Materials Science

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XAS and XMCD of dilute magnetic semiconductor $(Fe,Co)_xNb_yTiO_{2-x-y}$

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Introduction

Oxide dilute magnetic semiconductors (DMS) are gathering much attention since their discovery[1] and yet there are still arguments on the origin of the magnetism. We measured X-ray magnetic circular dichroism (XMCD) and X-ray absorption spectroscopy (XAS) of a group of those materials, $(Fe\ or\ Co)_xNb_yTiO_{2-x-y}$ [2-4] to shed light on the oxide DMS. It is considered that local spin of Fe or Co is the origin of the magnetism whereas Nb provides n-type carriers that induce the ordering of the spins of magnetic dopants (Fe and Co). Nevertheless the energy levels of dopants have not been measured directly and it has been awaited in order to elucidate the origin of the magnetism.

Experiments

The samples were prepared by pulsed laser deposition epitaxial growth technique on $SrTiO_3(001)$ or $LaAlO_3(001)$ substrates. X-ray diffraction showed anatase TiO_2 structure. XAS and XMCD were measured at BL-7A under high vacuum (~ $3x10^{-6}$ Pa) with remanent condition after the application of ± 2000G. The XAS and XMCD signals were detected by using total electron yield technique. It is established that the n-type carrier concentration is nearly proportional to the Nb dopant concentration[4].

Results and Discussions

It was found that the XAS spectra changes during the measurement and the change was more significant when the carrier concentration was low. Figure 1 shows the time evolution of Fe L_3 - XAS of $Fe_{0.06}Nb_{0.002}TiO_2$. Two peaks, corresponding to Fe^{2+} and Fe^{3+} as indicated in the figure, change their ratio during the measurement. The change saturates after about two hours. It is reported that oxygen adsorbates on TiO_2 surface are removed by photoirradiation and it changes the band bending of TiO_2[5]. The time dependence of Fe^{2+}/Fe^{3+} ratio indicates that the energy level of Fe 3d is in the band gap of the doped material.

Figure2 shows the XAS of $Fe_{0.06}Nb_{0.01}TiO_2$ and $Fe_{0.06}Nb_{0.01}TiO_2$ after the X-ray irradiation effect was saturated. It shows that the ratio of Fe^{2+} is increased when Nb concentration is large, which indicates Nb donates electron to the Fe-TiO_2 system. XMCD of Fe,Co-Nb-TiO_2 system was observed and the analysis is underway.

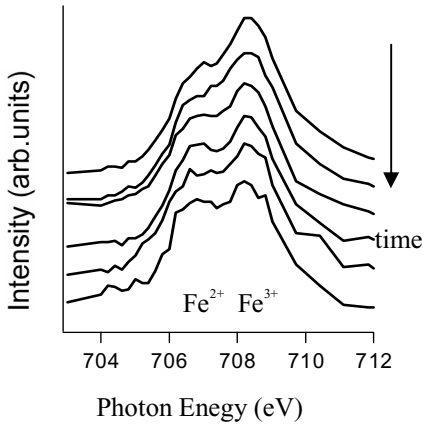

Fig. 1: Time evolution of Fe-L_3 XAS of $Fe_{0.06}Nb_{0.002}TiO_2$

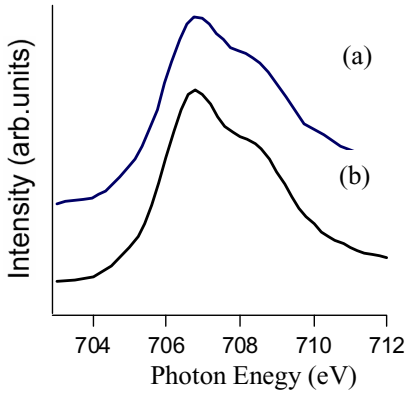

Fig. 2: Fe-L_3 XAS of (a) $Fe_{0.06}Nb_{0.01}TiO_2$ and (b) $e_{0.06}Nb_{0.01}TiO_2$

References

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