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X-ray diffraction study of RRu$_2$Al$_{10}$ (R=La, Ce, Yb, Lu) under high pressure

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1 Introduction

RRu$_2$Al$_{10}$ (R=La, Ce, Yb, Lu) crystallizes in the orthorhombic YbFe$_2$Al$_{10}$-type (space group *Cmcm* No. 63) crystal structure [1]. CeRu$_2$Al$_{10}$ exhibits a long range ordering (LRO) at unusually high temperature (T_0~27 K) [2-3]. The LRO suddenly disappears under pressure at 4 GPa. The sudden disappearance of LRO against pressure suggests that structural change could be happened at 4 GPa. On the other hand, YbRu$_2$Al$_{10}$ does not exhibit any particular order at ambient pressure. Yb^{3+} has one hole in 4f electron orbit while Ce^{3+} has one electron. Yb ion of YbRu$_2$Al$_{10}$ is in the intermediate valence state [4]. Thus, YbRu$_2$Al$_{10}$ may exhibit pressure-induced valence transition. In order to investigate a structural change on CeRu$_2$Al$_{10}$ and YbRu$_2$Al$_{10}$, we performed synchrotron X-ray diffraction study at room temperature under high pressure. In addition, we also measured LaRu$_2$Al$_{10}$ and LuRu$_2$Al$_{10}$ as a reference material of CeRu$_2$Al$_{10}$ and YbRu$_2$Al$_{10}$, respectively.

2 Experiment

Single crystals of RRu$_2$Al$_{10}$ (R=La, Ce, Yb, Lu) were grown by using Al self-flux method. The single crystals of RRu$_2$Al$_{10}$ were crushed into a fine powder. The X-ray diffraction measurements under high pressures were conducted using synchrotron radiation. An imaging plate was used as a detector. The pressure was applied by diamond anvil-type pressure cell. A 4:1 mixture of methanol/ethanol was used as a pressure-transmitting medium. The applied pressure was determined by a ruby fluorescence method.

3 Results and Discussion

Figure 1 shows the X-ray diffraction patterns of YbRu$_2$Al$_{10}$ under pressure. Although each peak is shifted to higher angle with pressure, no peak splitting or disappearance is observed. CeRu$_2$Al$_{10}$ shows the same behaviour. These indicate no structural change in both compounds. Fig. 2 shows pressure dependence of volume on LaRu$_2$Al$_{10}$, CeRu$_2$A$_{10}$, YbRu$_2$Al$_{10}$ and LuRu$_2$Al$_{10}$. Each volume monotonically decreases with pressure, which indicates no structural modification up to 10 GPa. While the volume of YbRu$_2$Al$_{10}$ and that of LuRu$_2$Al$_{10}$ is almost the same at ambient pressure, the volume of YbRu$_2$Al$_{10}$ is smaller than that of LuRu$_2$Al$_{10}$ over 4 GPa. This result suggest that valence of Yb in YbRu$_2$Al$_{10}$ gradually changes with pressure. Since the valence changes against pressure can lead valence transition, X-ray diffraction study over 10 GPa is needed.

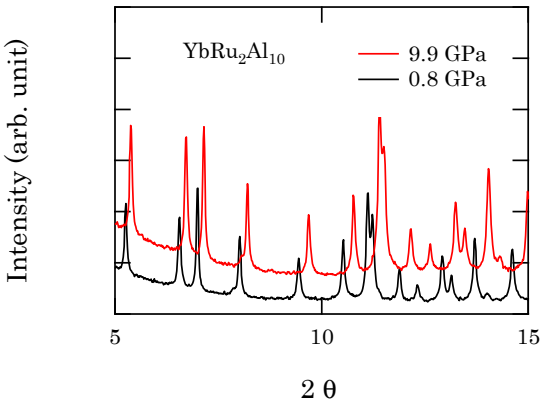

Fig. 1: X-ray diffraction pattern of YbRu$_2$Al$_{10}$ under 0.8 GPa (black) and under 9.9 GPa (red).

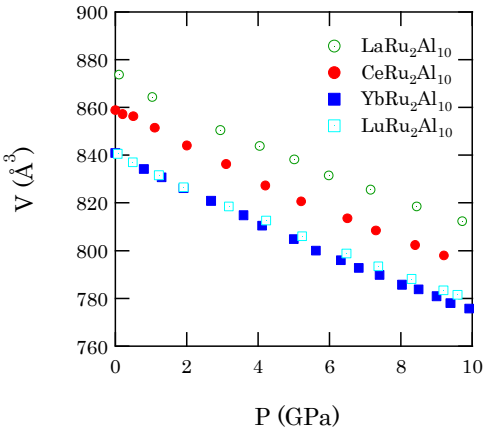

Fig. 2: Pressure dependence of volume on LaRu$_2$Al$_{10}$ (open circle), CeRu$_2$Al$_{10}$(closed circle), YbRu$_2$Al$_{10}$(closed square), LuRu$_2$Al$_{10}$(open square).

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References

[1] V. M. T. Thiede *et al.*, J. Mater. Chem. **8** (1998) 125.
[2] A. M. Strydom : Physica B **404** (2009) 2981.
[3] T. Nishioka *et al.*, J. Phys. Soc. Jpn **78** (2009) 123705.
[4] M. Sera et al., J. Phys. Soc. Jpn **82** (2013) 024603.

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