THE SUPERCONDUCTING TRANSITION TEMPERATURE OF TIN WITH THALLIUM ADMIXTURES*

By C. Sułkowski and J. Mazur

Low Temperature Laboratory, Institute of Low Temperatures and Structural Research, Polish Academy of Sciences Wrocław**

(Received March 31, 1970)

The influence of the thallium admixtures (concentration 0.02, 0.043, 0.12 and 0.210 atomic percent) was studied; from the measurements of the current transition curves the transitions temperatures T_c were estimated. The lowering of the transition temperatures is in good agreement with predictions of Anderson theory.

The influence of an admixture on the superconductive properties of tin has been studied extensively by Lynton and his co-workers; for several metallic admixtures the changes of the electric resistance in the low temperature region and the transition temperatures of tin have been estimated [1].

In the present paper the results of investigations on tin with thallium admixture are summarized: the system tin-thallium has not been yet studied at all.

In order to compare the results of our measurements with those of Lynton we have investigated tin with indium admixture and we have obtained the same results as Lynton and his co-workers.

Our specimens were of a cylindrical shape; their diameters were about 2 mm and the admixture concentration varied from 0 to 0.5 atomic percent.

The electric resistance was measured both at room and boiling helim temperatures (4.2°K). From the measurements of the current transition curves transition temperatures were found.

The variation of the ratio of reduced resistance

$$\varrho = \frac{R_{4,2}{}^\circ K}{R_{273}{}^\circ \mathrm{K} - R_{4,2}{}^\circ \mathrm{K}}$$

with admixture concentration in tin is depicted in Fig. 1.

* Some preliminary results of this paper have been presented during the International Conference on Physics and Techniques of Low Temperatures, held in Dresden, November 1969.

** Address: Zakład Niskich Temperatur, Instytut Niskich Temperatur i Badań Strukturalnych PAN, Wrocław, Próchnika 95, Polska.

It is evident, that in the region tin about 0.25 atomic percent of thallium the variation is rather linear: in this region there is a solid solution of thallium in tin.

From theoretical considerations of the influence of the admixture on the electrical resistance of metals in low temperatures [2] it is clear that the value of ϱ depends primarily

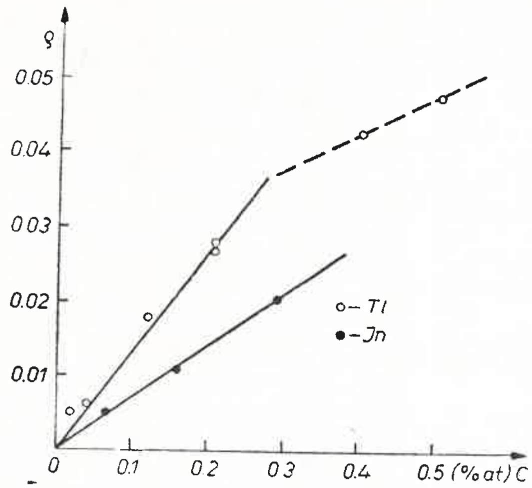

Fig. 1. Reduced resistance *versus* the concentration of admixture

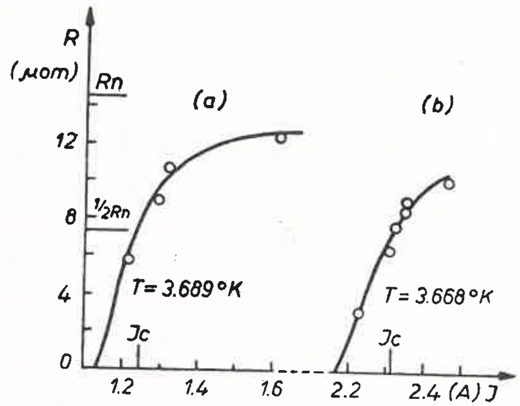

Fig. 2. Current transition curves for specimen Sn + 0.02% at. Tl

on the difference in the number Z of valence electrons, in our case between thallium and tin or indium and tin respectively.

If for different admixtures Z is th same, the influence of the admixtures on the reduced resistance ϱ should be identical.

For thallium and indium in tin in both cases $Z = -1$, but the influence of thallium on tin electric properties is more profound than that of indium.

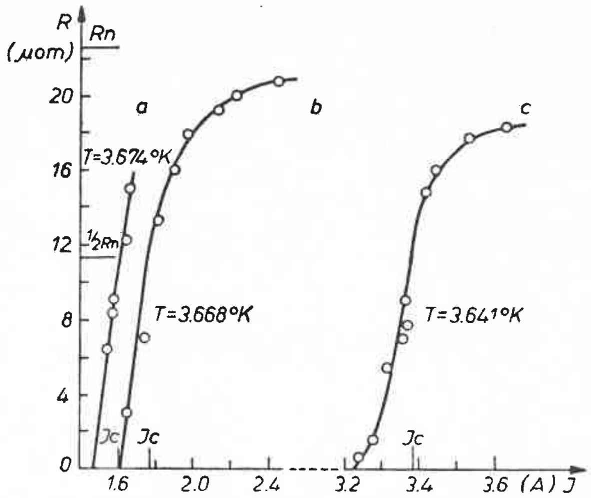

Fig. 3. Current transition curves for specimen Sn + 0.043% at. Tl

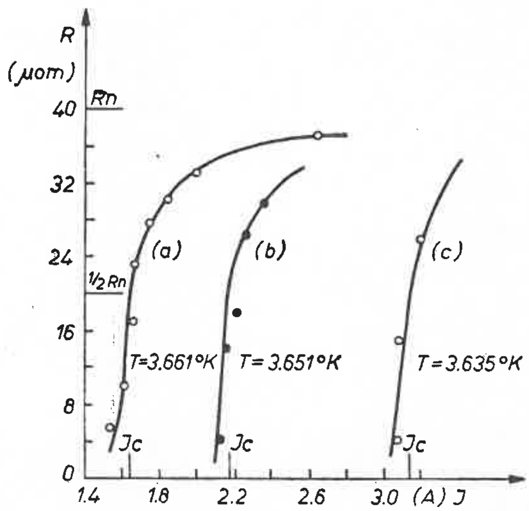

Fig. 4. Current transition curves for specimen Sn + 0.12% at. Tl

From the above we conclude that not only Z but also such properties of the admixture as atomic mass and atomic radius play part in the influence on ϱ.

The transition temperature T_c for all specimens was estimated from the electric resistance measurements. The current transition curves were determined at steady temperatures.

Fig. 2–5 show the current transition curves for four different samples of tin with thallium admixture. From these curves the values of the critical current I_c for given temperatures were estimated.

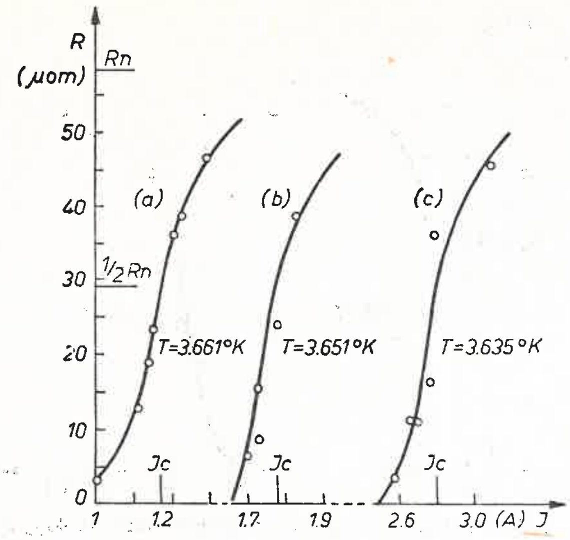

Fig. 5. Current transition curves for specimen Sn + 0.21% at. Tl

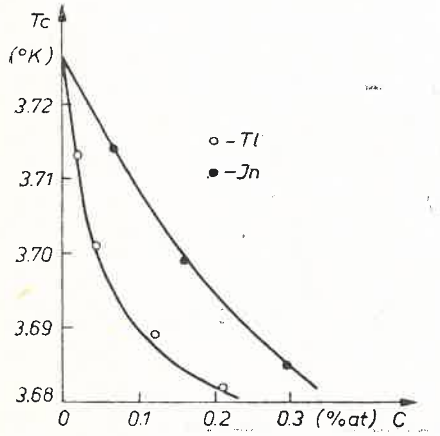

Fig. 6

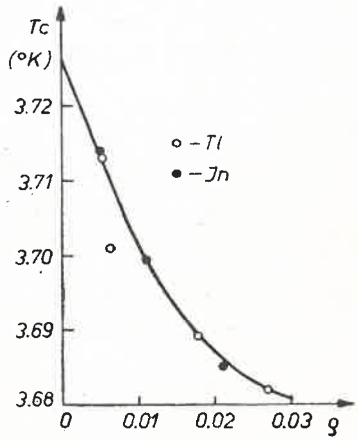

Fig. 7

Fig. 6. The change of critical temperature T_c with admixture concentration
Fig. 7. The change of critical temperature with reduced resistance

From the extrapolation of the curves I_c *versus* T to the value $I_c = 0$, the critical temperature T_c for every specimen was obtained.

In Fig. 6 the variation of the critical temperature T_c with admixture concentration is depicted. The critical temperature T_c varies at first linearly and afterwards with increasing concentration of admixture the change is somewhat slower, and thallium admixtures cause further lowering of the T_c than the indium admixtures. When one puts the variation of critical temperature T_c with reduced resistance ϱ for both admixtures on the same graph, the course of change is identical in the whole investigated range of the admixture concentration.

Such a variation of T_c with ϱ is in good agreement with Anderson's model [3]; according to his theory the initial lowering of T_c connected with the decay of anisotropy of the energy gap should be independent of the admixture type, because the decay of anisotropy depends only on the decrease of the mean free paths of electrons which is proportional to ϱ.

The correlation between the variation of critical temperature T_c and the mean free path of the electrons explains why the critical temperature T_c and reduced resistance ϱ depend in the same manner on the admixture concentration.

REFERENCES

[1] E. A. Lynton, B. Serin, M. Zucker, *J. Phys. Chem. Solids*, **3**, 165 (1957).
[2] J. Friedel, *J. Adv. Phys.*, **3**, 446 (1954).
[3] P. W. Anderson, *J. Phys. Chem., Solids*, **11**, 26 (1959).