High-resolution resonant photoemission and MCD of $CeCo_{5-x}B_x$

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Ternary compounds of rare-earth (R), cobalt and boron atoms show a variety of interesting magnetic properties. RCo_4B and RCo_3B_2 are derivatives of RCo_5 with the $CaCu_5$-type structure. Nevertheless, the magnetic moments of Co atoms in these compounds are very different from those in RCo_5. In most cases, RCo_5 is a ferromagnet. Increase of the B concentration suppresses the ferromagnetic character leading to the decrease of T_C and in some cases ferromagnetism disappears in RCo_3B_2.

The crystal structure of these compounds is basically the hexagonal one composed of the Co and B atom layers. In RCo_5, there are two kinds of layers. One is the layer with R and Co, and the other is that with only Co. When B is substituted, Co sites of the former are replaced by B.

In the case of R=Ce, magnetic moment per Co atom is about 1.2 μ_B for $CeCo_5$, 0.35 μ_B for $CeCo_4B$ and $CeCo_3B_2$ shows paramagnetism. In addition, R=Ce systems are considered to be quite anomalous compared to the other systems in the sense that itinerant Ce 4f electrons partly fill the Co 3d band.

The purpose of this study is to reveal x dependence of the electronic and magnetic state of $CeCo_{5-x}B_x$ by observing the Co and Ce partial density of states through photoemission spectroscopy (PES) and the Co 2p and Ce 4f magnetic state through magnetic circular dichroism in the soft x-ray absorption (MCD).

For both PES and MCD, the polycrystalline sample was scraped in situ in the ultra-high vacuum of about 5×10^{-8} Pa in order to obtain a clean surface.

In order to obtain the Ce 4f and Co 3d partial density of state(PDOS), resonant photoemission at the Ce 3d→4f absorption was performed. The on(off)-resonance spectrum is considered to correspond to the Ce 4f (Co 3d) PDOS. The total resolution was set to about 100 meV. Both Ce 4f and Co 3d PDOS was found to be strongly dependent on x. The measured PDOS will be compared with the calculated PDOS of the CeCo5 and $YCo_{5-x}B_x$.

Ce 4f (Co 3d) magnetic state was probed using the MCD in Ce 3d→4f (Co 2p→3d) XAS. XAS was measured by the total photoelectron yield method by connecting the sample to the ground through a picoammeter. MCD was measured by altering the direction of the 1.4 T magnetic field applied to the sample at each photon energy. Prominent MCDs were observed in both XAS. By analyzing the MCD spectra, the direction and strength of both the spin and the orbital contributions to the magnetization will be discussed.