Hard X-ray Magnetic Circular Dichroism of Laves Phase Compounds

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I. Introduction

X-ray magnetic circular dichroism (XMCD) has attracted much attention as a useful tool to investigate local magnetic states in ferromagnetic or ferrimagnetic materials.

Intermetallic compounds $HfFe_2$ and $TaFe_2$ crystallize in the hexagonal (C14) Laves phase structure. In pseudobinary system $Hf_{1-x}Ta_xFe_2$ magnetic properties change from ferromagnetic to antiferromagnetic ones with increasing x. Near the concentration of x = 0.2 a first order phase transition from ferromagnetic to antiferromagnetic state occurs with increasing temperature.

II. Experimental

The XMCD and XANES spectra were obtained in transmission method by using the right and left circularly porlarized X-ray on the BL39XU. The circularly polarized X-rays are produced by a diamond transmission phase plate. The photon helicity can be quickly reversed by changing the offset angle of the phase plate. The XMCD (XANES) spectrum are defined as the different (average) absorption with reversing the photon helicity under the magnetic field of 6 kOe. The spectrum was measured at the Fe K-edge and Hf $L_{2,3}$-edges for $Hf_{1-x}Ta_xFe_2$ (x=0.1,0.2).

III. Results and Discussion

Figure 1 shows the Fe K-edge XMCD spectrum in $Hf_{0.9}Ta_{0.1}Fe_2$ at room temperature. Magnitude of the spectrum is rescaled to the normalized XANES spectrum. The spectrum has three negative peaks at 7.111 keV, 7.118 keV and 7.125 keV. This means that 4p-electrons of Fe porlarized to negative direction.

Figure 2 shows the Hf $L_{2,3}$-edges XMCD spectrum in $Hf_{0.8}Ta_{0.2}Fe_2$ at T=30 K. The XMCD spectrum is negative (positive) at the Hf L_3-edges (L_2-edges). The feature directly shows the ferromagnetic ordering between the TM 3d and Hf 5d magnetic moments. We have evaluated the Hf 5d orbital, spin and total magnetic moments for $Hf_{1-x}Ta_xFe_2$ (x=0.1,0.2) by applying the present XANES and XMCD data to the sum rules. For x=0.1 we obtained <Lz> = -0.009 and <Sz>= -0.029. For x=0.2 we obtained <Lz> = 0.014 and <Sz>= -0.013. We think that the orbital moment play the important role of the AF-F phase transition.

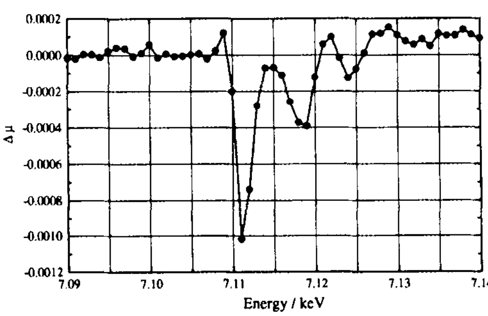

Fig.1 The MCXD spectrum at Fe K-edge in $Hf_{0.9}Ta_{0.1}Fe_2$

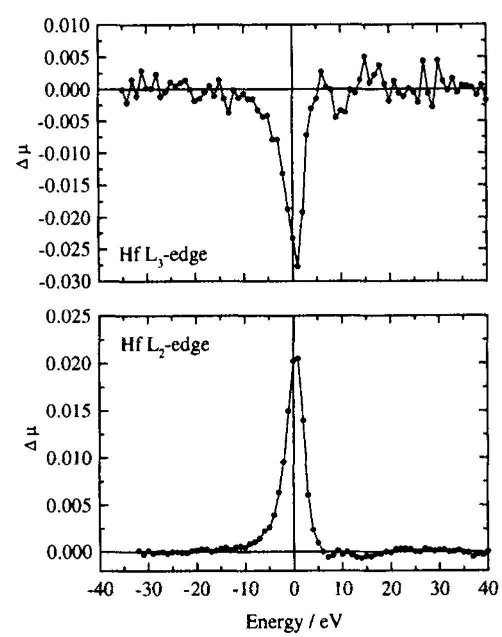

Fig. 2 The XMCD spectra at Hf $L_{2,3}$ edges in $Hf_{0.9}Ta_{0.1}Fe_2$