High field magnetostriction of $CeRh_2Si_2$

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Abstract

Magnetostriction measurements on a single crystal $CeRh_2Si_2$ were performed by using a strain gauge in pulsed high magnetic field. Both longitudinal and transverse magnetostrictions for $H//[001]$ show expansions around the field of 26T where a metamagnetic transition has been observed in the magnetization curve. The volume change at the transition, $\Delta V/V$, is estimated to be about 1.0×10^{-3}, suggesting a large volume(pressure)effect on the matamagnetic transition in $CeRh_2Si_2$.

Key words: magnetostriction ; $CeRh_2Si_2$; metamagnetic transition ;

1. Introduction

Ternary silicides CeT_2Si_2 with the $ThCr_2Si_2$-type tetragonal crystal structure have been attracting a great deal of interest because they show a variety of phenomena such as an antiferromagnetic order, Kondo lattice and superconductivity. $CeRh_2Si_2$ is the antiferromagnet with the ordering temperature $T_N = 36$ K and has an ordered moment of about 1.4 μ_B below T_N.[1] The high field magnetization measurement [2] revealed that a two-step metamagnetic transition occurs at 25.5 T for $H//[001]$. When an external pressure is applied on the sample, T_N and the value of the ordered moment decrease with increasing pressure, and T_N vanishes at a quantum critical pressure of $p_c \sim 10$ kbar,[1,3] where superconductivity was found as well.[4] The pressure effect on the magnetism was studied by susceptibility and magnetization measurements and it was found that the metamagnetic transition shifts to higher field, becoming broad with increasing pressure, and the metamagnetic transition does not disappear but survives above p_c.[5] The temperature dependence of this transition field shows monotonous increase with increasing temperature, indicating this metamagnetic transition is not related to the antiferromagnetic order but to the heavy fermion paramagnetic state as observed in $CeRu_2Si_2$. In this paper, we studied the magnetostriction on a single crystal $CeRh_2Si_2$ in order to have a further information about the volume effect on the metamagnetic transition.

2. Experimental

Single crystals of $CeRh_2Si_2$ were grown by the Czochralski pulling method in an argon atmosphere by using a tri-arc furnace. The high magnetic field was generated by a long pulse magnet driven by a D-2 capacitor bank of 1 MJ. The pulse duration is about 50 ms. Longitudinal and transverse magnetostrictions were measured by using strain gauges which were pasted on the sample so as to detect parallel and perpendicular strains along [001], respectively. Figures 1 (a) and (b) show an electrical circuit and a schematic view around the sample stage, respectively. Circuit lines of the sample and dummy gauges are connected in series in order to compensate background signals, and remaining field-induced signals are canceled by
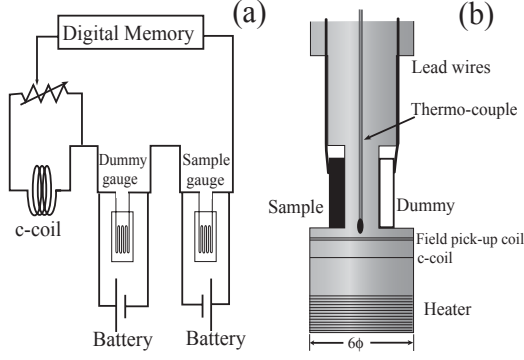
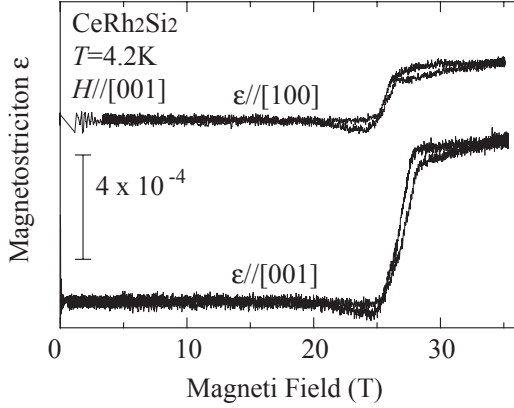Fig. 1. Electrical circuit(a) and a schematic view around the sample stage(b).

Fig. 2. Magnetostriciton curves of $CeRh_2Si_2$ measured at 4.2K for $H//[001]$.

using a c-coil. We used a quartz as the dummy sample. Two sets of the data were recorded by changing the polarity of currents and they are subtracted each other to extract the voltage change due to the magnetostriction of the sample.

3. Results and Discussion

Figure 2 shows longitudinal and transverse magnetostrictions with the field applied along [001] at 4.2 K. There is almost no length change below 25 T. The magnetostriction begins to increase at about 25 T and almost saturates above 27 T for both directions. The length changes at the transition are 6×10^{-4} and 2×10^{-4} for [001] and [100] directions, respectively, so that the volume expansion is estimated as $\Delta V/V \sim 1.0 \times 10^{-3}$. This volume change at the transition was the same order of magnitude as that in the typical heavy fermion compound $CeRu_2Si_2$.[6]

The longitudinal magnetostriction curves at several temperatures are shown in Fig. 3. The magnetostric-
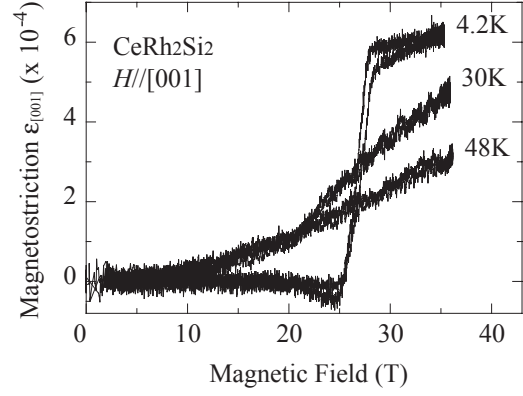

Fig. 3. Longitudinal magnetostriction curves in $CeRh_2Si_2$ at several selected temperatures for $H//[001]$.

tion at 30 K increases slowly in a low field region, and changes the slope at about 20 T, where the magnetization shows a metamagnetic transition.[2] The magnetostriction at 48 K, which is above T_N, only gradually increases with increasing field. From these results, it is suspected that the step-like magnetostriction corresponds to the metamagnetic transition in the magnetization. As mentioned above, the metamagnetic transition field shifts to higher fields and the value of the ordered moment is suppressed by applying pressure.[1,5] The positive volume change at the metamagnetic transition seems to be consistent with the pressure effect on the magnetization.[5]

Acknowledgements

References

[1] S. Kawarazaki, M. Sato, Y. Miyako, N. Chigusa, K. Watanabe, Phys. Rev. B**61** (2000) 4167.

[2] R. Settai, A. Misawa, S. Araki, M. Kosaki, K. Sugiyama, T. Takeuchi, K. Kindo, Y. Haga, E. Yamamoto, Y. Ōnuki, J. Phys. Soc. Jpn. **66** (1997) 2260.

[3] H. Mori, N. Takeshita, N. Môri, T. Uwatoko Physica B**259&261** (1999) 58.

[4] R. Movshovich, T. Graf, D. Mandrus, J. D. hompson, J. L. smith, Z. fisk Phys. Rev. B**53** (1996) 8241.

[5] T. Hamamoto, K. Kindo, T. C. Kobayashi, Y. Uwatoko, S. Araki, R. Settai, Y. Ōnuki Physica B**281&282** (2000) 64.

[6] A. Lacerde, A. de Visser, L. Puech, C. Paulsen, P. Haen, P. Lejay, J. Flouquet Physica B**171** (1991) 312.