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TECHNOLOGICAL FEATURES OF OBTAINING STRENGTH SENSITIVE POLYCRYSTALLINE FILMS $Bi_{2-x}Sb_xTe_3$

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Abstract. *The results of studying the effect of substrate temperature and evaporation rate on the kinetic coefficients and strain sensitivity of $Bi_{2-x}Sb_xTe_3$ films obtained by thermal evaporation in vacuum are presented.*

Keywords: *Strain sensitivity, evaporation, condensation, thickness, charge.*

The electrical properties of thin-layer polycrystalline samples largely depend on their structure and the state of crystallite boundaries. Both are set by the film preparation technology. Therefore, by establishing a correspondence between the technology parameters and the electrophysical properties of the films, one can trace the correlation between the structure of the films and electronic processes.

We have investigated the relationship between the electrophysical parameters and technological factors (substrate temperature, evaporation and condensation times). As noted in [1], the composition and structure of $Bi_{2-x}Sb_xTe_3$ films improves with increasing T_c. In this case, the electrical conductivity of the films increases, as can be seen from Fig. 1.

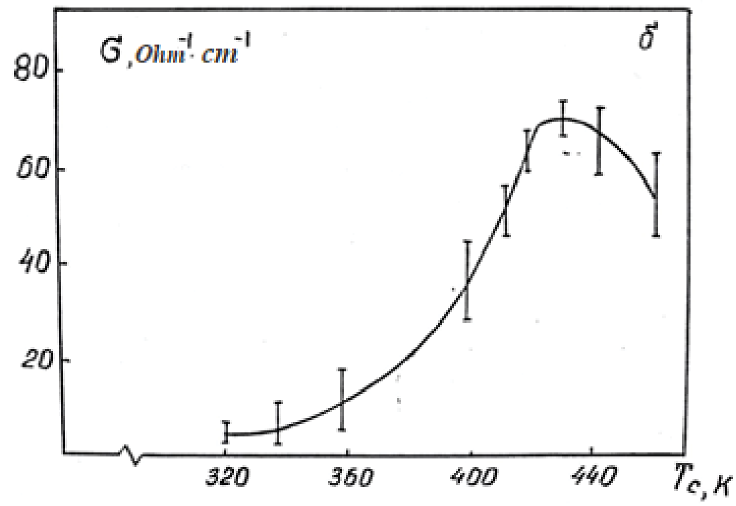

Fig. 1 Typical dependences of the electrical conductivity of bismuth-antimony telluride films obtained by preliminary evaporation of 1/6 of the charge on the condensation temperature

The concentration of charge carriers in the films depends very complicatedly on the preparation conditions and can differ markedly from the concentration of holes in the initial charge (bismuth-antimony telluride with a composition near x = 1.5 has only hole conductivity). Since the vapor over $Bi_{2-x}Sb_xTe_3$ in the initial interval of the evaporation process is strongly saturated with tellurium, the condensate is enriched in it and the concentration of holes in the films obtained from this portion of the charge is less than the initial value in it. In the films obtained by preliminary evaporation of a part of the charge (this is achieved by means of a shutter placed between the evaporator and the substrate, which opens after a certain time has elapsed since the beginning of the evaporation process), enrichment with a metal component (mainly antimony) is observed. The enrichment of the metal component is accompanied by an increase in the concentration of holes, which becomes higher than in the initial charge.

In addition to the evaporation conditions, the concentration of charge carriers in polycrystalline $Bi_{2-x}Sb_xTe_3$ films is significantly affected by the condensation temperature. Fig. 2 the dependence of the hole concentration in vacuum condensates obtained by evaporation of the entire charge of the composition $Bi_{0.5}Sb_{1.5}Te_3$ on the condensation temperature (T_c) is given. The same figure shows the dependence of p on (T_c) for films obtained by evaporating part of the charge. In both cases, the maximum concentration of holes is observed at $T_c \approx 350 \div 360$ K.

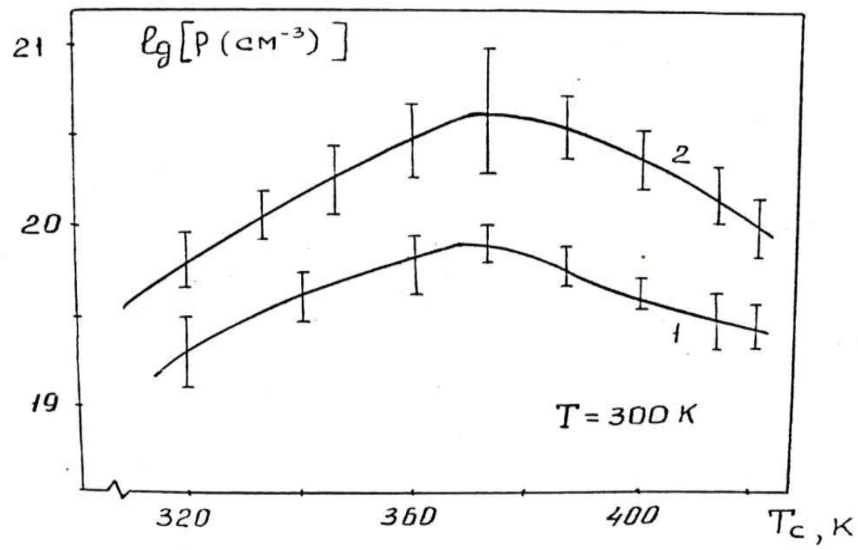

Fig. 2. Dependences of hole concentration on condensation temperature in films obtained by evaporation of the entire charge (1) and preliminary evaporation of a part of it (2)

The maximum concentration of holes achieved in films obtained from an undoped charge is p = (6-8) $\cdot 10^{20}$ cm^{-3}. If up to 3 wt % of antimony is added to the charge, at the same condensation temperatures it is possible to achieve a hole concentration p = (1-2)$\cdot 10^{21}$ cm^{-3}, as is observed in films on polyamide tape [2]. An increase in the concentration of holes at $T_c \approx 350 \div 360$ ° K is associated with the enrichment of condensates with antimony. At $T_c > 350 \div 360$ K, excess antimony begins to be removed from the condensates. An excess of bismuth on $Bi_{2-x}Sb_xTe_3$ condensates does not have such a strong doping effect as Sb.

Fig. 3 shows the dependences of the resistance R and the tensosensitivity (K) of films with a thickness of 6 μm on Tc. It can be seen that at the same film thickness, the resistance sharply decreases at Tc> 900C. This decrease is accompanied by the appearance of a maximum at $T_c = 90 \div 100$ ºC depending on K (T_c). A similar behavior of the dependences K (T_c) and R (T_c) was observed by the authors of [3].

The results presented show that the resistivity and the tensosensitivity coefficient of the films obtained from the $(Bi_{0.25}Sb_{0.75})_2Te_3$ compound depend on the film thickness, the substrate temperature during deposition, and the layer growth rate. Annealing the films after deposition can significantly improve their tensometric properties and parameter stability.

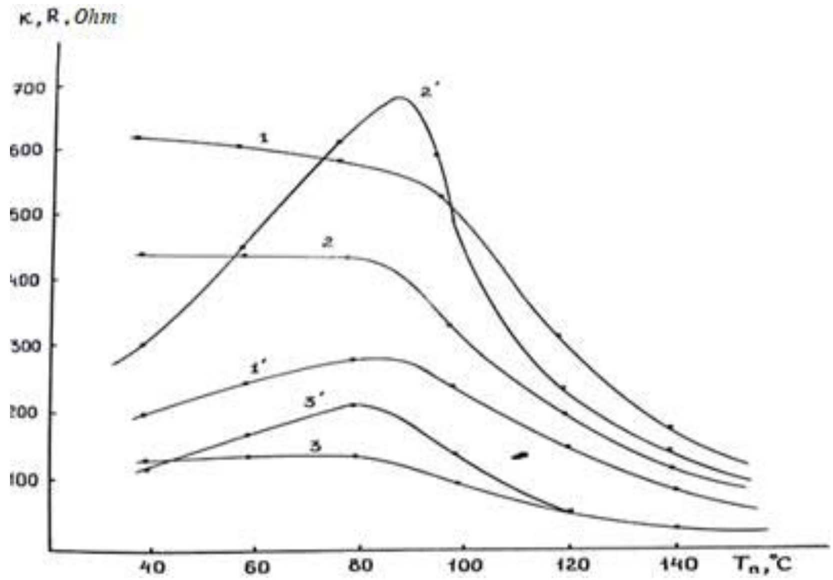

Fig. 3. Dependence of the resistance (1-3) and the tensosensitivity coefficient (1-3) of the $(Bi_{0.25}Sb_{0.75})_2Te_3$ films on T_n. W=100 (1.1^1), 200 (2.2^1) and 400 (3.3^1)

The thermoelectric coefficient of films also noticeably changes with an increase in the condensation temperature. The noticeable conditionality of the Seebeck coefficient by the condensation temperature is mainly related to the dependence of the hole concentration on T_c, since the α (P) dependence is complex due to the two-band structure of the valence band of bismuth-antimony telluride.

References

1. Ahmedov M.M. Gajnazarova K.I., Kadyrov K.S., Onarkulov M.K. // Universum: *Tehnicheskie nauki: elektron.nauch.zhurn*. [Engineering Sciences: Electronic Science Journal] 2020. № 2(71). (in Russ.).

2. Atakulov Sh.B. Gafurov U.A., Kazmin S.A.// S.1988. v.22, n.3. pp. 567-569. (in Russ.).

3. Atakulov B.A., Abdullaev E. A., Afuzov A. Ya., Bilyalov E. I., Rahimov A. U. *Deformacionnye effekty v neodnorodnyh poluprovodnikah* [Deformation effects in inhomogeneous semiconductors]. – Tashkent: Fan, 1978. 266 p.(in Russ).