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Investigation of the Properties of Limited Solid Solutions InSb • CdTe

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Figure 1

Figure 1: Figure 1

Abstract**Full Text****Physics****E. N. Khabarov, P. V. Sharavskii****Investigation of the Properties of Limited Solid Solutions InSb • CdTe***(Presented by Academician B. P. Konstantinov, 14 XI 1963)*

Complex semiconductor compounds exhibit new physical properties. Solid solutions based on these compounds possess still greater possibilities in this respect. Only in a few works devoted to the study of the latter are solutions with a limited range of solubility considered (¹⁻⁵), and comprehensive investigations of their electrical properties are in fact absent, although the study of the properties of solid solutions in the region of small concentrations of one of the components is of interest, since here in a number of cases (⁶⁻⁹) peculiarities are observed in the change of the properties of a substance as a function of composition.

We undertook a study of the electrical properties of the solid solution InSb–CdTe, which, according to data (¹⁰), has a limited range of solubility of CdTe in InSb. The electrical properties in systems of this type ($A_3B_5-A_2B_6$) have not been investigated up to the present time.

InSb was synthesized from In-000 and “extra” antimony, after which it was subjected to zone purification. The carrier concentration at the temperature of liquid nitrogen was of the order of 10^{15} cm^{-3} , with an electron mobility of $6 \cdot 10^4 \text{ cm}^2 \cdot \text{sec}^{-1} \cdot \text{V}^{-1}$. The maximum impurity in cadmium was zinc, present in an amount of $5 \cdot 10^{-4}\%$. The carrier concentration in tellurium at the temperature of liquid nitrogen was 10^{15} cm^{-3} .

Fig. 1. Dependence of the electrical conductivity (curves *a*) and the Hall coefficient (curves *b*) on temperature.

1 –sample containing 99% InSb, 1% CdTe; 2 –98% InSb, 2% CdTe; 3 –97% InSb, 3% CdTe.

The samples were prepared from ingots obtained by melting in quartz ampoules with vibration. The use of a two-temperature furnace, through which the ampoule was drawn, ensured sufficient homogeneity of the ingots. As a rule, the samples had a polycrystalline structure and electronic conductivity.

The temperature dependence of the conductivity, the Hall coefficient, the dif-

Figure 2

Figure 2: Figure 2

Figure 3

Figure 3: Figure 3

ferential thermo-emf, the Hall mobility, the transverse and longitudinal Nernst–Ettingshausen effect, and the change in resistivity in a magnetic field were measured. All measurements were carried out in the temperature range from 77 to 700 K on samples containing from 1 to 5% CdTe in InSb in steps of 1%.

Typical measurement results are presented in Figs. 1, 2, and 3.

As was shown in (10) and confirmed by our later experiments, the existence range of the solid solution under study is limited to a content of 5.5% CdTe in InSb. The physical properties of the solid solutions exhibit a definite dependence on the concentration of CdTe in InSb. Thus, in (10) it was shown that at 3% CdTe the microhardness reaches a maximum value. The thermal coefficient of expansion measured by us for powders has in this case a clearly pronounced minimum. Analysis of the experimental data from electrical measurements makes it possible to assert that the character of the change in the physical quantities with changing temperature reveals a definite dependence on the composition of the solid solution, which is likewise observed only up to 3% CdTe in InSb. At higher concentrations, up to the solubility limit, these regularities are violated.

Fig. 2. Dependence of the mobility, the transverse and longitudinal Nernst–Ettingshausen effects, and the differential thermoe.m.f. on temperature for samples containing 99% InSb, 1% CdTe (A); 98% InSb, 2% CdTe ();

In the concentration region of CdTe up to 3%, the conductivity decreases with increasing CdTe content, and the semiconducting character of its temperature dependence becomes more distinct.

The Hall constant depends only weakly on the composition of the solid solution. It is interesting to note its increase with increasing temperature, which becomes greater the higher the concentration of CdTe. The latter circumstance indicates a decrease in the number of carriers in the conduction band with increasing temperature, which may be connected, for example, with a change in the band structure of InSb or with the appearance of impurity traps in the conduction band. The increase in electrical conductivity with increasing temperature in this case will be provided by an increase in mobility.

Fig. 3. Dependence of the mobility, the transverse and longitudinal Nernst–Ettingshausen effects, and the differential thermo-e.m.f. on temperature for samples containing 97% InSb and 3% CdTe

The temperature course of the thermo-e.m.f. is practically independent of com-

position. The longitudinal Nernst–Ettingshausen effect becomes measurable only in samples with 3% CdTe. The resistance of the samples in a magnetic field up to 6000 oersteds remained practically unchanged.

The assumption expressed above regarding the appearance of impurity traps can to a certain extent also be confirmed by consideration of the temperature ...

the course of the transverse Nernst–Ettingshausen effect. The positive sign of this effect and its increase with rising temperature make it very probable that an additional band with a high density of states exists deep in the conduction band of the solid solutions.

In conclusion, we consider it our pleasant duty to express our gratitude to Prof. N. A. Goryunova, as well as to O. V. Emelyanenko and D. N. Tretyakov, for organizing and conducting a number of valuable discussions in the course of the present work.

Leningrad Civil Engineering Institute

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