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Superconductivity and magnetism of the R_6Ni_2Sn (R = Y and rare earth) compounds

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Abstract

We have performed AC electrical resistivity ρ, DC magnetic susceptibility χ_{DC} and heat capacity $C(T)$ measurements on the ternary compounds R_6Ni_2Sn (R = Y and rare earth). Our results show that La_6Ni_2Sn becomes superconducting with $T_c \sim 2.3$ K. Except for R = Y, Ce, and Pr, most of the R_6Ni_2Sn compounds undergo various magnetic transitions as revealed from the appearance of features in both $\chi(T)$ and $C(T)$ curves, and changes of the slopes in the $\rho(T)$ curves. Ce_6Ni_2Sn is a heavy fermion compound with its specific heat C/T increases logarithmically for $1\,K < T < 7\,K$ and reaches a value of $\sim$160 mJ/mol Ce–K^2 at 0.35 K.

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Keywords: Superconductivity; Magnetic transition; Heavy fermion

The R_6Ni_2Sn (R = rare earth) compounds belong to the Ho_6Ni_2Ga-type structure with space group Immm [1]. Among them, Er_6Ni_2Sn has been mostly studied because of its usage for the magnetic refrigeration [2,3]. Recent study reveals that La_6Ni_2Sn is a type-II superconductor with a transition temperature T_c of 2.25 K [4]. To have further understanding about these compounds, we have studied the transport, magnetic, and specific heat properties of these systems.

Polycrystalline samples of R_6Ni_2Sn (R = Y and rare earth) were prepared by arc-melting stochiometric amounts of the constituent elements (R: 99.99%, Ni: 99.99%, Sn: 99.9999%) together on a water-cooled copper hearth in a Zr-gettered argon atmosphere. The as-melted samples were subsequently wrapped in Ta foil, sealed in quartz tube in argon atmosphere, and annealed at 550 °C for 3 days. AC electrical resistivity of bar-shaped samples has been measured in a ^{4}He cryostat

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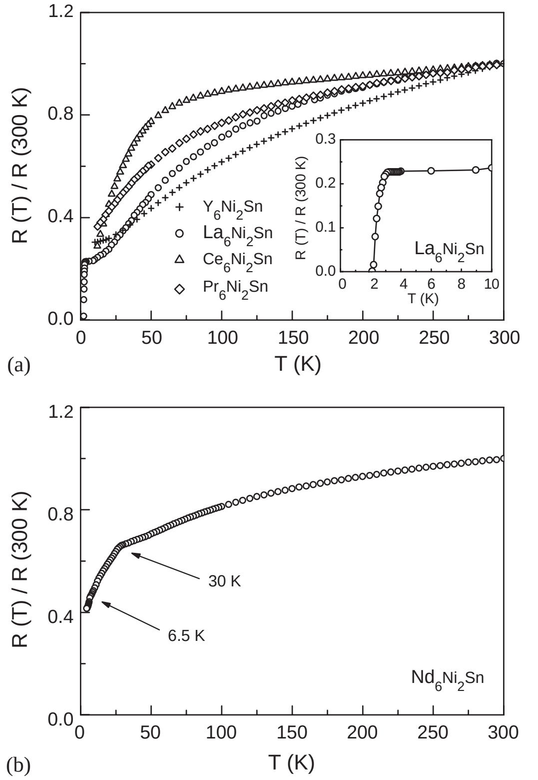

Fig. 1. (a) $R(T)/R(300\,\mathrm{K})$ curves for R_6Ni_2Sn (R = Y. La, Ce, and Pr). (b) $R(T)/R(300\,\mathrm{K})$ curves for Nd_6Ni_2Sn.

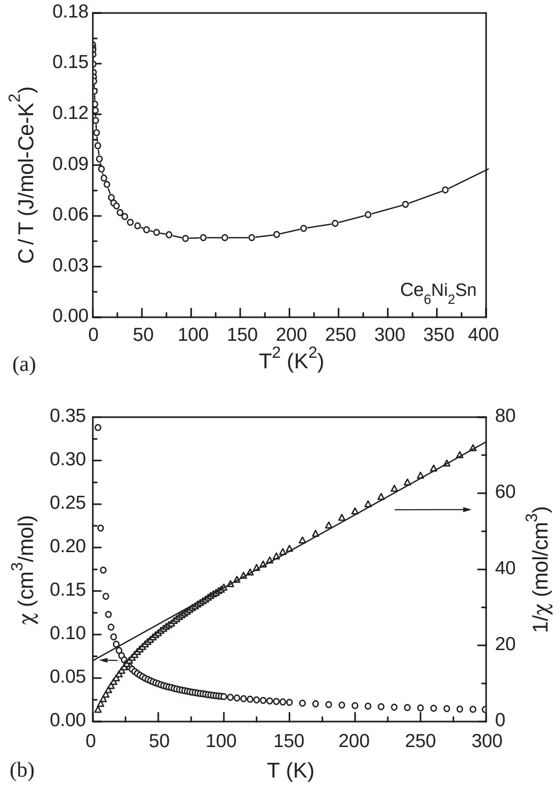

Fig. 2. (a) C/T vs. T^2 and (b) $\chi(T)$ and $\chi^{-1}(T)$ curves for Ce_6Ni_2Sn.

using a four-probe AC technique. DC magnetic susceptibility measurements were performed in a commercial superconducting quantum interference device (SQUID) magnetometer from 2 to 300 K in various applied magnetic fields. The specific heat of Ce_6Ni_2Sn was measured using in ^{3}He microcalorimeter in the temperature range between 0.35 and 20 K with $H = 0$.

The normalized electrical resistance $R(T)/R(300\,\mathrm{K})$ vs. T curves for the R_6Ni_2Sn (R = Y, La, Ce, and Pr) compounds are plotted in Fig. 1(a) for $0\,\mathrm{K} \leqslant T \leqslant 300\,\mathrm{K}$. The $R(T)/R(300\,\mathrm{K})$ curves for these samples exhibit typical characteristics of common metal and decrease monotonically with decreasing temperature T. The abrupt drop of $R(T)/R(300\,\mathrm{K})$ to zero value, as shown in the inset, reveals that La_6Ni_2Sn becomes superconducting below 2.3 K [4]. Shown in Fig. 1(a) is the $R(T)/R(300\,\mathrm{K})$ curve for Nd_6Ni_2Sn. A rapid drop at 30 K and a change of the slope at 6.5 K in the $R(T)/R(300\,\mathrm{K})$ curve indicates the occurrence of two magnetic transitions in this compound. This is consistent with the result of the magnetic susceptibility study which reveals that Nd_6Ni_2Sn undergoes antiferromagnetic transition at 29 K followed by an order–order transition at 6.2 K. Various magnetic transitions at low temperatures were also observed in the R_6Ni_2Sn compounds with R = Sm, Gd, Tb, Dy, and Ho [5].

The low-temperature specific heat of Ce_6Ni_2Sn is depicted in Fig. 2(a), where C/T vs. T^2 are plotted. The specific behaviour for this compound reveals characteristics of heavy fermion compounds. A characteristic logarithmic divergence of C/T data over the temperature range of $1\,\mathrm{K} < T < 7\,\mathrm{K}$ indicates non-Fermi liquid behaviour in this compound. The obtained value of C/T is $\sim$160 mJ/mol Ce–K^2 at 0.35 K. The $\chi(T)$

and $\chi^{-1}(T)$ vs. T curves for Ce_6Ni_2Sn, as plotted in Fig. 2(b), reveal that this compound is non-magnetic for $T > 2$ K. Above ~100 K, the $\chi(T)$ curve follow a Curie–Weiss behaviour with a value of effective moment $\mu_{\text{eff}} = 2.68\mu_B$.

In summary, we have studied the electrical, magnetic, and specific properties of the R_6Ni_2Sn compounds. We found that La_6Ni_2Sn becomes superconducting below 2.3 K. Two magnetic transitions were observed in Nd_6Ni_2Sn at 30 and 6.5 K, respectively.

We found that Ce_6Ni_2Sn is a non-magnetic heavy fermion system with an obtained value of $C/T = 160$ mJ/mol Ce–K^2 at 0.35 K.

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References

[1] O.M. Sichevich, L.P. Komarovskaya, Yu.N. Grin, Ya.P. Yarmolyuk, R.V. Skolozdra, Ukr. Fiz. J. 29 (1984) 1342 (in Ukrainian).

[2] K.A. Gschneidner Jr., V.K. Pecharsky, M. Gailloux, in: R.G. Ross Jr. (Ed.), Crycollers, vol. 8, Plenum Press, New York, 1995.

[3] O. Syshchenko, Yu. Stdnyk, L. Romaka, Yu. Mudryk, R.V. Dremov, V. Sechovsky, J. Alloy Comp. 319 (2001) 14.

[4] J.W. Chen, N.S. Jou, B.K. Wang, C.-R. Chang, R.C. Yang, Physica C 384 (2003) 71.

[5] J.W. Chen, et al., to be published.