Extreme ultraviolet photoabsorption spectroscopy by total electron yield method at BL1

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Photoabsorption spectroscopy in the energy range between several eV and several tens of eV may give information about electron excitation from the deeper part of valence bands or shallow core levels to conduction bands.

The number of secondary electrons excited by a photon is expected to depend strongly on photon energy in lower energy region. Therefore measurement by total electron yield (TEY) method is not necessarily straightforward. However, normalization by a representative material would, at least partially, remove this difficulty. Energy-loss spectrum of gold [1] does not have prominent peaks in the energy region between 5 and 20 eV. Although it has a step-like feature and peaks in the energy region between 20 and 40 eV, the heights of these features do not exceed twice of the intensity. Therefore, normalization of TEY intensity of the sample by that of gold is expected to be useful.

Photoabsorption measurements of rare-earth compounds by means of TEY method have been performed at BL-1 [2] at the SR Center of Ritsumeikan University. In the case of LaB_6, powder was spread on a piece of carbon tape. In the case of $CeAuSb_2$, a single crystal was fractured *in situ*. TEY was measured as drain current by ammeter. TEY of gold was measured at the post-focusing mirror, which is coated with gold, just before the sample.

Figure 1 shows typical photon energy dependence of I_0, the TEY current of gold on the

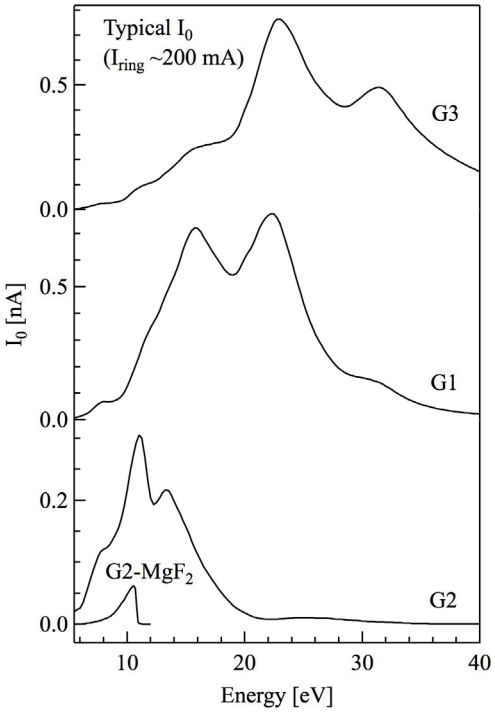

Figure 1. TEY current from gold on the post-focusing mirror for different settings of the monochromator.

mirror for different settings of the monochromator, namely, the choice of the grating (G2, G1 and G3 in the order of optimized photon energy range) and whether MgF_2 low-pass filter, which removes photons higher than 10.7 eV, was introduced (not introduced unless indicated). Spectra are normalized to a synchrotron ring current of 200 mA. The hump around 8 eV found in spectra without MgF_2 filter is not found when MgF_2 filter is introduced. Therefore, intensity found below ~ 9.5 eV is mainly due to higher order diffraction of the monochromator when the MgF_2 filter is not used.

Figure 2 shows the total electron yield spectrum of LaB_6 normalized by that of gold, i.e. I, the total electron yield current of the sample, divided by I_0, under settings without MgF_2 filter. Because higher order light dominates below ~ 9.5 eV, structures found in that regions are not intrinsic. Since the spectral shape between ~ 9.5 ev and ~ 13 eV depends on grating, real spectral shape cannot be determined in this region. The spectral shape between ~13 eV and ~ 25 eV is quite similar among the three gratings. For above ~ 25 eV spectral shape is similar between G1 and G3, whereas spectrum for G2 cannot be used because I_0 is too small in this region. Therefore, the spectral shape for G1 and G3 in the energy range above ~ 13 eV could be a good approximation of the intrinsic spectrum. The strong intensity around 20 eV is considered to be coming from the excitation of the La 5p core levels, which are at about 17 and 20 eV, to the s and d components of the conduction band. On the other hand, origin of the structure around 31 eV is not clear; La 5s has too large binding energy of 34 eV.

Figure 3 shows the total electron yield spectrum of LaB_6 and $CeAuSb_2$ with grating G2 and the MgF_2

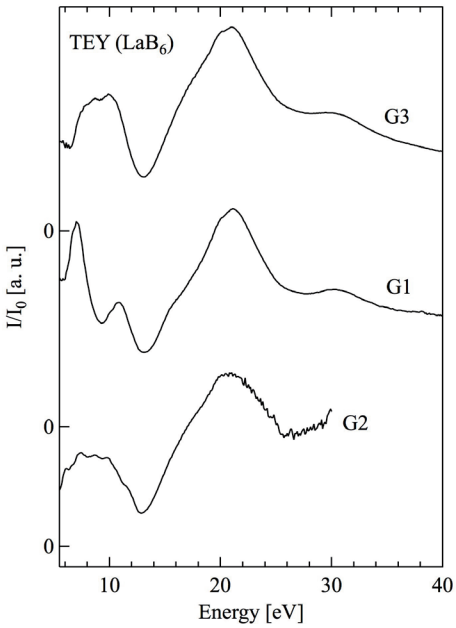

Figure 2. TEY spectrum of LaB_6 measured with different gratings at monochromator. Effect of higher order light is present

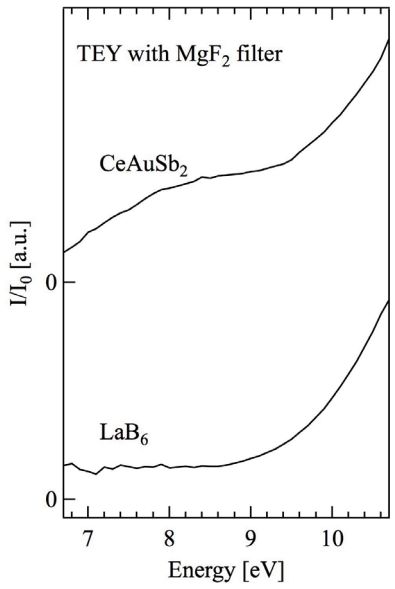

Figure 3. TEY spectrum of $CeAuSb_2$ and LaB_6 measured using MgF_2 filter. These spectra are not affected by the higher order diffraction of the monochromator.

filter. Since photons above 10.7 eV are removed by MgF_2 filter, the spectra shown in Fig. 3 is not affected by higher order diffraction. In the spectrum of $CeAuSb_2$, a broad hump is found around 8 eV and a steep increase above ~ 9.5 eV is also seen. The hump around 8 eV may be related to the electron excitation from the Au 6s component around the bottom of the conduction band to the unoccupied Au 6p state. Increase above 9.5 eV can be related to the excitation from Sb 5s around 10 eV to the unoccupied part of Sb 5p state. For LaB_6, on the other hand, photoabsorption intensity below ~ 9 eV is very weak and a steep increase is found above ~ 9.5 eV. This increase may be coming from excitation from the B 2s state around 10 eV to the unoccupied B 2p state.

References

[1] B. R. Cooper, H. Ehrenreich, and H. R. Philipp, Phys. Rev. **138**, A494 (1965).

[2] M. Yoshimura, S. Imada, K. Terashima, H. Eto, T. Ohta, Memoirs of The SR Center Ritsumeikan University, **14**, 147 (2012).