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Fluorescence spectra of manganite films measured by silicon drift detector

Hironori Nakao[1], Hiroyuki Yamada[2], Yuichi Yamasaki[1], Youichi Murakami[1] and Akihito Sawa[2]
[1]Condensed Matter Research Center and Photon Factory, Institute of Materials Structure Science, High Energy Accelerator Research Organization (KEK)
[2]Nanoelectronics Research Institute, National Institute of Advanced Industrial Science and Technology

Introduction

Fabrication technology of artificial lattice is remarkably improved. Then many kinds of superlattice structures composed of different chemical compositions have been made by atomic resolution. Hence intrinsic physical properties in artificial suplerlattice system were reported. Recently Yamada et al. have discovered large negative magnetoresistance in manganite superlattice system $(LaMnO_3)_2(SrMnO_3)_2$ as an intrinsic physical properties in artificial superlattice system. [1] They indicated that a possible origin of the magnetoresistance effect is metal-insulator transition (MIT) at the interface. To clarify the origin of the MIT, we performed x-ray diffraction study under magnetic field. There we utilized the resonant and non-resonant x-ray scattering technique, which could elucidate not only the crystal structure but also the valence distribution of Mn ions in the similar superlattice system. [2] The energy dependence of scattering intensity was measured at 0.0 T and 7.5 T in order to elucidate the magnetic field effect of Mn valence state. Then clear magnetic field dependence was found at (1 0 0)+1 only near Mn *K*-edge energy, although there is no dependence at (1 0 0). We expected that this magnetic field dependence reflects the Mn valence state changing near the interface between $LaMnO_3$ and $SrMnO_3$. To analyze the energy spectra, we used the anomalous scattering factors (ASF) of $La_{0.5}Sr_{0.5}MnO_3$/STO obtained from the fluorescence spectra [3]. However, the energy spectra cannot explain well by our model calculations using the ASF, even in that of the fundamental reflection. Hence we tried to measure the fluorescence spectra of manganite film to determine the ASF of Mn ion in the film.

Experiment

The manganite films were fabricated on a (1 0 0) surface of $La_{0.3}Sr_{0.7}Al_{0.65}Ta_{0.35}O_3$ (LSAT) substrate using a combinatorial pulsed laser deposition system. [3] The fluorescence experiment was carried out at short gap undulator beamline (BL) 3A using a silicon drift detector (SDD) with the energy resolution (< 150 eV). As a result, we could reduce the background from the La fluorescence, the air elastic scattering, and so on. This detector was quite effective to perform such experiment because the background is much larger than the fluorescence signal of Mn in this film system.

Results and Discussion

To determine the ASF of Mn^{3+} and Mn^{4+} on the film, the fluorescence of $LaMnO_3$/LSAT and $SrMnO_3$/LSAT were measured as shown in the figure. By using the SDD, we could obtain the clear fluorescence spectra, although it was difficult to reduce the background in previous experiment utilizing the NaI scintillation counter. The chemical shift of Mn^{3+} and Mn^{4+} is clearly measured. Moreover, the difference of the fluorescence between in-plane and out-of-plane is observable; the anisotropy of MnO_6 octahedron *c/a* can be correctly discussed. Here the imaginary part of ASF f'' can be obtained directly from the fluorescence spectrum. Moreover, the real part of ASF f' can be transformed by Kramers-Kröning transformation of f''. Finally, the ASF of Mn^{3+} and Mn^{4+} could be determined including the polarization dependence. The detailed data analysis using the obtained ASF is in progress now.

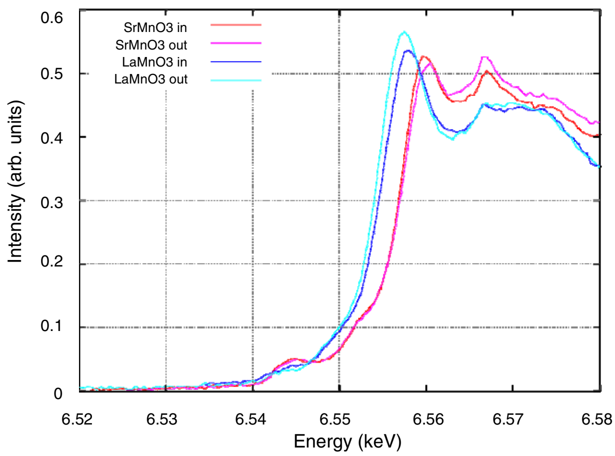

Figure: Fluorescence spectra of $LaMnO_3$/LSAT and $SrMnO_3$/LSAT. Here the polarization dependence of the spectra; the polarization is parallel to the in-plane and the out-of-plane, was also measured.

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* hironori.nakao@kek.jp