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XPS study of $Sm_2Ti_2O_7$ thin films of layered perovskite structure

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Introduction

Layered perovskite oxides $Ln_2Ti_2O_7$ (Ln = La, Pr, Nd) have attracted much attention for their ferroelectricity with very high T_C (1500 °C for $La_2Ti_2O_7$). They are the n = 4 members of the homologous series of layered perovskites which have a general formula $A_nB_nO_{3n+2}$. With respect to the usual perovskite structure, $Ln_2Ti_2O_7$ layered perovskite structure has an extra oxygen layer inserted along perovskite (110) plane after every four (n = 4) distorted perovskite units as shown in Fig. 1.

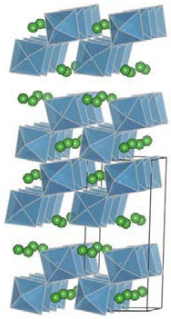

Fig.1 Structure of $Ln_2Ti_2O_7$ layered perovskites

On the other hand, $Ln_2Ti_2O_7$ with smaller size lanthanide atoms, such as $Sm_2Ti_2O_7$, are known to have a pyrochlore structure as the most stable phase.

Recently, we have succeeded in fabricating $Sm_2Ti_2O_7$ thin films of a layered perovskite structure on $SrTiO_3$ (110) substrates by pulsed laser deposition (PLD) method. In this study, X-ray photoelectron spectroscopy study has been performed to investigate the valence states of the Sm and Ti atoms.

Experiment

$Sm_2Ti_2O_7$ epitaxial films of the layered perovskite structure were fabricated on $SrTiO_3$ (110) substrates by PLD method using a pyrochlore $Sm_2Ti_2O_7$ target. The substrate temperature was 800 °C and the oxygen partial pressure was $1x10^{-4}$ Torr. The film thickness was about 60 nm. The crystal structure and the growth orientation of the films were determined by X-ray diffraction analysis and cross-sectional TEM measurement. The films have the epitaxial layered perovskite structure with oxygen additional layers parallel to the surface of the substrates. The layer-by-layer growth of the films was confirmed by RHEED observation during deposition.

The X-ray photoelectron spectra of the samples were measured at BL-7A of the the Photon Factory, KEK.The photon energy of synchrotron radiation was 800eV.

Results

The valence states of Sm and Ti in $Sm_2Ti_2O_7$ have been estimated by the core-level XPS results. Fig.2(a) shows the spectrum of Sm 4*d* core level. In this spectrum, only Sm^{3+} components are observed at the binding energies of 125 -1 42 eV. There is no Sm^{2+} component , which appears at the lower binding energy of 120 - 123 eV (ref. 1).

Fig. 2(b) shows the spectrum of Ti 2*p* doublet. There is only one component observed. The difference of binding energy between O 1*s* and Ti $2p_{3/2}$ levels is 71.4 eV, which is typical value for Ti^{4+} compounds (ref. 2).

The valence states determined from this XPS study, Sm^{3+} and Ti^{4+}, agree with the ones expected from the crystal structure obtained from XRD and TEM measurement, and thus support the growth of stoichiometric $Sm_2Ti_2O_7$ films.

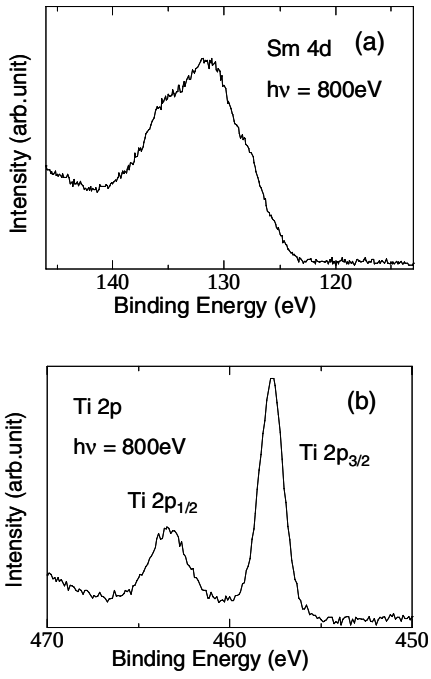

Fig.2 Core-level spectra of Sm 4*d* and Ti 2*p*

References

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