Resonant photoemission spectroscopy of $CeFe_4P_{12}$ and $CeRu_4Sb_{12}$

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Introduction

Ternary intermetallic compounds RT_4X_{12} (R= rare earth element, T= Fe, Ru, Os and X= P, Sb) with the filled skutterudite structure exhibit various interesting properties. According to the measurements on a high quality single crystal [1, 2], $CeFe_4P_{12}$ shows the complex temperature dependence of resistivity unexpected for a simple single-gap semiconductor; $CeRu_4Sb_{12}$ was thought to be a Kondo system with T_K=100 K. We investigated the electronic states of $CeFe_4P_{12}$ and $CeRu_4Sb_{12}$ by the Ce 3*d*-4*f* and Ce 4*d*-4*f* resolution resonant photoemission spectroscopy.

Experimental

The photoemission experiments were performed using synchrotron radiation at the beam lines BL-11D and BL-2C of the Photon Factory, High Energy Accelerator Research Organization (KEK). The instrumental resolutions were 65 meV and 250 meV for the 4*d*-4*f* resonance and the 3*d*-4*f* resonant photoemission, respectively.

Results and discussion

Figure 1 shows the Ce 4*f* spectra of $CeFe_4P_{12}$ measured by the Ce 3*d*-4*f* and Ce 4*d*-4*f* resonant photoemission. These spectra were obtained by subtracting the respective resonance minimum spectra from the respective resonance maximum spectra in the Ce 3*d* or 4*d* excitation regions. In the 4*f* spectra, the peaks located at ~2.6 eV and ~0.5 eV correspond to the f^0 and f^1 peaks, respectively.

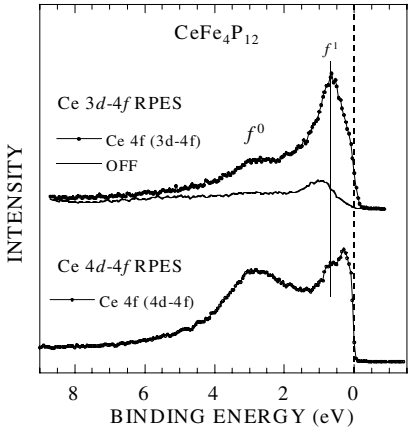

Figure 1: Ce 4*f* spectra of $CeFe_4P_{12}$ obtained by the Ce 3*d*-4*f* and 4*d*-4*f* resonant photoemission.

In the Ce 4*f* spectrum obtained by the 3*d*-4*f* resonant photoemission with a high bulk sensitivity, the intensity of the f^1 peak is very strong. This fact indicates the strong hybridization between the Ce 4*f* and the valence band states. The f^1 peak obtained by the Ce 3*d*-4*f* resonance was observed as a peak structure at 0.7 eV. On the other hand, the f^1 peak measured by the Ce 4*d*-4*f* resonance was observed as a shoulder at 0.7 eV. This different in spectral shape may due to the strong hybridization between the Ce 4*f* state and the Fe 3*d* band.

Figure 2 shows the Ce 4*f* spectra of $CeRu_4Sb_{12}$ measured by the Ce 3*d*-4*f* and Ce 4*d*-4*f* resonant photoemission. In the both spectra, the $f_{5/2}^1$ peak located just below E_F was observed as a shoulder structure. According to the experimental and theoretical results of the Ce 4*f* spectrum of a Kondo system [3], the spectral shape of the $f_{5/2}^1$ peak ascribed to the tail of the Kondo resonance peak varies from a shoulder to a prominent peak with increasing T_K. The shoulder structure for $CeRu_4Sb_{12}$ is similar to the feature observed in the very low-T_K Ce system. From that point of view, $CeRu_4Sb_{12}$ is a low-T_K system.

References

[1] H. Sato *et al*., Phys. Rev. **B 62** (2000) 15125.
[2] N. Takeda and M. Ishikawa: J. Phys.: Condens. Matter **13** (2001) 5971.
[3] F. Patthey *et al*., Phys. Rev. **B 42** (1990) 8864.

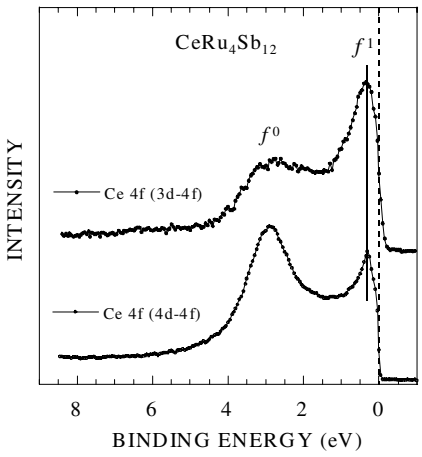

Figure 2: Ce 4*f* spectra of $CeRu_4Sb_{12}$ obtained by the Ce 3*d*-4*f* and 4*d*-4*f* resonant photoemission.

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