SOME URGENT PROBLEMS OF ELECTROPHYSICAL PROPERTIES OF BISMUTH AND ITS ALLOYS

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Last years bismuth and its alloys attract great attention of a wide circle of researchers. This is determined first of all by the fact that in low dimensional structures based on bismuth one can expect significant increasing of thermoelectric efficiency Z in the low temperature region. Construction of these systems, if it is realizable, would considerably increase possibilities of cryogenic electronics, especially the one based on high temperature superconductors. For this purpose it is necessary to solve a number of complicated technological, applied and fundamental scientific problems, this implying significant extension of spectrum of scientific researches. The main aim of the present report is to draw attention to a number of the most important problems standing in the way of increasing of applied parameters of bismuth based structures.

Due to concentration and temperature anomaly the thermopower behaviour in bismuth and alloys bismuth-stibium at strong doping with donor and acceptor impurities (Te, Se, Pb, Sn) it is difficult to find conditions for increasing and optimization of thermoelectric parameters on the basis of these materials, especially alloys and structures for p-branch. These anomalies reflect the specificity of impurity states in bismuth and its isoelectronic analogues of binary compounds A^4B^6. In the general case, the impurity atoms in these materials form peculiar quasi-local resonance states in the continuous spectrum of the conduction band or valence band. In bismuth and alloys bismuth-stibium due to low density of states of the charge carries in actual energy extremes even comparatively low concentration of impurities may lead to an appreciable "local" perturbation of the Fermi surface topology so that dynamics of the charge carriers resembles analogous behaviour of charged elementary excitations in metals with complex energy structure. In the narrow energy interval the Fermi surface curvature changes in both value and sign. As a result, when the Fermi level is in this energy interval specific electron effects may be observed. Here one should find

reliable methods for determination of contribution of effects connected to change of the surface topology and ratio of values, different mechanisms of charge carrier scattering inherent in crystals with complex multi-valley energy spectrum. In totality, these factors determine the upper limit of possibility to improve thermoelectric parameters of bismuth and alloys bismuth-stibium.

In low dimensional structures based on bismuth (thin layers and thin wires) at rather low temperatures the thermopower has positive value and achieves its maximal value $\alpha \approx +(40\text{-}100)$ $\mu V*degree^{-1}$. In these structures at optimal doping with acceptor impurities in narrow temperature interval it is possible to increase the thermal efficiency Zp almost by an order in the positive branch. However, this is insufficient for practical purposes. Probably, one should search for solution in construction of more complicated structures by complex doping of bismuth and obtaining of multilayered heterostructures, with the use of narrow band semiconductors of p-type.

Study of behaviour of impurity states in size quantum structures of bismuth and alloys bismuth-stibium is of a special importance. In these structures due to localization increasing, the concentration efficiency of impurities significantly grows approaching unit even for impurities of lead and selenium. At the same time here appears a problem of change of mechanisms of charge carrier scattering in the bulk and on the surface of the structures. In bulk samples anisotropy of the relaxation time at not very low temperatures is insignificant. In ultimately thin structures one should expect considerable influence of orientation of double crystal layers relative to the critical size (thickness or diameter), since on the layer surface the Van der Waals forces prevail, whereas in the plane the covalent forces do. This may change the topology of the surface potential and distribution of the surface-bound charges and anisotropy of transport phenomena, especially in nano- and mesoscopic structures of various configuration.

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