THERMOWER IN WEACLY DEGENERATED SYSTEMS

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Doping of semimetals with impurities of the IV and VI groups considerably influences kinetic properties of these systems and it is one of the methods for investigation of peculiarities of the free carrier band spectrum [1]. Bismuth doping with selenium and tellurium leads to an increase of concentration of free electrons, and accordingly to the Fermi level increase. Smooth shift of the Fermi level gives a possibility to study the band structure, in the given case the conduction band of bismuth. However, small concentration region of solubility of selenium impurities in bismuth did not give a possibility using the traditional method of zone recrystallization to obtain strongly doped alloys of high quality, and thus to investigate a wide energy interval of the conduction band. We have used a new method to obtain strongly doped qualitative single crystals of bismuth, it allows smooth shifting of the Fermi level deep into the conduction band [1]. Using this method we have obtained qualitative single crystals of alloys Bi-Se with the impurity concentration up to 2,5at%Se. The present paper gives the results of investigation of the temperature and concentration dependences of samples in a wide interval of temperatures and concentrations. Fig.1 shows the temperature dependences of the thermopower component α_{33}(T). As it is seen from the figure, weak doping (0,3at%Se) preserves the curve similarity with the temperature dependence of pure bismuth. For the alloy Bi-Se with the concentration 0,8at%Se the curve changes its sign twice, achieving the thermopower maximal value +8 μV/degree. Further increase of selenium impurity concentration leads to disappearance of the thermopower anomaly.

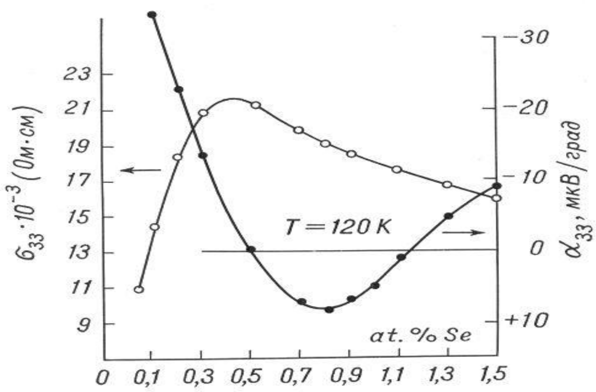

Fig. 1 Temperature dependence of the thermopower component α_{33} of Bi-Se alloys of various degree of selenium doping.

For the concentration of Bi-Se alloy with 1,3at%Se the thermopower component in the whole temperature interval remains negative. Fig.2 shows concentration dependences $\alpha_{ii}(c)$ at the temperature 120 K corresponding to the maximum of the anomaly in thermopower in Bi-Sealloys. At this temperature the thermopower anisotropy appears again at 0,1at%Se and increases with the selenium concentration as in pure bismuth. At the concentrations 0,8at%Se we have the anisotropy maximum, and then again a tendency to its decreasing. The thermopower component α_{33} at 120 K changes its sign twice depending on Se concentration, and the maximal value +8 μV/degree corresponds to the concentration 0,8at%Se. For the second thermopower component α_{11} sign inversion does not takes place at any temperature and selenium concentration. With Se concentration increase the thermopower component α_{11} decreases at the beginning, approaching zero, and then again increases towards the negative value. The analysis of the obtained experimental results gives a possibility to consider that the absence of the thermopower anisotropy

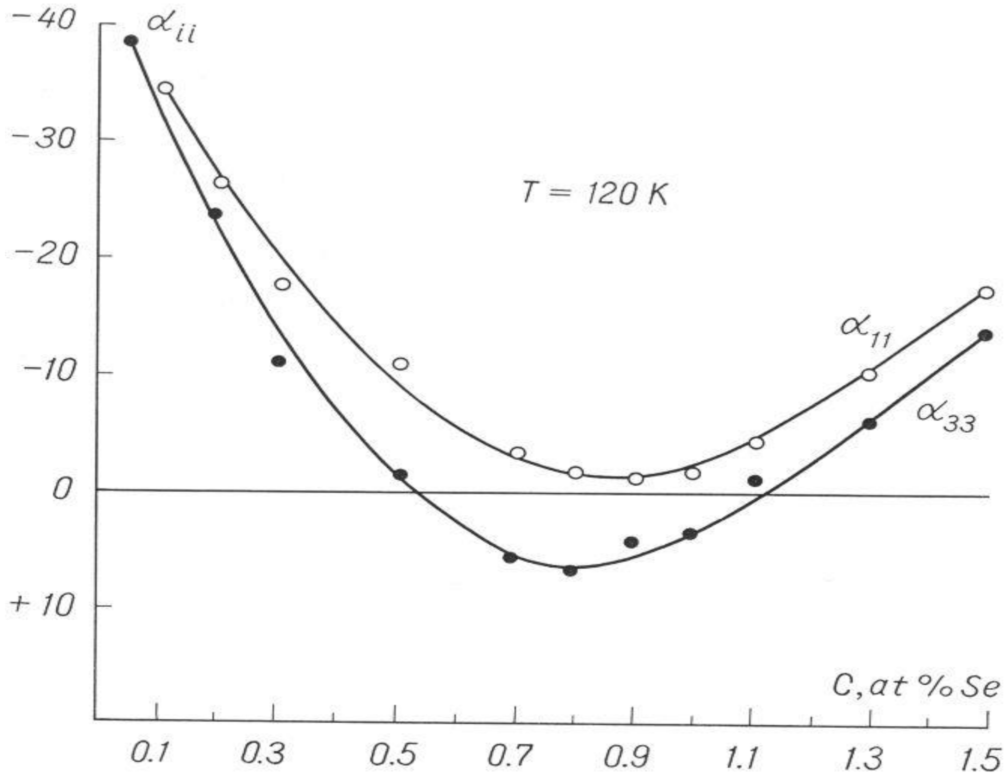

Fig. 2 Concentration dependence of the thermopower $\alpha_{ii}(c)$ at the temperature T=120 K.

in the concentration interval (0,07-01,0 at%) is due to the fact that in transport only one type of the carriers takes part, precisely electrons. Increase of the doping impurity concentration leads again to appearance of the thermopower anisotropy, which may be explained by appearance of a new group of the carriers. However, further doping leads to absolutely unexpected result - the thermopower sign change from negative to positive. Using the language of the bismuth three-band model it is difficult to explain the appearance of the new group of holes in the conduction band. The obtained experimental results may be interpreted according to [2].

Consideration of the behaviour of doped semimetal kinetic characteristics is based on the idea on impurity localized states and their intermixing with the band states. This intermixing is possible due to the decrease of symmetry of the unit cell containing an impurity atom. It is found that the most intensive intermixing takes place with the states of A_{2u}-symmetry (hole T-band). Here, the energy of the impurity level E_d is degenerated in the impurity band with higher effective mass of the carriers.

Contribution of the impurity band and decrease of the efficiency coefficient η_d with increase of the temperature T and impurity concentration C_d determine completely the peculiarities of behaviour of the thermopower and conductivity of the considered systems.

Figure captions:

Fig.1. Temperature dependence of the thermopower component α_{33} of Bi-Se alloys of various degree of selenium doping. Fig.2. Concentration dependence of the thermopower $\alpha_{ii}(c)$ at the temperature T=120 K.

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2. Bodiul P.P., Garabazhiu V.F., Gitsu D.V. Phys. Stat. Sol. b, 1987, p.245-256.