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Ce-L_{III} XANES and XRD measurements using an asymmetrical diamond anvil cell

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Introduction

Alloys and compounds of Ce exhibit anomalous physical properties such as dense Kondo effect. The anomalies are very sensitive to changes in external pressure. In order to understand the origin of the anomalies, it is very important to estimate the quantitative values for Ce valences and Ce volumes in the alloys and compounds under high pressures. The present authors [1] developed a new technique for high pressure Ce-L_{III} x-ray absorption near edge structure (XANES) measurement using a Be-gasketed diamond anvil cell (DAC). In this work, a new optical geometry for obtaining a high pressure x-ray diffraction (XRD) pattern and a high pressure Ce-L_{III} XANES spectrum from a same specimenin the DAC is proposed, and a practical measurement for β-Ce_3Al alloy is described.

Optical Design and Experimental

Fig. 1 illustrates an essential part of our designed DAC, together with the path of x-ray beam. The powder sample imbedded in a Be-gasket is pressurized between an asymmetrical pair of diamond anvils with different thickness (0.8 and 1.8 mm). The incident x-ray beam penetrates the sample in the gasket through the upper anvil of a thin diamond. Theoretically, low energy x-rays around the Ce-L_{III} edge (~5.7 KeV) decrease to about 3% of the initial intensity after passing the diamond of 0.8 mm in thickness. When the penetrated x-rays are absorbed at the Ce-L_{III} edge, fluorescence Ce-L_α radiation occurs in all directions. We detected a part of the fluorescence x-rays passing through the Be-gasket using an SSD. Continuously, we can measured diffracted x-rays passing through the anvils using an imaging plate (IP) if only the incident x-ray changes to higher energy (> ~8 KeV).

The XANES and XRD measurements using an asymmetrical DAC were carried out at the facilities of BL-12C in PF-KEK. The XANES signals were collected at a 1 eV step (100 sec for 1 step) around the Ce-L_{III} edge. The XRD data were recorded with a x-ray beam of about 12.6 keV with a slit size of 0.2*0.2 mm^2.

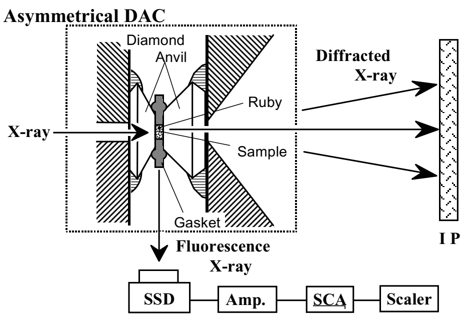

Fig. 1 Essential part of the diamond anvil cell, demonstrating the path of X-ray beams.

Results

Fig. 2 shows fluorescence Ce-L_{III} XANES spectra for β-Ce_3Al alloy, taken with the standard method (a) and the present method (b)~(d). These spectra exhibit only a single lines assigned to $4f^1$ configuration. It is clearly seen that the relative intensity and the fine structure of the spectrum (b) obtained at the newest (2003.2) is almost equivalent to those of the spectrum (a). This indicates that the present XANES measurement using the asymmetrical DAC is reliable and sufficient for evaluating the quantitative value of Ce valence under high pressure.

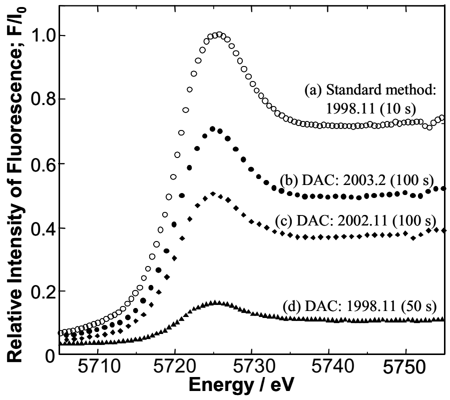

Fig. 2 Fluorescence Ce-L_{III} XANES spectra for β-Ce_3Al alloy, measured in different years.

Fig. 3 shows a example of the XRD photograph, obtained by the present DAC. Several diffraction rings from the powder alloy specimen (β-Ce_3Al) appear in Fig. 3, but the rings are some diffuse and ambiguous. In order to obtain more reliable XRD pattern, it is necessary to use a collimated incident beam and longer exposure time.

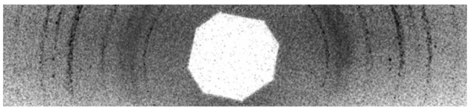

Fig. 3 XRD photograph for β-Ce_3Al powders, obtained with the asymmetrical DAC

References

[1] M. Itakura et al., Sci. Tech. High Press. 1, 479 (2000).

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