

Pressure effect in metal-insulator transition system (Y,Ca)TiO₃ and Kondo insulator, CeRhAs and YbB₁₂

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The rare earth compounds CeRhAs and YbB₁₂ which form an energy gap and show semiconducting behavior by Kondo effect, and the transition metal alloys (Y,Ca)TiO₃ which causes metal-insulator transition due to strong Coulomb correlation have attracted the attention of many researchers.

It is known that CeRhAs successively forms a super-lattice structure at $T = 370$, 235 and 165 K, respectively. The mechanism of an energy gap formation may have an relation to the lattice instability due to this super-lattice formation. In order to acquire the information about energy gap formation from the response of the lattice against pressure, we investigated the relation between a lattice constant and pressure by using a DAC, up to 2.5 GPa, and from $T = 100$ to 260 K. The temperature dependence of the lattice constant, a , of orthorhombic structure at various pressures is shown in Fig. 1. From this figure, at the temperature below T_3 , we have found that the lattice constant changes from decreasing behavior to increasing with increasing pressure.

Fig. 2 shows pressure dependence of the lattice constant at $T = 230$ K of cubic Kondo semiconductor YbB₁₂. The loaded pressure was up to 50 GPa. Observed hump around 30 GPa at 300 K by T.L. should be related f -state of YbB₁₂, but strange hysteresis at this work is shown at 230 K.

Furthermore we have studied the pressure dependence of lattice constant of metal-

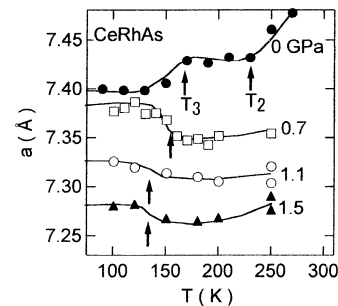


Fig. 1 Temperature dependence of lattice constant of CeRhAs at each pressure.

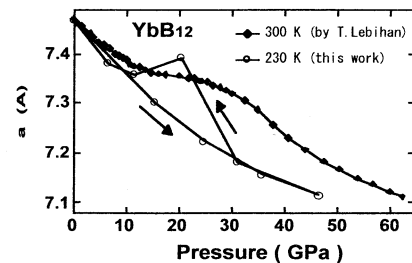


Fig. 2 Pressure dependence of lattice constant of YbB₁₂ at $T = 230$ K.

insulator transition system Y_{0.63}Ca_{0.37}TiO₃ up to 46 GPa. Phase separation was entirely disappeared at $P > 2$ GPa. The lattice volume became small with increase in pressure, and especially abnormalities were not seen in this variation.

The process of iron nitrides syntheses under high pressure and temperature.

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Iron and nitrogen forms many kind of iron nitrides, in which interstitial nitrogen atoms influence upon the magnetic properties. Although iron nitrides of Fe₄N, Fe₃N, and Fe₂N, can be synthesized from iron (*bcc* phase) and gaseous nitrogen at atmospheric pressure, there are composition limits in nitrogen content due to the difficulty in the interstitial of nitrogen atoms into *bcc* iron structure. We try to synthesize iron nitrides from high pressure phases of iron (*hcp* or *fcc* phase) and a supercritical fluid of nitrogen using a *in-situ* laser heating method under high pressure up to 30 GPa. In the previous study, we confirmed two kinds of iron nitride compounds for different pressure ranges by using a high pressure x-ray diffraction method and Moessbauer spectroscopy for laser-heated samples. One is known as a Fe₃N compound, which appears below 10 GPa after a laser heating. The other is a new magnetic phase, which can be synthesized at high pressure above 15 GPa. However, it partially decompose to *fcc* phase at atmospheric pressure. The high pressure phase of *hcp* iron is stable above 15 GPa even at room temperature. On the other side, *hcp* iron

converts into *fcc* structure at high temperature. In the present study, we tried to check which phase reacts with nitrogen to produce the new magnetic phase.

An iron foil sample was placed into a rhenium gasket with liquid nitrogen in a DAC. After applying a pressure up to 30 GPa, a continuous Nd:YAG laser was focused on to the sample from both sides. The temperature was monitored by radiation spectra. During heating, the sample was exposed by a monochromatic x-ray at BL-10XU. The diffraction patterns were continuously taken by an imaging plate under high P, T condition. The *hcp* iron quickly changes into the new magnetic phase at around 1300 K, which coincides with a transition temperature to *fcc* iron. Furthermore, we could not obtain the diffraction pattern from the *fcc* iron. Consequently, we conclude that the formation of the new phase occurred on the phase boundary between *fcc* and *hcp*, and the *fcc* is a key phase to produce the new phase.