Magnetic circular dichroism of resonant X-ray emission for transition metals and rare-earth metals

Yasuhiro TAKAYAMA[1*], Motoki SHINODA[1], Chol LEE[1], Kenji OBU[1], Hidetsugu SHIOZAWA[1]
Hiroyoshi ISHII[1], Tsuneaki MIYAHARA[1], Jun OKAMOTO[2]
[1]Tokyo Metropolitan Univ., 1-1, Minamiohsawa, Hachioji-shi, Tokyo 192-0397, Japan
[2]JAERI, 1-1-1, Mikazuki-cho, Sayo-gun, Hyogo 679-5148, Japan

Introduction

Measurement of the magnetic circular dichroism (MCD) of x-ray absorption has been a powerful technique to study magnetism. Recently, some experiments of measuring the MCD of x-ray emission have been reported in soft and hard x-ray regions. In VUV region, however, only a few experiments of the resonant x-ray emission and no experiment for its MCD have been performed. In this study, we have developed the experiments of the x-ray emission spectroscopy in VUV region. For this purpose, we have measured 3p-3d and 4d-4f resonant x-ray emission for transition metals and rare-earth metals, respectively.

Experimental

The experiment was performed at a helical undulator beamline BL-28A. The detail of the instrument was explained in the reference [1]. The instrument was composed of a sample chamber and a spectrometer. The energy resolution of the spectrometer was about 0.14 eV and 0.40 eV for the photon energies of 60 eV and 120 eV, respectively. By reversing the magnetic field applied to the sample, MCD signal of the x-ray emission was observed. The total accumulation time for an excitation energy was about 3 hours.

Result and Discussions

Figure 1 shows the x-ray emission spectra of Cobalt metal for the excitation energies of 60.8 eV (A), 61.6 eV (B), 62.3 eV (C) and 63.1 eV (D). The energies of 60.8 eV and 63.1 eV are below and above the threshold of 3p-3d excitation, respectively. Energy Shift is defined as the subtraction of the energy of the incident photon from that of the emitted photon. A sharp peak and a broad peak of the Raman scattering were found at the energy shift of -0.6 eV and -3.9 eV, respectively. The origin of the broad peak is assumed to be the excitation to the non-bonding final state of the $3d^7$ and $3d^8$ configurations. A broad peak was also found in the x-ray emission spectra of Nickel metal at the energy shift of -4.6 eV, which may be assigned as the non-bonding final state of $3d^8$ configuration. No clear sharp peak, however, was observed in the x-ray emission spectra of Nickel. Figure 2 shows the x-ray emission spectra and their MCD for Terbium metal. We changed the excitation energies between 140.4 eV (a) and 153.9 eV (h). The excitation energy between 143.9 eV (b) and 147.5 eV (e) (149.6 eV (f) and 153.9 eV (h)) correspond to the 4d-4f resonant excitation to the pre-threshold (giant) peaks of the x-ray absorption spectra. At the energy shift of about -22 eV, a sharp peak of the Raman scattering was observed and the intensity of the peak resonantly enhanced for the excitation energy of 143.9 eV (b). A large negative MCD was also found in this peak. The peak is originated from the excitation of the electron in the 5p state to the 4f state. Another peak was found at the energy shift of about -4 eV. This peak is originated from the spin-flipped final state. These peaks were also observed in the spectra of Gadolinium, Dysprosium and Holmium metals, and the qualitative features of the spectra were very similar for these rare-earth metals.

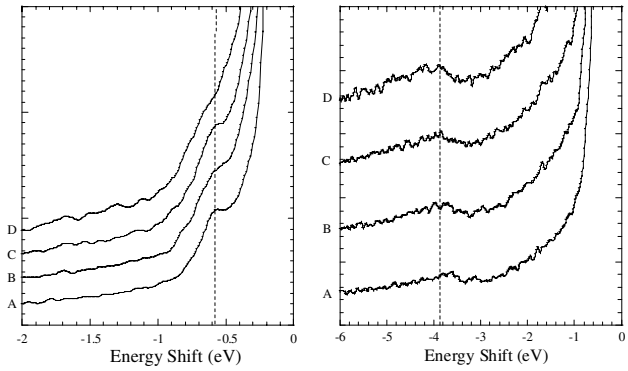

Figure 1: X-ray emission spectra for Cobalt metal.

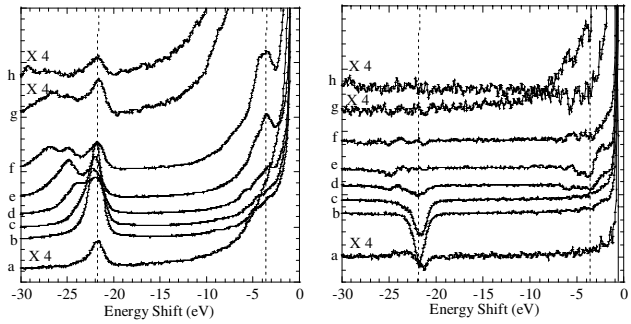

Figure 2: X-ray emission spectra (left) and their MCD (right) for Terbium metal.

References

[1] Y. Takayama et al., J. Phys. Soc. Japan, **71**, 340(2002).
[2] Y. Takayama et al., Surface Review and Letters (Proc. of VUV13,Trieste), (2002). to be published.

*takayama@phys.metro-u.ac.jp