Magnetic Circular Dichroism of $2p \rightarrow 1s$ Resonant X-ray Emission Spectroscopy in Ferrimagnetic Ferrites $MFe_2O_4$ ($M=$Mn, Fe, Co, and Ni) and Y$_3$Fe$_5$O$_{12}$

Naomi KAWAMURA*1, Hitoshi OSAWA2, Syunsuke NOZAWA1, Toshiaki IWAZUMI3
1JASRI/SPRING-8, 1-1-1 Kouto, Mikazuki, Hyogo 679-5198, Japan
2Univ. of Tokyo, 5-1-5 Kashiwanoha, Kashiwa, Chiba 277-0882, Japan
3KEK-PF, 1-1 Oho, Tsukuba, Ibaraki 305-0801, Japan

Introduction

X-ray emission spectroscopy (XES) is a powerful tool to investigate electronic states in details. In particular, magnetic circular dichroism (MCD) of XES provides information about magnetic states. The pre-peak feature peculiarly observed in X-ray absorption spectrum (XAS) at the $K$-edge is still discussed as a possibility of $1s \rightarrow 3d$ electric quadrupole (E2) transition. MCD-XES can give us the answer about E2 transition more clearly. In this report we present the results of MCD-XES of $2p \rightarrow 1s$ emission, and discuss the electronic states of Mn, Fe, and Co in the ferrites.

Experimental

The experiment was performed at the beamline BL-28B. Polycrystalline ferrites ($MFe_2O_4$; $M=$Mn, Fe, Co, and Ni, Y$_3$Fe$_5$O$_{12}$) were used in this work. Magnetic field of Y$_3$Fe$_5$O$_{12}$ becomes opposite in sign to each other although observed at together with XES spectrum. MCD-XES signal is clearly spectrum is mainly shown two dispersion-type profiles; a negative one for $K\alpha_2$ of Y$_3$Fe$_5$O$_{12}$, while the MCD-XES spectrum at Mn, Fe and Co K-edges is obviously different from each other.

Results and Discussion

Figure 1 shows Fe $2p \rightarrow 1s$ MCD-XES and XES spectra in (a) Fe$_2$O$_4$ and (b) Y$_3$Fe$_5$O$_{12}$. Incident photon energy is 7111.5 eV, whose energy is corresponding to the pre-peak energy of $K$-edge XAS spectrum. The resemblance of these MCD-XES spectral profiles indicates that the origin of the dichroism in ferrites and its electronic states are quite similar, while the MCD-XAS spectrum at Mn, Fe and Co K-edges is obviously different from each other.

Mn and Co $2p \rightarrow 1s$ MCD-XES in MnFe$_2$O$_4$ and CoFe$_2$O$_4$ have been also observed. Figure 2 shows the result of MCD-XES for Mn $K\alpha_1$. The spectral profile is similar to the result of Fe$_2$O$_4$. The energy resolution was estimated to be about 2.0 eV in the measurement energy range.

Figure 1: Fe $2p \rightarrow 1s$ MCD-XES and XES spectra in (a) Fe$_2$O$_4$ and (b) Y$_3$Fe$_5$O$_{12}$. Incident photon energy is 7111.5 eV, whose energy is corresponding to the pre-peak energy of $K$-edge XAS spectrum.

Figure 2: Mn $2p \rightarrow 1s$ MCD-XES and XES spectra in (c) MnFe$_2$O$_4$. Incident photon energy is 6541.0 eV, whose energy is corresponding to the pre-peak energy of $K$-edge XAS spectrum.

References


* naochan@spring8.or.jp