Effect of Pressure on the Electrical Resistivity of Heavy Fermion Antiferromagnet Ce_2RhIn_8

Shigeo Ohara [1], Yoshinobu Shomi, Isao Sakamoto

Department of Electrical and Computer Engineering, Nagoya Institute of Technology, Nagoya 466-8555, Japan

Abstract

Heavy-fermion antiferromagnet Ce_2RhIn_8 is structurally related to the pressure-induced superconductor $CeRhIn_5$. We have measured pressure dependence of the electrical resistivity up to 1.6 GPa in the temperature range 1.5-300 K for Ce_2RhIn_8. We have found that the Néel temperature T_N decreases by pressure at the rate of -0.8 $KGPa^{-1}$. This large decrease of T_N is a contrast to the case of $CeRhIn_5$ in which T_N has very weak pressure dependence.

Key words: heavy fermion, pressure effect,electrical resistivity, Ce_2RhIn_8

1. Introduction

In recent years, heavy-fermion antiferomagnet Ce_nRhIn_{3n+2} (n=1, 2 or ∞) have attracted much attention, since pressure-induced superconducting transition were discovered for cubic $CeIn_3$ (n=∞) and tetragonal $CeRhIn_5$ (n=1). At ambient pressure, $CeIn_3$ and $CeRhIn_5$ are antiferromagnet below T_N =10 and 3.8 K, respectively.[1,2] Applying pressure, both exhibit superconducting transition with T_C=0.25 K at P=2.5 GPa for $CeIn_3$ and T_C =2.0 K at P=1.6 GPa for $CeRhIn_5$. [2,3] Ce_nRhIn_{3n+2} can be viewed n layers of $CeIn_3$ are stacked separated by a layer of $RhIn_2$. [4] Tetragonal Ce_2RhIn_8, which is a n=2 member, has an intermediate crystal structure between $CeIn_3$ (n=∞) and $CeRhIn_5$ (n=1). Ce_2RhIn_8 orders at T_N=2.8 K and the magnetic structures are the same as those in $CeIn_3$. [5] For further understanding magnetic and electronic properties of Ce_2RhIn_8, we have grown the single crystals of Ce_2RhIn_8 and carried out the resistivity measurements under hydrostatic pressure.

[1] Corresponding author. Present address: Department of Electrical and Computer Engineering, Nagoya Institute of Technology, Nagoya 466-8555, Japan E-mail: ohara@elcom.nitech.ac.jp

2. Experimental

Single crystals of Ce_2RhIn_8 were grown using a flux technique described elsewhere.[6] Powder X-ray diffraction spectra, which obtained using the crushed single crystals, were well indexed by the tetragonal Ho_2CoGa_8-type structure with lattice parameters a=4.664 Åand c=12.25 Å. [4] The crystal orientation was determined by a usual Laue method. The typical sizes of grown crystals were 3 mm along the ab-plane and 0.5 mm along the c-axis. Measurements of the electrical resistivity along the a-axis were carried out using a four-probe DC method under hydrostatic pressure in a clamp-type pressure cell.[6] The temperature dependence of resistivity were measured under fixed pressures up to 1.6 GPa in the range 1.5-300 K.

3. Results and Discussion

Figure 1 illustrates the resistivity along the a-axis for Ce_2RhIn_8 as a function of logarithmic temperature log T under the hydrostatic pressure P=0,1.0 and 1.6 GPa. In any pressure,the resistivity shows -log T dependence below about 100 K, and exhibit a peak at T_{max}. As shown in the inset of Figure 1, T_{max} increases linearly

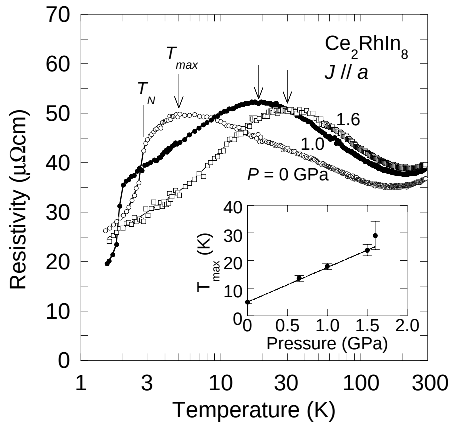

Fig. 1. The resistivity as a function of log T for Ce_2RhIn_8 along the a-axis at $P = 0$ (open circle),1.0 (closed circle) and 1.6 GPa (open square) . The arrows indicate the resistivity maximum temperature T_{max}. The inset shows pressure dependence of T_{max}.

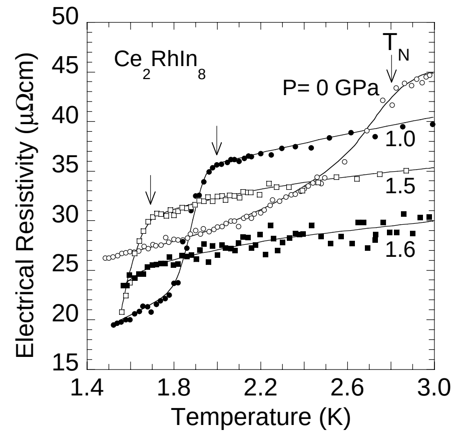

Fig. 2. The low temperature resistivity for Ce_2RhIn_8 along the a-axis at several constant pressures P=0, 1.0, 1.5 and 1.6 GPa. The arrows indicate the T_N.

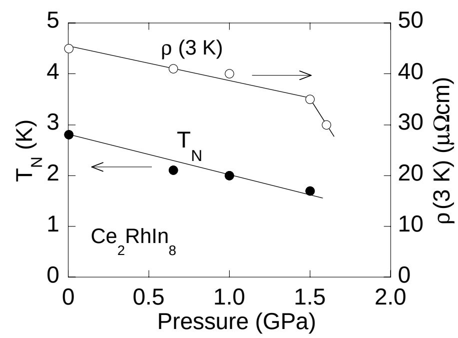

Fig. 3. The pressure dependences of the T_N and the resistivity at 3 K, ρ(3 K), for Ce_2RhIn_8.

by pressure with the rate +12.5 $KGPa^{-1}$. Since T_{max} is roughly proportional to Kondo temperature T_K, the pressure dependence of T_K may be inferred in the inset of figure 1. With increasing the pressure, the resistivity increased linearly at high temperature region and the negative logarithmic slope becomes steeper.These results are typical for Ce-based heavy-fermion compounds.

At ambient pressure (P=0), the resistivity exhibits a large drop at the Néel temperature T_N= 2.8 K and gradually reaches residual resistivity about 26 $\mu\Omega$cm with decreasing temperature. The details of the low temperature variations of resistivity under several fixed pressures are shown in Figure 2. Applying the pressure, T_N decreases as indicated by arrows in Figure 2. At 1.6 GPa, magnetic order is not observed above 1.5 K.As shown in Figure 3, T_N decreases linearly up to 1.5 GPa at the rate of -0.8 $KGPa^{-1}$. This large decrease is contrast to the case of $CeRhIn_5$, in which T_N slightly increases with pressure.

As clearly seen in Figure 2, the low temperature resistivity is largely reduced by pressure. We could not determine the residual resistivity above 1.5 GPa, thus we plot the resistivity at 3 K,ρ(3 K), versus pressure in Figure 3. The ρ(3 K) decreases linearly with pressure up to 1.5GPa, and show a drop at 1.6 GPa.

Very recently pressure-induced superconducting transition and P-T phase diagram for Ce_2RhIn_8 were reported in ref. 7. Above 1.6 GPa, magnetic order is disappeared and only a superconductivity phase exists. [7] The decreasing rate of T_N with pressure is good agreement with our data. The sharp bend in the ρ(3 K) - P line at 1.6 GPa in Figure 3 may be related to the disappearance of magnetic order at this pressure.

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