron Diffraction oscillation data. Crystallographic properties examination by Atomic Force Microscope shows a step-and-terrace structure and well-ordered surface. The *in-situ* SX-PES spectra were taken at room temperature with a total energy resolution of 171 meV near Fermi level at a photon energy of 464.8 eV.

Results and Discussion

Ti 2*p*-3*d* resonance SX-PES spectra taken at hν= 464.8 eV are shown in Figure 1. The photoemission spectrum of the thin film LSTO clearly shows a sharp coherent part (the quasi-particle band crossing the Fermi level) of the Ti 3*d* band near the Fermi level and the incoherent part (the remnant of the lower Hubbard band) is suppressed compared with that of the surface-sensitive spectra of bulk LSTO reported in Refs.4 and 6. As Shown in Figure 2, the density of states at the Fermi level and Ti^{3+} concentration increase with decreasing *x*.

Figure 1: Ti 2*p*-3*d* resonance SX-PES spectra of LSTO thin films near the Fermi level for various hole concentrations taken at hν = 464.8 eV.



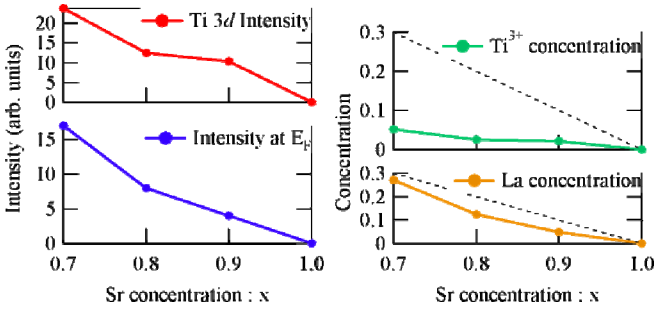


Figure 2: Doping dependence of the spectral intensity in LSTO thin films.

References

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