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Large negative magnetoresistance in superlattice $(LaMnO_3)_2(SrMnO_3)_2$ studied by a resonant x-ray scattering

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Introduction

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 at the interface. To make clear the origin, we have 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]

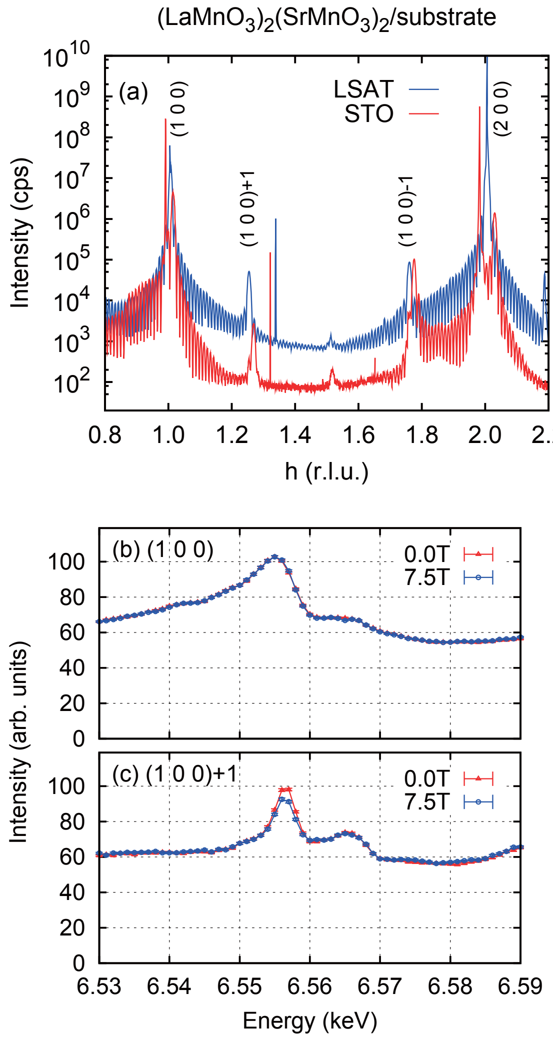
Experiment

The $(LaMnO_3)_2(SrMnO_3)_2$ (L2S2) was 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 film thickness is about 370 Å. The x-ray diffraction experiment was carried out at short gap undulator beamline (BL) 3A using a vertical field superconducting magnet on a two-axis diffractometer. A four-circle diffractometer was also used at the bending magnet BL-4C. The x-ray energy near Mn *K*-edge (~6.55 keV) was used for measuring resonant x-ray scattering (RXS) signals.

Results and Discussion

The sample quality was characterized by *Q* dependence of intensity along the stacking direction [1 0 0] as shown in Fig. (a); the *h* is defined by the LSAT lattice constant, *a*=3.87 Å. The L2S2 fabricated on $SrTiO_3$ (STO) substrate is also shown in the figure. The fundamental reflections, (1 0 0) and (2 0 0), and superlattice reflections, (1 0 0)±1, were clearly observed in both films, although the peak positions are different each other reflecting the difference of the substrate. The important difference is the visibility of the Laue function around *h*~1.5. We can easily see the Laue function in L2S2/LSAT and the intensity is much stronger than that of L2S2/STO. This result indicates that the stacking quality of the superlattice structure is remarkably improved in L2S2/LSAT compared with the case of L2S2/STO. It is consistent with that the intrinsic physical properties in artificial superlattice, large magnetoresistance effect, was only found in L2S2/LSAT.

In order to elucidate the magnetic field effect of Mn valence state, next, we have measure the energy dependence of scattering intensity at 0.0 T and 7.5 T as shown in Figs. (b) and (c). Clear magnetic field dependence was found at (1 0 0)+1 [Fig (c)] only near Mn *K*-edge energy, although no dependence was observed at (1 0 0) [Fig (b)]. Now, we think that this magnetic field dependence reflects the Mn valence state changing at the interface between $LaMnO_3$ and $SrMnO_3$. A detailed experiment and the data analysis will be continued.



[1] Y. Yamada *et al.*, Phys. Rev. B **81** (2010) 014410.
[2] H. Nakao *et al.*, J. Phys. Soc. Jpn. **78** (2009) 024602.
[3] M. Kawasaki *et al.*, Mater. Sci. Eng. **63** (1999) 49.