Electrical resistivity of $CeTIn_5$ (T=Rh,Ir) under high pressure

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Abstract

We have researched the superconducting natures of $CeTIn_5$ (T=Rh,Ir) under high pressure in terms of electrical resistivitiy and superconducting phase in pressure-temperature phase diagram were determined for both samples and those exist in a wide pressure range (1.5 GPa $\leq P \leq$ 6.5 GPa :$CeRhIn_5$, 0 GPa $\leq P \leq$ 5.2 GPa :$CeIrIn_5$).

Key words: superconductivity; pressure; electrical; resistivity

Recently new heavy fermion superconductors, $CeTIn_5$ (T=Rh, Ir) were discovered [1,2]. The crystal structures for both samples are tetragonal $HoCoGa_5$-type structure. In $CeRhIn_5$ antiferro(AF)-magnetic order at ambient pressure is eliminated by the pressure at 1.4 GPa and induced the superconductivity at around 2 K above 1.6 GPa. $CeIrIn_5$ undergoes superconducting transition at two different temperatures in each measurement at ambient pressure. Electrical resistivity measurement indicates the zero-resistivity at 1.2K, while it indicates the bulk superconducting transition at T=0.4 K by Meissner effect of the magnetic susceptibility or the jump in the heat capacity.

We have already investigated the T_C-P phase diagram in $CeRhIn_5$ [3,4] and the natures in $CeIrIn_5$ under high pressure have been reported by magnetic susceptibility and specific heat [5], however, above 2 GPa no measurements have achieved yet. In this work, we perform the additional measurement of resistivities in $CeRhIn_5$ and $CeIrIn_5$ in order to verify the T_C-P phase diagram.

Electrical resistivity measurements under high pressure over 3 GPa were accomplished by the diamond-anvil-cell (DAC) [6]. The commercial oil (Daphne oil 7373) [7] is used as the pressure medium. Single crystals of $CeIrIn_5$ and $CeRhIn_5$ were grown up by Indium-flux-method and high purity of samples with residual resistivity ratios of 106 for $CeRhIn_5$ and 72 for $CeIrIn_5$ were cut out and selected for the purpose of these measurements. The electrical currents run parallel to the c-planes for both samples.

The low temperature resistivities in $CeTIn_5$ (T=Rh, Ir) do not obey T^2 law of the Landau Fermi liquid behavior in our measurement pressure range. In $CeRhIn_5$ T-dependence of resistivity in low temperature show T-linear which means the 2D AF fluctuation by SCR theory [8]. Typically at 4.0 GPa in $CeRhIn_5$ T-linear behavior reveal in $T_C \leq T \leq 8$ K [Fig. 1]. In $CeIrIn_5$ T-dependences indicating $T^{1.5}$ at 2.2 GPa and 3.1 GPa reveal in $T_C \leq T \leq 4$ K and $T_C \leq T \leq 6$ K, respectively and especially at 3.1 GPa and the magnetic field of 3 T where the superconductivity completely disappears the power of resistivity is 1.5 at least over 0.3 K [Fig. 2]. In all pressure range resistivity exponents of $CeIrIn_5$ in low temperature region are within the bound of $1.2 \leq n \leq 1.7$ ($\rho=\rho_0+aT^n$) at low temperature limits. These behaviors are approximately compatible with 3-D AF fluctuation in SCR theory. The difference might originates from the variation of the ratio of crystal lat-

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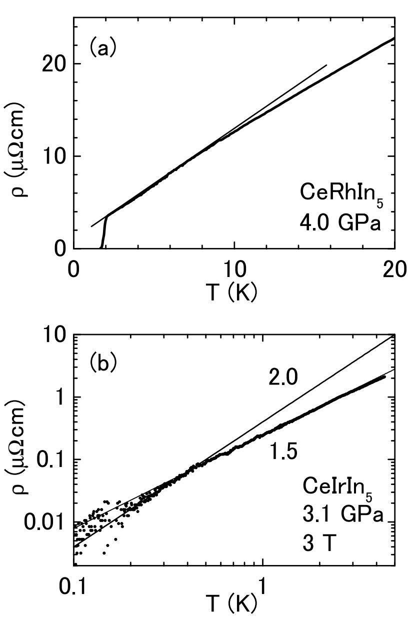

Fig. 1. (a) Resistivity at low temperature at 4.0 GPa in $CeRhIn_5$, which indicate T-linear variation. (b) Logarithmic plot of resistivity at 3.3 GPa and 3.0 T in $CeIrIn_5$, of which exponent is 1.5 at least over 0.3 K.

tice lengths between c- and b-axis (c/a), (c/a=1.611 in $CeIrIn_5$ $\leq$ c/a=1.621 in $CeRhIn_5$) by the substitution of Rh and Ir.

The T_C-P phase diagram of $CeTIn_5$ (T=Rh, Ir) determined by the temperatures at which resistivities indicate zero value are shown in Fig. 2. In our previous works for $CeRhIn_5$ we had already reported about the minimum of T_C at 5.2 GPa in superconducting phase. However, in this work, superconducting phase exists in the pressure range of 1.5 GPa $\leq$ P $\leq$ 5.2 GPa and no minimum in superconducting phase is observed by the additional measurements. This reason is possibly due to the reduction of the hydrostaticity above 2 GPa where the pressure medium is predicted to solidify at room temperature. In $CeIrIn_5$, we have also confirmed T_C-P phase diagram and it exists in the pressure region of 0 GPa $\leq$ P $\leq$ 5.9 GPa. T_C goes on increasing up to 1.05 K at 2.2 GPa with pressure and exhibits a broad maximum at around 2.2 GPa $\leq$ P $\leq$ 3.1 GPa. The behavior of T_C in low pressure region under 2.2 GPa is consistent with the latest reports [5].

In conclusion we have confirmed the superconducting phase diagrams under high pressure region in $CeTIn_5$ (T=Rh, Ir) and the exponents in the low temperature resistivities are 1 for $CeRhIn_5$ and around 1.5 for $CeIrIn_5$ under the influence of the crystal structures.

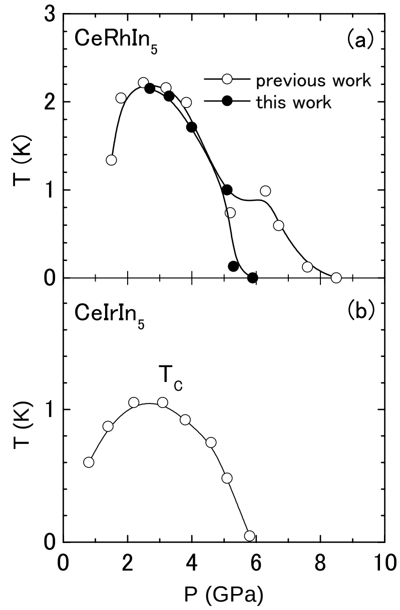

Fig. 2. Pressure-temperature phase diagram of superconductivity in (a) $CeRhIn_5$ and (b) $CeIrIn_5$. T_C was determined at zero resistivity temperature. Superconducting phase diagram in $CeRhIn_5$ is different from previous work. Superconductivity phase in $CeIrIn_5$ exists from 0 GPa to 5.8 GPa and has the maximum around 2.2 GPa $\leq$ P $\leq$ 3.1 GPa.

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