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"Conductivity Characteristics of Acceptor-Mixed in Semiconductor in the Metal-Dielectric Boundary Region N-Zrnisn Resistance to External Influence"

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Annotation:

n-ZrNiSn to study the effect of heavy duty mode (concentration of acceptors NA, donors ND (1019-1021 cm-3) on magnetic, thermoelectric, resonant and structural properties of intermetallic p-type MgAgAs structural semiconductors ra, it consists in observing that semiconductors are resistant to external influences in high temperature and concentration ranges and studying conduction mechanisms processed. This means that the sample under consideration is a solid solution. The Mott transition and the appearance of defects in semiconductors due to impact are related to the appearance of metallic conductivity in the conduction band of impurities. considered.

Keywords: lead-selenium, photosensitive, film, thermoresistive evaporation, nitrogen oxidation, Raman spectrum, insulating metal, glass substrates, diffractometry, photoelectronic, monoclinic, surface layers, air oxygen, selenide phase.

1 Introduction

It is possible to observe a lot of the work that is being carried out in the period of comparing theoretical and experiential research using modern science and technology. Here, the article presents the results of an experimental study of the conductivity and thermoelectric effect of an intermetallic (metal-dielectric boundary region) semiconductor with a mixture of heavy substances as an acceptor In. The *n–ZrNiSn* work is a logical continuation of the study of the effect of heavy mode. (concentration of acceptors N_A, arrange donors N_D (10^{19}-10^{21}cm^{-3}) intermetallic *p*-type *MgAgAs* structured semiconductors according to their magnetic, thermoelectric, resonant and structural properties, these semiconductors are resistant to external influences in high temperature and concentration ranges made it possible to observe and create transmission mechanisms.

The resulting sample is considered as a model of an amorphous semiconductor with a maximum amplitude of oscillations (modulation) of continuous energy bands in the mixed and fully compensated semiconductor theory equal to half of the band gap of the semiconductor. This means that the sample under consideration is a solid solution. (*Eg/2*) and the Fermi level (E_F) lies between the forbidden level, the experimental results below were obtained.

First, it proves that the amorphous semiconductor $ZrNiSn_{1-x}In_x$ is a solid solution. Secondly, they are defined in such energy ε_1^a strongly doped, and the temperature dependence of the compensated semiconductor thermal power coefficient corresponds to the average amplitude of continuous energy band oscillations. Its determination makes it possible to estimate the amplitude of

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vibrations. From the third. B.I. Shklovsky's theoretical conclusions concerning the energy properties of a fully compensated semiconductor were reviewed [1].

On the one hand, in all scientific centers known to us, the technology for obtaining intermetallic semiconductors consists in dissolving the charge of the initial components with subsequent uncontrolled cooling of the solution; in which one of the methods of obtaining amorphous solids leads to distortion of the structure, local deformations and, as a result, oscillations of continuous energy bands. On the other hand, in a strongly doped semiconductor, the energetically charged particles acquire properties due to the change in impurity concentration [2].

In addition, in amorphous semiconductors, continuous energy band oscillations are manifested, in particular, as determined by activation energies. Temperature dependence of resistance ε_1^{ρ} and thermoelectric coefficient (ε_1^{α}) temperature is significantly different [3]. In conventional lightly doped semiconductors without band oscillations, the value of the energy barrier is invariant to the methods of its determination.

In the case of Anderson transition of insulator-metal conductivity observed in intermetallic semiconductor $TiCo_{1-x}Cu_xSb$, correlation of metal electron gas, free electrons can appear during Anderson transition, which leads to change of sign of thermoelectric coefficient will come.

a (if the sample is compensated) and the crystalline substance on the non-metallic side of the transition is antiferromagnetic [3-4]. The three experimentally observed results are the change of sign α(x) of the conductivity from dielectric to metal, a significant difference in the magnetic order and activation energies of the semiconductor *TiCoSb*. It can be seen that ε_1^{ρ} and ε_1^{α} are levels near the semiconductor boundary region. In this context, we focus on the amorphous semiconductor, because the studied intermetallic semiconductors *ZrNiSn* and *TiCoSb* crystallize in the same structural type (*MgAgAs*), and the conditions for obtaining these semiconductors are also the same. All this allows us to observe the manifestation of properties in the case of $ZrNiSn_{1-x}In_x$. However, due to unknown reasons, the bonding resistance of *TiNiSn*, *ZrNiSn* and *HfNiSn* intermetallic compounds at high temperatures and compensated electron p-type semiconductors have not been sufficiently considered. Therefore, the amorphous semiconductor considered in our work is $T \geq 1.7$ *K*, regardless of the sample synthesis conditions (melting conditions and subsequent homogenizing annealing regimes), and *TiCoSb* strongly doped and highly compensated *p*-type semiconductors were obtained. $T \leq 95$ *K*, however, it is sensitive to the synthesis conditions and is easily transformed into an electronic *n*-type semiconductor.

In other words, the electronic type of electrical conductivity of *ZrNiSn* (or *p*-type *TiCoSb*) is based on the presence of donor (acceptor) defects of unknown origin, which, in our opinion, is related to the technological characteristics of obtaining alloys. We know that the resistance of semiconductor materials depends on the temperature (r), the thermoelectric coefficient (α), and also based on the structural properties of the *ZrNiSn* intermetallic (metal dielectric boundary region) semiconductor, the acceptor mixture by replacing Sn($4d^{10}5s^25p^2$) atoms formation of a solid solution of substances with In($4d^{10}5s^25p^1$) and replacement with atoms $ZrNiSn_{1-x}In_x$ was considered appropriate. At the same time, there is a change in electron acceptor states in concentration, i.e. from $N_A=9.5\cdot10^{19}$ cm^{-3} (x=0.005) to $NA\approx3.0\cdot10^{21}cm^{-3}$ (x=0.15). Allows observing the state of electrons in the substance, its kinetic and thermoelectric properties are manifested at much higher temperatures [5].

EXPERIMENTAL RESULTS AND REVIEW

The obtained experimental result showed that the In atoms exchange places with the Sn atoms in the crystal lattice, which was the main reason for our assumption. It allowed a more detailed analysis of the influence of $ZrNiSn_{1-x}In_x$ alloys on changes in lattice periods. It can be seen from

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the first result obtained using Siemens D5000 X-ray diffractometer and CSD [6] software package that it is shown to be in agreement with the theoretical research.

Figure 1: Changing the duration of the grid a hard

with a change in the composition of $ZrNiSn_{1-x}In_x$ in the solution

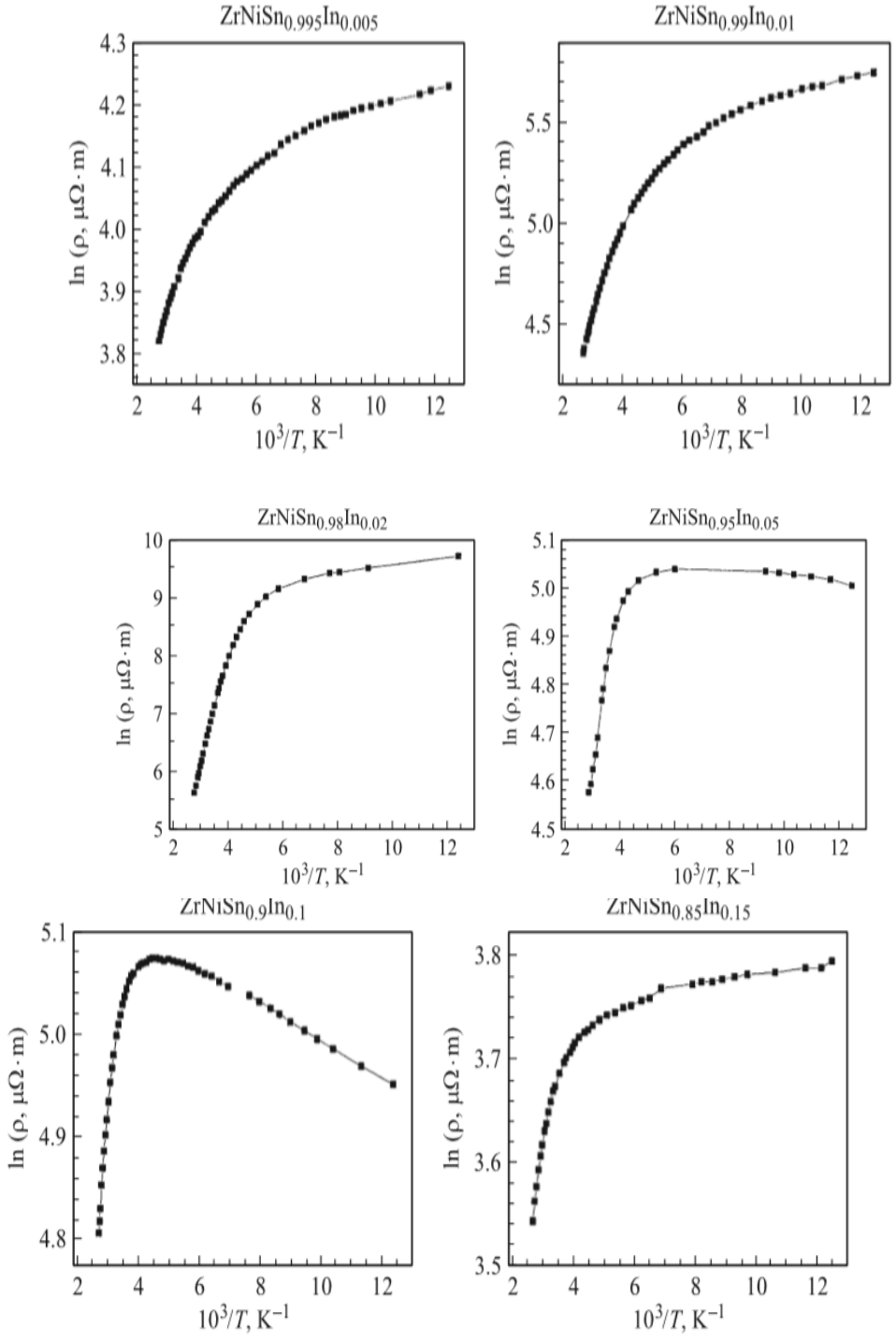

Figure 2: Dependence of resistance on temperature p solid solution $ZrNiSn_{1-x}$ In_x acceptor compounds at different solution concentrations In

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The analysis of layers in the interplanar lattice spacing of the complex $ZrNiSn_{1-x}In_x$ alloys led to an unexpected preliminary conclusion: a decrease in lattice constant periods in $ZrNiSn_{1-x}In_x$ alloys. The difference from the structurally accepted type of *MgAgAs* shows that the lattice period decreases in $ZrNiSn_{1-x}In_x$ alloys only if *Zr* and *Sn* atoms do not have a strong position or the positions of the atoms are randomly exchanged. The result of experimental research is that this substance *MgAgAs* structure is in the crystal lattice of *p*-type solid solutions. made it possible to consider the mechanism of atomic vibrations in more detail, the $ZrNiSn_{1-x}In_x$ samples obtained show that the resistance has a complex dependence on temperature, but activation at temperatures higher than $\rho(1/T)$ present in all dependences is not consistent with the theoretical studies showed.

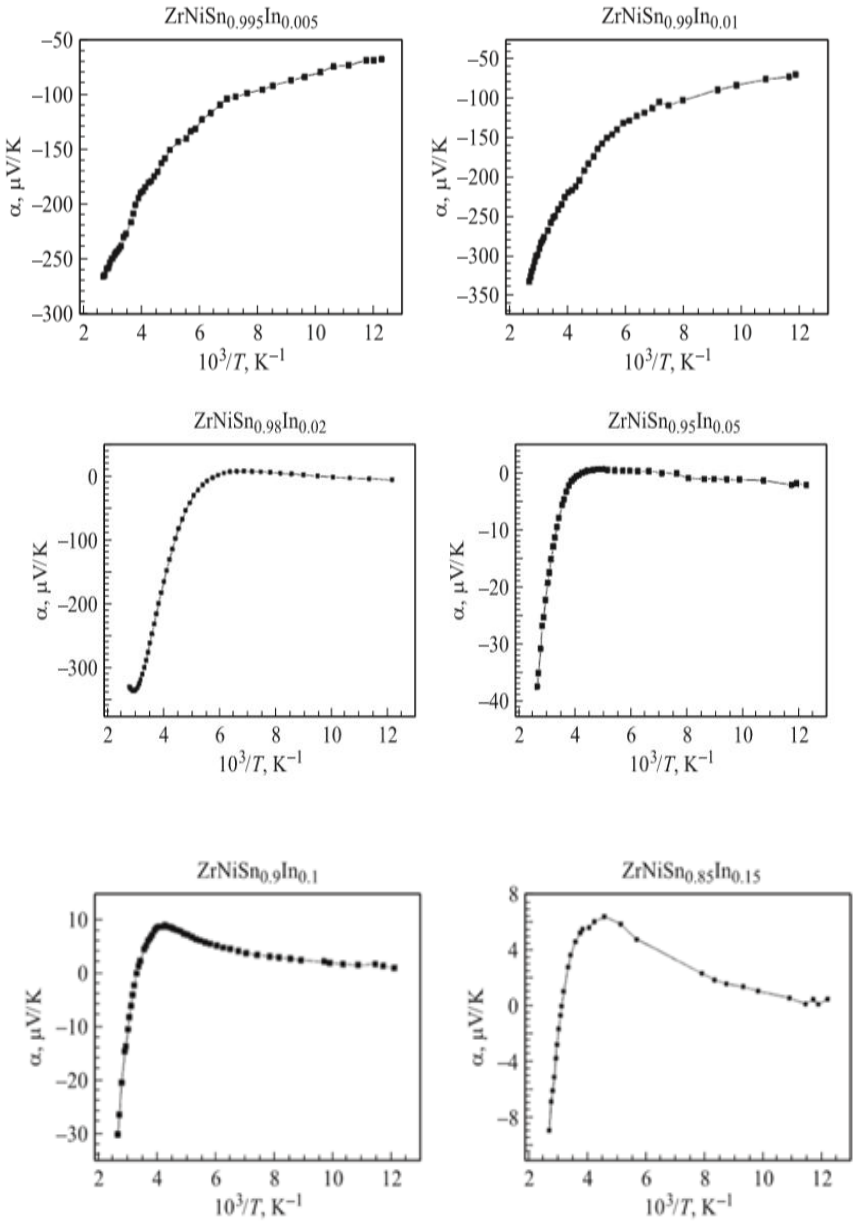

Figure 3: The heat capacity coefficient depends on the temperature of solid $ZrNiSn_{1-x}In_x$ in the concentrations of the receiving mixture In

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It is also possible to distinguish regions of low-temperature activation of *lnρ(1/T)* according to dependences x=0.005, 0.01, 0.02 and 0.15 for samples with concentrations of acceptors corresponding to the composition of $ZrNiSn_{1-x}In_x$ alloys. We can interpret this material as the existence of a jump conduction mechanism. In the second sample x=0.05 and 0.1 there are no low-temperature activation levels, and it is shown that the resistance increases with increasing temperature. This is due to the properties of the metal type of conductivity and the Mott transition in conventional semiconductors, as well as the appearance of defects due to impact, and the appearance of metallic conductivity in the conduction zone of mixed substances. In all samples of $ZrNiSn_{1-x}In_x$ alloys, it was shown that due to the fact that the nature of the conductivity of mixed semiconductors depends on the temperature of the thermoelectric coefficient, they correspond to the ln dependences based on their shape. According to the *ρ(1/T)* dependence, there are *α(1/T)* high-tesmperature activation zones for all samples. The concentration and energy properties of $ZrNiSn_{1-x}In_x$ alloys for samples with acceptor concentrations corresponding to the compositions are presented in the table below.

Table 1

X	N_A, sm^{-3}	ε_1^p, meV	ε_1^a, meV	ε_3^p, meV	ε_3^a, meV	$\Delta = \varepsilon_1^p - \varepsilon_1^a$ meV
0.005	$9.5 \cdot 10^{19}$	18.3	64.9	1.0	4.9	46.6
0.01	$1.9 \cdot 10^{20}$	48.7	133.1	2.9	5.0	84.4
0.02	$3.8 \cdot 10^{20}$	182.0	182.6	5.6	-	0.6
0.05	$9.5 \cdot 10^{20}$	42.4	59.0	-	-	16.6
0.1	$1.9 \cdot 10^{21}$	42.0	60.1	-	-	18.1
0.15	$2.9 \cdot 10^{21}$	24.2	24.0	0.3	-	0.2

With these $ZrNiSn_{1-x}In_x$ alloys x=0.005 and 0.01 dependences *α(1/ T)* can be, but for other samples they are observed maxima, after which the decrease in temperature leads to a decrease in the value of the thermopower coefficient. If we interpret the obtained results, we will not face any difficulties, since we have considered that all the above samples of *ZrNiSn* alloys are strongly mixed and compensated electronic *p*-type semiconductors. The introduction of certain acceptor compounds before the semiconductor concentration can increase the compensation level of the semiconductor. *n*-type conductivity type (we can consider that the concentration of uncontrollable defects (impurities) is the same in all samples. The technology of their synthesis is the same, and the donors and acceptors are completely ionized). Then, $N_D=N_A$ is fully compensated in the semiconductor, and further increase in acceptor doping leads to overcompensation of the material. The *n-p* type of conduction leads to a decrease in the level of compensation of the semiconductor, but already from the high-temperature sections of the conductivity depending on the type of cavity, *lnρ(1/T)* and *α(1/T)* for the thermopower coefficient using the Mott-expression [7]

$$\alpha = \frac{2\pi^2}{3} \frac{k_B^2 T}{\varepsilon} \frac{d[In\, n(E_F)]}{dE}$$

The values of all studied samples are derived activation energies. The values ε_1^ρ and ε_1^a respectively give the value of the energy barrier in conventional semiconductors. The Coulomb gap in the mixture E_F is determined by the mobility limit of the continuous energy band. As can be seen from the table, the activation energies ε_1^ρ and ε_1^a are significantly different, and the above considerations are taken into account in the received results. It also shows that $ZrNiSn_{1-x}In_x$ is studied as a result of structural studies of the solid solution. The samples show significant distortions (composition fluctuations) [8], fluctuations due to significant charge impurity concentration [9] and, as a result,

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fluctuations of continuous energy bands [10]. Therefore, traditional approaches used for the analysis of light-duty semiconductors are not applicable in our case. We have qualitatively discussed the experimental results obtained by the authors of [11-12] based on their approaches to the description of heavily doped and heavily compensated semiconductors. To begin with, we defined the main difference between the electrokinetic phenomenon of conduction and the thermoelectric effect (thermoelectric coefficient) in semiconductor materials with oscillations of continuous energy bands and for this case. If only one external force acts on charge carriers in a lightly doped semiconductor, the temperature gradient ∇T, the flow of <101>- charges in this direction ∇T disappears. It appears in the crystal under the influence of the field created due to the stationarity of the system and is covered by another current, and the resulting electromotive force is thermoelectric power. In a heavily doped semiconductor, large-scale fluctuations in the concentration of impurities create a large potential [13] that exceeds the potential difference between two points on the semiconductor, if the temperature difference between them is maintained, the measured value is ε_1^a og ir must be at least proportional to the mean band oscillation amplitude (proportional to u) in a doped and compensated semiconductor. Semiconductor conductivity Sn is mainly determined by the concentration of current carriers m s, $\propto$ m , and their mobility is activated only in the presence of an external electric field. The activation energy thus determined is proportional to the energy ε_1^ρ and is the gap between the Fermi level and the percolation level. This interpretation implies that ε_1^a and ε_1^ρ must not be less than . We observe in the experiment (see the table). In addition, with an increase in the concentration of the acceptor impurity (i.e. the compensation level of the semiconductor of the electron conduction type), the Fermi energy decreases and the potential relief increases due to the weakening of the electron screening [14]. So, ε_1^a changes by the amount of change, the distance between the modulation amplitude ε_1^ρ by the amount of change E_F depends on the current and their speed. We pay attention to the fact that the sign of the heat capacity coefficient changes from electron to hole at the concentration of acceptor compounds corresponding to the compositions $ZrNiSn_{1-x}In_x \geq 0.02$. This indicates that the semiconductor is overcompensated for the electron-hole-to-conduction type. At the acceptor impurity concentrations corresponding to compositions with this x=0.01−0.02 (picture 4,5), full compensation of semiconductor substances occurs, E_F level should be located between forbidden zones, [15] it can be seen that the bandgap of the semiconductor and the value of the activation energy increase from ε_1^ρ 3. Should be a maximum from the Fermi level to the percolation level. As can be seen from the table, in the composition of the solid solution of the semiconductor $ZrNiSn_{1-x}In_x$ mixtures, x=0.02 and the largest value are observed. Separate heating is observed in the quantities ε_1^ρ and ε_1^a. In our opinion, this experimental result [20] directly confirms our theoretical conclusions. In a fully compensated semiconductor, the maximum modulation amplitude of continuous energy bands should not exceed half of the band gap, and E_F must be located in the middle of the band gap of the semiconductor. Indeed, if we reach this value, we can consider that ε_1^a corresponds to the average modulus in heavily doped and compensated semiconductors. Bands of continuum energies and activation energy correspond to the energy gap between ε_1^ρ E_F percolation level, the following values of ε_1^p and ε_1^α can be matched, only if given by the full compensation of the semiconductor: Modulation amplitude distance *Eg/2* and the distance between the Fermi level and the percolation threshold *Eg/2*.

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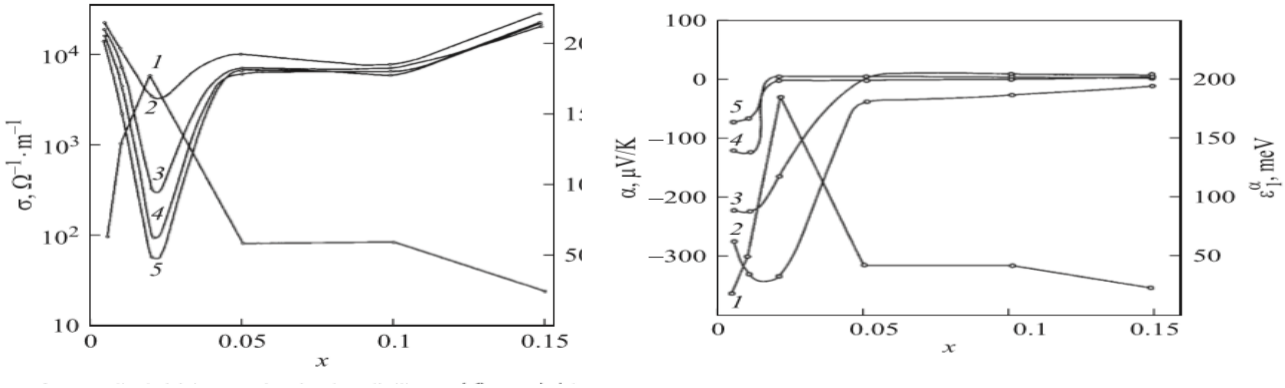

Figure 4: ep electrical water content depending on activation energy at T=370K (2), 250K (3), 160K (4), 80K (5) from *ZrNiSn$_{1-x}$In$_x$* the composition of the solid solution

The analysis of dependence behavior shows that the overcompensation phenomenon of a(x) and *ZrNiSn$_{1-x}$In$_x$* compound semiconductor is temperature dependent. When semiconductor materials are mixed with receiver compounds, it tries to change the signal. As the temperature increases, correlations appear, a(x) appears to be minimal, and in the temperature range 80 K<T<370 K, a tendency to change sign begins x ≈ 0.01. When a sign change at T=370 K is observed at x≈0.015 at acceptor compound concentrations x>0.02, $N_A > N_D$, we get p-conductivity heavily doped and heavily compensated semiconductor. A further increase in the acceptor impurity concentration reduces the level of semiconductor compensation and, as a result, the amplitude of the band modulation decreases, shifting towards where E_F is the valence band. The distance between the Fermi and percolation levels decreases. This is exactly the result we observe in the experiment. The dependences for samples *lnρ(1/T)* and *α(1/T)* determine the activation energy values in the presence of low-temperature activation regions. Dependence on the activation energy bog'liqlik ε_3(ε_1^p and ε_1^a) of the solid solution of $ZrNiSn_{1-x}In_x$ compounds from T =370 K (2), 250 K (3), 160 K(4), 80 K (5) in electric water composition Group 5, dependence on activation energy ε_1^p and ε_1^a coefficient thermoenergetic a composition of *ZrNiSn$_{1-x}$In$_x$* solid solution at T =370 K(2), 250 K (3), 160 K (4) and 80 K(5). ε_3 (ε_1^p and ε_1^a) are compatible. In our opinion, in a strongly doped semiconductor, the amplitude of small-scale oscillations (oscillations of the "fine structure") is proportional. As can be seen from the table, the value ε_1^p increases from 1.0 meV (x =0.005) to 5.6 meV (x =0.02) of the concentration of acceptor impurities. The nature of the change of these values indicates an increase in the depth of small-scale oscillations when the ε_3 is introduced into the semiconductor, up to concentrations that are overcompensated by the p-semiconductor, the p-type of the donor compound is turned on *n*-type [17]. For intermetallic semiconductor doping *n-ZrNiSn* donor mixture Cu, a monotonic decrease in the value of ε_3 was observed with an increase in the concentration of the donor mixture [16]. In case of doping p-TiCoSb donor compound Cu value is ε_3 (x). increases with concentration in the range x ≤ 0.005 and almost does not change in the 0.005 < x ≤ 0 . 02 (ε_3^a=0.05 meV at x=0.001, 0,4 meV at x=0.005 and 0,4 meV at x =0.02)[18]. Semiconductors *n-ZrNiSn* and *p-TiCoSb* are fundamentally different in the type of conductivity, that is, doping them with the same impurity, for example, with *Cu*, leads to opposite results in terms of the amplitude of the potential relief. Considering the concentration of donor and acceptor compounds in the samples, *n-ZrNiSn* and *p-TiCoSb* are constant, as well as the conditions of sampling, increasing the concentration of *Cu*. *n-ZrNiSn* leads to an increase in the Fermi energy and a decrease in the potential relief (fluctuation amplitude), and in this case *p-TiCoSb* is primarily to increase the potential relief (x≤0.005). in the concentration of the donor compound that changes the type of conductance from

As in the *p* and *n* - switched state, further increase of the donor impurity *n-ZrNiSn* leads to a decrease in the potential relief and the observed decrease $\varepsilon_3(x)$. Thus, we found a clear correlation (proportionality) between the oscillation parameters of continuous energy ranges, the oscillation depth and the depth of the potential well and its small-scale oscillations.

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