TRANSPORT PROPERTIES OF $(AgSbSe_2)_{0.9}(PbTe)_{0.1}$

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It was investigated the temperature dependence of specific resistivity of $(AgSbSe_2)_{0.9}(PbTe)_{0.1}$ in 40-300K temperature region. A transition to a state with zero resistance similar to the superconducting transition was observed at 66K. The thermal power and Hall- effect were measured in 100-400K temperature interval. It was estimated the carrier concentration and its mobility.

Keywords: thermoelectric material, specific resistivity, thermal power, superconductor phase transition, concentration, temperature dependence.
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INTRODUCTION

Thermoelectric materials have many applications in the conversion of thermal energy to electrical one. The energy conversion efficiency of a material is characterizes by the thermoelectric figure of merit, $zT = \alpha^2\sigma T/\kappa$. Where α is the Seebeck coefficient (thermal power), σ -electrical conductivity, and κ- thermal conductivity of materials. For improve this efficiency parameter the material by high Seebeck coefficient, high electrical conductivity and low thermal conductivity is required [1-3].

It is known, that the ternary compound $AgSbSe_2$ and PbTe are the thermoelectric material for midrange temperature (400–800 K) applications [1]. $AgSbSe_2$ crystallizes in the NaCl structure where the Ag and Sb atoms are randomly distributed in the Na sites [4]. On the other hand PbTe is also crystallized in the NaCl crystal structure with Pb atoms occupying the cation sites and Te forming the anionic lattice. $AgSbSe_2$ as the other ternary compound of $A^IB^VC_2^{VI}$ system have low thermal conductivity [5]. But the value of electrical conductivity is low at room temperature. To increase the value of electrical conductivity and thermoelectric figure of merit of $AgSbSe_2$ there was sintered the solid solution $(AgSbTe_2)_{0.9}(PbTe)_{0.1}$. The results of experimental investigation of structural and transport properties of $(AgSbSe_2)_{0.9}(PbTe)_{0.1}$ are presented in this work.

EXPERIMENTAL RESULTS AND DISCUSSION

$(AgSbSe_2)_X$ $(PbTe)_{1-X}$ solid solutions material was prepared by direct fusion of stoichiometric amounts of their consistent elements (Ag, Sb, Se, Pb and Te) of purity 99.99% in sealed, evacuated silica ampoule. The ampoule was heated at 1050K for 16 hours with vibrational shaking to ensure homogeneity of the sample. After the synthesis the ampoule was slowly cooled to room temperature.

The phase purity of the obtained sample was investigated by X-ray diffraction and presented in fig.1. The XRD analysis was performed using a Brucker-D8 advance diffractometer at room temperature with scanning mode with a step size $\Delta(2\theta)=0.021^0$ and $5^0\leq 2\theta \leq 80^0$. From the XRD data, various structural characteristics such as, lattice parameter: (a=b=c=5.8322A, system-cubic, space group (Fm-3m), and grain sizes (813.6A) were deduced.

The resistivity and thermal power were determined by the four-point probe technique. Measurements were taken from a sample in the form of a 8x3x1,2mm parallelepiped. The thermal power was measured by applying a longitudinal heat flux with a constant power released in the heater. A heater was fixed to the end face of the sample by indium. In the range 80-350K, the temperature was measured with copper-constantan thermo-couples. The thermocouples were fixed to the end face of the sample by indium at a distance of 5-6mm. To eliminate the background e.m.f, which is due to a temperature drop between the cold and hot junctions, copper-constantan wires were wound on a copper rod (being in contact with a coolant) immediately at the exit from a cell in which the sample was placed and fixed with BF-2 adhesive. The temperature gradient in the sample between probes varied from 0.5 to 3K.

At room temperature the $(AgSbSe_2)_{0.9}(PbTe)_{0.1}$ exhibit very high thermopower values of about 770 µV/K. The sign of Seebeck coefficient is positive which indicated to hole conductivity and its value decrease slightly with temperature increase.

More interesting results was obtained on the temperature dependence of specific resistivity. The obtained results are presented on fiq.2

The temperature dependence of specific resistivity was measured for two times. At first by the HL5500 PC Hall effect measurement system in the 100-400K temperature interval. The carrier concentration of sample according Hall measurement was $5.9.10^{17}cm^{-3}$ at room temperature. It was estimated the mobility of carriers. The value of mobility was very little $\mu=0.3cm^2/V.s$. At 110K there was observed a maximum on the temperature dependence of electrical resistivity. In order to determine more accurately this situation the measurement was carry out in 40-280K interval of temperature. The value of resistivity at maximum (110K) and room temperature on the temperature dependence were 234kOhm and 97 Ohm respectively. It should be noted that below 110K the value of specific resistivity decrease up to zero at 66K. There is a reasonable question: maybe this is the superconducting transition!? It is known that the superconducting transition T_c plays an important role. Usually the superconducting transition temperature is determined by follow way [6]: a) $T_c=T_c(0)$, when the resistivity equal 0; b) T_c equal midpoint of the transition; and c) $T_c= T$ (temperature in the transition region where $d\rho/dT$ have a maximum value). The values of T_c estimated by the above-mentioned three methods were 66K, 88K and 93.8K respectively. As seen the temperature range in which the resistivity decreases its zero rather wide ($\Delta T=44K$). It should be noted that all Y-and Bi-based high-temperature superconductors are superconductors of the second kind. The transition temperature interval to the superconducting state is quite wide in these compounds. The temperature dependence of resistivity of high T_c superconductors is mainly metallic in the normal state. On the other hand, in some samples the temperature dependence of the resistivity has a semiconductor behavior in the normal state [7].

According to our knowledge, no studies have been published on the structure and thermoelectric properties of $(AgSbSe_2)_X$ $(PbTe)_{1-X}$ solid solutions. Moreover there is very few studies been devoted $AgSbSe_2$ at low temperatures [8].

Previously, the temperature dependence of the resistivity of other ternary compounds $A^IB^VC_2^{VI}$ not observed a similar dependence. It seems to us that in any case the observed experimental fact is of great interest. Transition into a state with zero resistance is difficult to explain in this case, excluding superconductivity.

CONCLUSIONS

On the temperature dependence of the specific resistivity of $(AgSbSe_2)_X$ $(PbTe)_{1-X}$ was observed transition into a state with zero resistance at 66K-like superconducting transition.

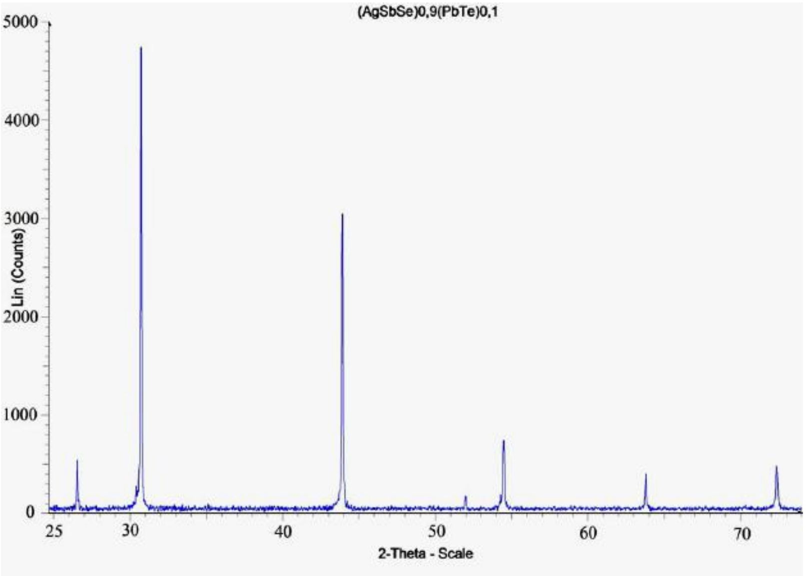
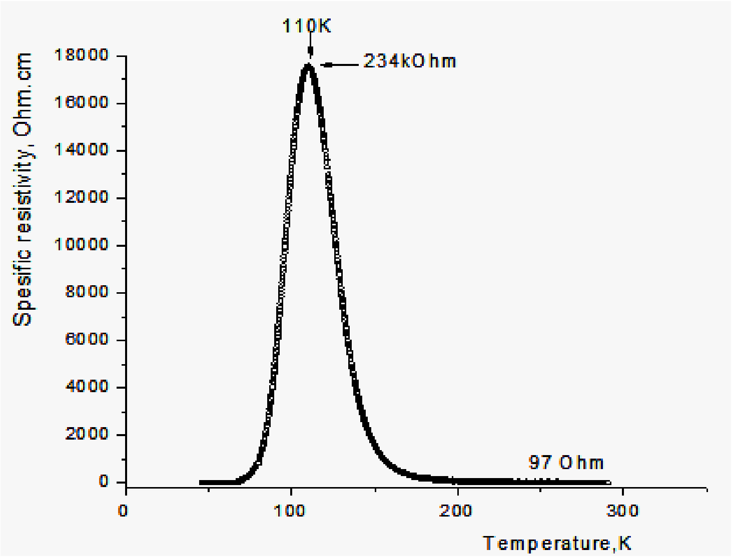


Fig.1. The XRD analysis results of $(AgSbSe_2)_{0.9}(PbTe)_{0.1}$



Fiq.2. The temperature dependence of specific resistivity of $(AgSbSe_2)_{0.9}(PbTe)_{0.1}$

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