Wavelength-dispersive X-ray fluorescence analysis in 35-60 keV region: high-resolution K spectra for Lanthanides

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Introduction

A brilliant X-ray source in the high-energy region is extremely attractive for studying heavy elements such as Lanthanides, because it is now possible to excite K shell electrons. In the present study, we developed a wavelength-dispersive X-ray fluorescence (XRF) spectrometer for high-energy X-rays (35-60 keV). This will help us to explore both the chemical environment and electronic structure of Lanthanides, which are strongly correlated to the materials' exotic properties.

Methods and Materials

The method is X-ray fluorescence spectrometry using an analyzing crystal as shown in Fig.1. The experiments were performed at BL37XU B-branch, SPring-8, Harima, Japan. The primary X-ray photons used are 10th harmonics of an undulator beam, and the energy is 75.5 keV. The samples measured were cerium and gadolinium compounds.

Results

Figure 2 shows preliminarily obtained $K\beta$ XRF spectra of metallic gadolinium (pellet of 10 mm dia., 5 mm thickness). The energy resolution obtained was 39 eV and 58 eV, at Ce $K\beta_1$ (39.2574 keV) and Gd $K\beta_1$ (48.6964 keV), respectively. The spectra are ca. 10 times better than those obtained by means of conventional energy-dispersive measurement using a Ge detector, which can usually resolve only 2 peaks, $K\beta_1$ and $K\beta_2$.

Discussion

The intensity ratio of $K\beta_1$ and $K\beta_2$ has often been discussed in the context of the chemical states of the system [1], but unfortunately most previous research based on the use of a Ge detector had limitations, because the energy resolution was insufficient to permit the observation of greater spectral detail. As it is now possible to separate $K\beta_1$ and $K\beta_3$ peaks, as well as $K\beta_2$ and $KO_{II,III}$, changes in the spectra due to chemical effects can be studied much better than before. However, in the present case, differences observed in several compounds – metal, oxide and fluoride – were unclear. This might be due to quite low counts for the $K\beta_5$ and $KO_{II,III}$ peaks. In addition, a further improvement in energy resolution is necessary to resolve $K\beta_1$ and $K\beta_3$ peaks more clearly. As the spectrometer is still in the commissioning stage, it will be optimized in the near future to solve those problems. In addition, more realistic and complex compounds that exhibit differences in properties will be studied. Another area of interest besides the spectral intensity ratio will be the exploration of novel satellite peaks. A high-resolution XRF spectrometer for a relatively high energy range will be a new tool in fundamental spectroscopic studies as well as materials research.

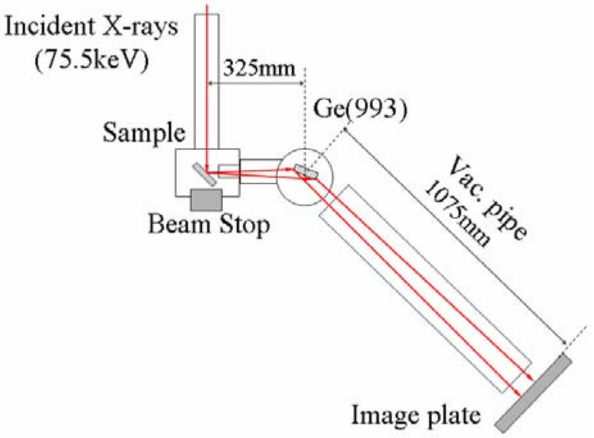

Fig. 1
Wavelength-dispersive XRF spectrometer for 35-60 keV.

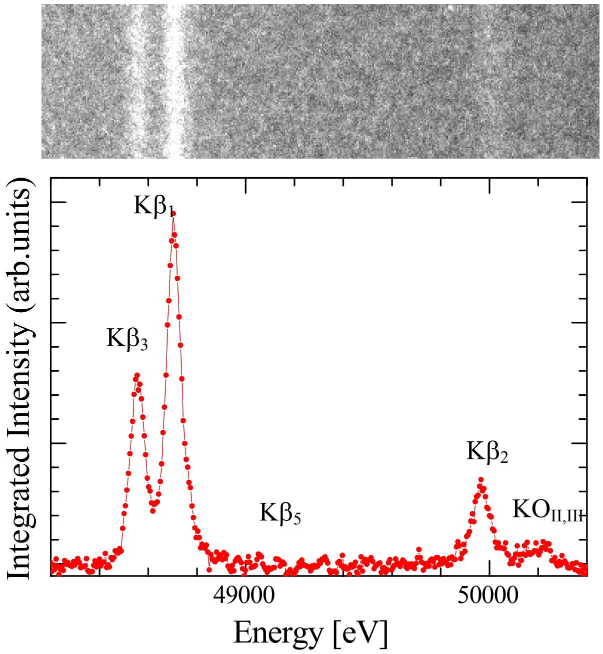

Fig. 2
$K\beta$ spectra of metallic gadolinium.

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References

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