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Bulk Moduli of Superconducting filled skutterudites YT_4P_{12}(T= Fe, Ru and Os)

Junichi HAYASHI[*1], Kazuki MATSUI[1], Koujiro ITO[1], Keita AKAHIRA[1], Chihiro SEKINE[1],
Ichimin SHIROTANI[1], Takumi KIKEGAWA[2]
[1] Muroran Institute of Technology, Muroran, Hokkaido 050-8585, Japan
[2] KEK-IMSS, Tsukuba, Ibaraki 305-0801, Japan

Introduction

Filled skutterudites YT_4P_{12}(T= Fe, Ru and, Os) have been prepared at high temperatures and high pressures. Electrical and magnetic properties of these compounds have been studied at low temperatures. We have found the superconducting transition at around 7 K for YFe_4P_{12}, 8.5 K for YRu_4P_{12} and 1.8 K for YOs_4P_{12} [1-3] In a previous report, we have reported the results of the powder x-ray diffraction study for YFe_4P_{12} and YOs_4P_{12} at high pressures. Using synchrotron radiation, we have studied the powder x-ray diffraction for filled skutterudites YRu_4P_{12} at room temperature and high pressures. The bulk modulus is also obtained from the volume vs. pressure curve fitted by a Birch equation of state.

Experimental

Using a wedge-type cubic-anvil high-pressure apparatus, YT_4P_{12} (T= Fe, Ru and Os) were prepared at high temperatures and high pressures. Using synchrotron radiation, powder x-ray diffraction patterns of YT_4P_{12} (T = Fe, Ru and Os) were systematically measured with a diamond-anvil cell (DAC) and an imaging plate up to 10 GPa at room temperature. The measurement of the x-ray diffraction was carried out under hydrostatic conditions because the 4:1 methanol-ethanol solution used as pressure medium was solidified at around 10 GPa. Pressure in the DAC was determined from a pressure shift in the sharp R-line fluorescence spectrum of ruby grain.

Results and Discussion

Figure 1 shows the relative cell volume (V/V_0) vs. pressure for YT_4P_{12} (T= Fe, Ru and Os). The cell volume with the skutterudite-type structure monotonically decreases with increasing pressure up to 10 GPa. The compression curve for each skutterudites is fitted by a Birch equation of state. Bulk moduli of YFe_4P_{12}, YFe_4P_{12} and YOs_4P_{12} are 144 ± 2 GPa, 183 ± 4 GPa and 189 ± 4 GPa, respectively. The bulk modulus of YT_4P_{12} (T = Fe, Ru and Os) increases with increasing lattice constant. Figure 2 shows T_c vs. bulk modulus for RT_4P_{12} (R = La and Y; T = Fe, Ru and Os). The T_c of the superconducting skutteudites is highest for the Ru compounds. However, the Os compounds has the biggest bulk modulus. The linear relation between T_c and bulk modulus is not obtained for the superconducting skutterudites.
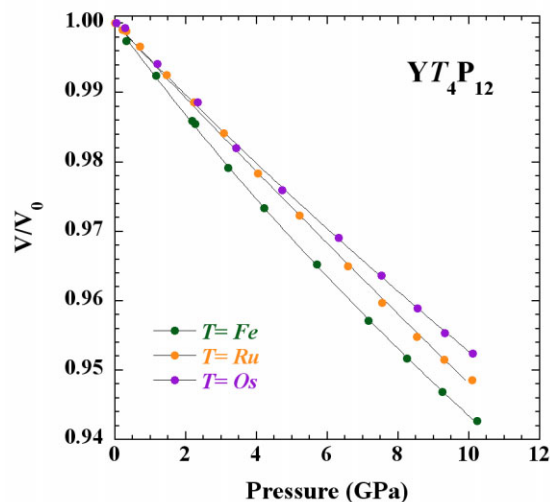

Fig. 1 The relative cell volume (V/V_0) vs. pressure curves for YT_4P_{12} (T = Fe, Ru and Os).

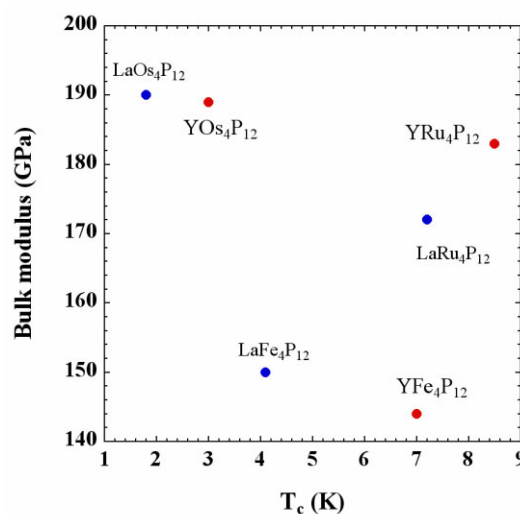Fig. 2 T_c vs. bulk modulus for RT_4P_{12} (R = La and Y; T = Fe, Ru and Os).

References

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* hayashi@mmm.muroran-it.ac.jp