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# Letter

## Electrical resistivity in the $R_5Si_3$ systems (R ≡ La, Ce, Pr, Nd, Sm)

F. Canepa, S. Cirafici, F. Merlo* and A. Palenzona
*Istituto di Chimica Fisica, Corso Europa 26, Università di Genova, Genova (Italy)*

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### 1. Introduction

In our previous paper [1], the electrical resistivity (10–800 K) of some heavy RE silicides $R_5Si_3$ (R ≡ Gd, Tb, Yb, Lu and Y) was examined: for $Gd_5Si_3$ and $Tb_5Si_3$, a magnetic transition was found and a heterogeneous mixed valence was observed for $Yb_5Si_3$.

In order to study the electronic behaviour of the $R_5Si_3$ phases in a systematic way, the present work reports the electrical resistivity (10–800 K) of the light $R_5Si_3$ compounds (R ≡ La, Ce, Pr, Nd and Sm).

### 2. Experimental details

The elements used were commercial products with the nominal purity ranging from 99.4 to 99.6 wt.% for the rare earths and 99.999 wt.% for silicon.

The preparation methods were similar to those described previously [1]. The samples containing La, Ce, Pr, Nd were melted in a high frequency induction furnace. In the case of $Sm_5Si_3$, to prevent losses of Sm, the alloy was prepared in a tantalum crucible, closed by arc-welding and heated in the high frequency furnace.

Micrographic examination showed samples to be homogeneous, well crystallized, brittle and compact. Little grain separation (1–2 at.%) was sometimes observed.

X-ray analysis, carried out on a Guinier camera, using silicon as internal standard ($a = 5.4308$ Å), confirmed the tetragonal $Cr_5B_3$ type of structure for the La, Ce, Pr and Nd phases, and the hexagonal $Mn_5Si_3$ type for $Sm_5Si_3$. Lattice constant values obtained in the present work are reported in Table 1.

*Author to whom correspondence should be addressed.

TABLE 1. Lattice parameters values ($a$,$c$) and transition points ($T^*$) for $R_5Si_3$ compounds

| Compound | Structure type | $a$ (Å) | $c$ (Å) | $T^*$ (K) |
|---|---|---|---|---|
| $La_5Si_3$ | $Cr_5B_3$ | 7.965 | 14.149 | – |
| $Ce_5Si_3$ | $Cr_5B_3$ | 7.866 | 13.783 | (10)[a] |
| $Pr_5Si_3$ | $Cr_5B_3$ | 7.812 | 13.772 | 47 |
| $Nd_5Si_3$ | $Cr_5B_3$ | 7.750 | 13.780 | 115 |
| $Sm_5Si_3$ | $Mn_5Si_3$ | 8.599 | 6.503 | 78 |

[a][7].

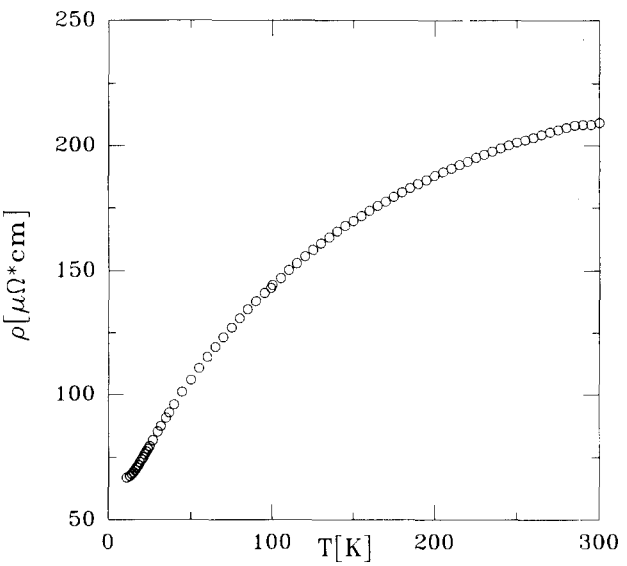


Fig. 1. Electrical resistivity of $La_5Si_3$ as function of temperature.

The electrical resistance was measured by the standard four point d.c. method [2]. The temperature was obtained by an Au + 0.07% Fe-chromel thermocouple.

### 3. Results and discussion

The thermal dependence of the resistivity for the examined phases is reported in Figs. 1–5.

The strongly negative curvature shown by the non-magnetic $La_5Si_3$ was also observed in other La-systems, such as $LaAl_2$ [3], $LaRh_2$ [4], $LaCu_6$ [5] and LaAg [2]. This not purely phononic behaviour can occur when the Fermi level lies in a region of a rapidly falling density of states [6]. A similar trend was also observed for the other non-magnetic $Lu_5Si_3$ and $Y_5Si_3$ [1], but in these cases the non-phononic contribution was one order of magnitude smaller than in $La_5Si_3$.


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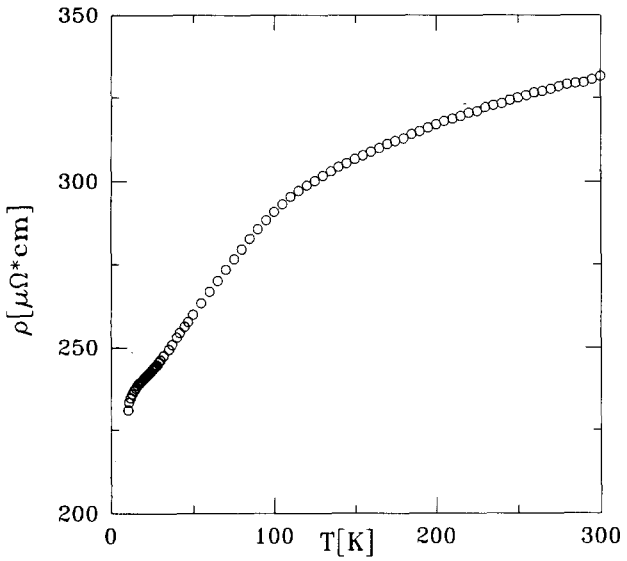


Fig. 2. Electrical resistivity of $Ce_5Si_3$ as function of temperature.

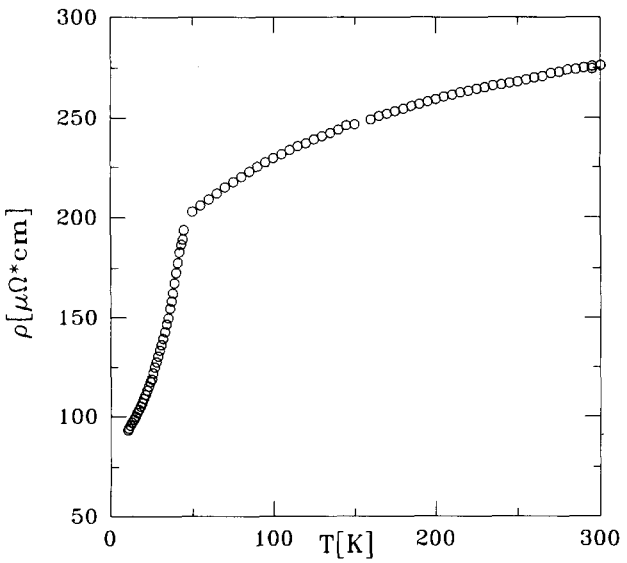


Fig. 3. Electrical resistivity of $Pr_5Si_3$ as function of temperature.

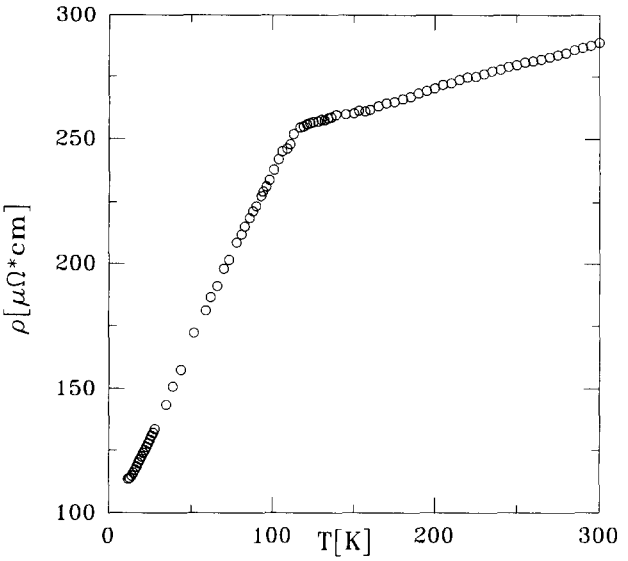


Fig. 4. Electrical resistivity of $Nd_5Si_3$ as function of temperature.

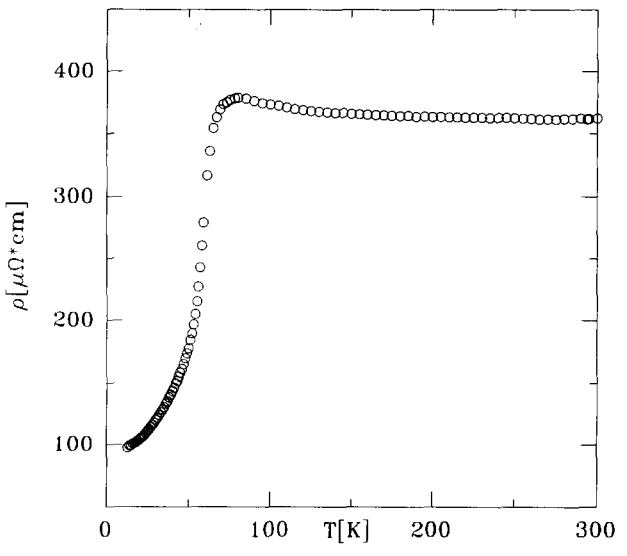


Fig. 5. Electrical resistivity of $Sm_5Si_3$ as function of temperature.

As can be seen in Figs. 2, 3 and 4 the Pr, Nd and Sm compounds show a sharp transition temperature at 47 K, 115 K and 78 K respectively. The specific heat measurements reported by Kontani *et al.* [7] for $Ce_5Si_3$ point out two transition temperatures at 2.5 K and 10 K. The beginning of the highest temperature was detected in the present resistivity data (Fig. 2). Above the respective transition temperatures, $Ce_5Si_3$ and $Pr_5Si_3$ show a negative curvature as found in $La_5Si_3$.

Most probably, the transformation points observed for the Pr, Nd and Sm phases should have a magnetic origin. Considering that the point at 10 K already observed for $Ce_5Si_3$ and partially confirmed here, is ascribed by magnetic data to an order–disorder transition to the antiferromagnetic state [7], we can suppose the onset of antiferromagnetism also for $Pr_5Si_3$ and $Nd_5Si_3$. The occurrence of a magnetic transition was reported for $Nd_5Si_3$, where the antiferromagnetic susceptibility behaviour with a positive Weiss constant was ascribed to a helical spin order [8].

A different hypothesis can be made for $Sm_5Si_3$, as the magnetic interaction in this compound should be like those of the other $Mn_5Si_3$-type $R_5Si_3$ phases. Actually, there is a close resemblance between the resistivity behaviour of $Sm_5Si_3$ and $Gd_5Si_3$ or $Tb_5Si_3$ [1], both in the form of the curve around the transition point and in the nearly constant values at higher temperatures. The same type of magnetic order probably occurs in these three systems, namely a helimagnetic structure with ferromagnetic and antiferromagnetic

components, similar to that determined by neutron diffraction data for $Tb_5Si_3$ [9].

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## References

1 F. Canepa, S. Cirafici, F. Merlo and A. Palenzona, *J. Magn. Magn. Mater., 118* (1993) 182.
2 F. Merlo and F. Canepa, *J. Phys.: F, 17* (1987) 2373.
3 E. Bauer, E. Gratz, H. Kirchmayr, N. Pillmayr and H. Nowotny, *J. Less-Common Met., 111* (1985) 369.
4 J. Diesling, *Diplomarbeit,* Universität zu Köln, 1985.
5 E. Brück, A. Nowack, N. Holn, E. Paulus and A. Freimuth, *Z. Phys. B, 63* (1986) 155.
6 N.F. Mott and H. Jones, *The theory of the properties of metals and alloys,* Oxford University Press, 1958.
7 M. Kontani, M. Senda, M. Nakano, J.M. Lawrence and K. Adachi, *J. Magn. Magn. Mater., 70* (1987) 378.
8 E.V. Garapathy, K. Kugimya, H. Steinfink and D.I. Tchernev, *J. Less-Common Met., 14* (1976) 245.
9 I.P. Semitelou, H. Konguetsof, J.K. Yakinthos and E. Roudaut, *J. Magn. Magn. Mater., 79* (1989) 131.