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Specific heat and transport properties of filled skutterudite compound $GdRu_4P_{12}$

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The filled skutterudite compound $GdRu_4P_{12}$ is reported to exhibit an antiferromagnetic ordering below $T_N = 22$ K.[1] The electrical resistivity first decrease from room temperature down to T_N, below which it shows a sudden increase.[1,2] To clarify this mechanism, we have investigated the temperature and magnetic field dependences of Hall effect and magnetoresistance. We also report the specific heat in magnetic fields in the temperature range $T = 0.2$ K to 50 K. Sample was prepared by high-pressure synthesis at 6 GPa and 1250   during 2 hours. X-ray diffraction indicates that a main impurity phase of RuP_2 is about 2%. The electrical resistivity $\rho \sim 500$ $\mu\Omega$·cm at room temperature is smaller than the previous reported value of $\rho \sim 3$ mΩ·cm, suggesting the better crystallinity of the present sample.[2] Figure 1 shows the temperature dependence of Hall coefficient. The sudden drastic increase of Hall coefficient below T_N indicates some change in Fermi surface as a result of superzone gap formation associated with the antiferromagnetic ordering. At room temperature, R_H is positive and the hole density is $n \sim 2.5$ /f.u. The hole density at $T = 5$ K is $n \sim 0.3$ /f.u., which is about 1/10 of the value at room temperature. R_H has a minimum close to zero at around $T = 40$ K, above which it gradually increases up to room temperature. Figure 2 shows the temperature dependence of specific heat divided by temperature C/T. As a remarkable feature, we found a large electronic specific heat coefficient of $\gamma \sim 500$ mJ/mol K^2 at $T = 0.2$ K. The large electronic specific heat coefficient decreases with increasing magnetic fields, and reaches $\gamma \sim 85$ mJ/mol K^2 at $B = 8$ T. Furthermore, C/T has a broad peak around $T = 6$ K, and a sharp peak at $T = 4.1$ K in zero magnetic field. The origins of both peaks are not yet clarified.
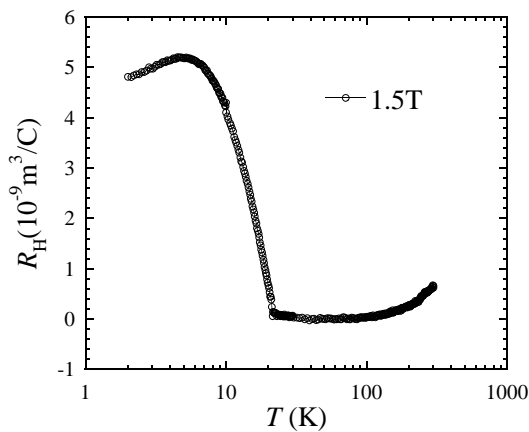

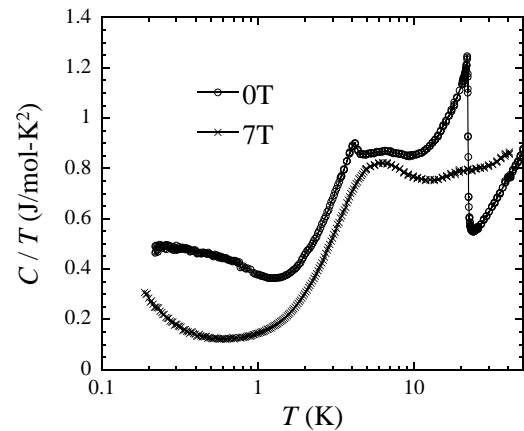Figure 1: Hall coefficient $R_H = \rho_H/B$ for $GdRu_4P_{12}$ at $B = 1.5$ T.

Figure 2: Specific heat divided by temperature C/T for $GdRu_4P_{12}$ at $B = 0$ T, 7 T.

[1] C. Sekine et al., Phys. Rev. B 62 (2000) 11581.
[2] K. Matsuhira et al., Physica B 378-380 (2006) 235.