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THERMOELECTRIC PROPERTIES OF *n*-PbTe FILMS

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Results of experimental investigation of the thermoelectric and galvanomagnetic properties of n-PbTe films have been given. It has been shown that the dependences of $\alpha^2\sigma$*, the conductivity, and the Hall concentration of the electrons on* T_c *have a narrow maximum near 620 K.*

Investigation of lead-chalcogenide films is of great practical importance from the viewpoint of the creation of high-sensitivity photodetectors and heat absorbers, strain gauges, and thermoelectric devices based on them. The conditions of preparation of PbTe films have also attracted attention because of their wide use as elements of primary converters of nonelectric disturbances to electric signals.

The technology of production of film branches with a high thermoelectric efficiency ($z = \alpha^2\sigma/\chi$) and its practical application are of independent interest [1].

One of the most important problems in creating film thermal converters is the development of the optimum technology of preparation of film branches. This involves, first, imparting a high thermoelectric power ($\alpha^2\sigma$) to the films [1] and, second, finding such macroscopic technological regimes that would ensure the recurrence of the parameters of the films in each technological cycle. This problem involves not only the selection of technological parameters (degree of vacuum in the technological chamber, evaporation and condensation temperatures, distance from the evaporator to the substrate) of the materials of the evaporator and the substrate but also a complex investigation of the regularities of formation of the structure and phase composition of condensates and the dependences of the main physical properties of the films on technological regimes. Therefore, one must begin solving each specific problem on creation of one film or another that is intended for use in different types of primary converters with the development of the technology.

In this work, we have given results of experimental investigation of the influence of the conditions of production of *n*-PbTe films on their thermoelectric and galvanomagnetic properties. An analogous investigation was carried out in [2] for $Pb_{1-x}Sn_xTe\langle Te\rangle$ solid solutions.

We produced *n*-PbTe films by thermal deposition in vacuum with a residual pressure of $5\cdot10^{-5}$–$5\cdot10^{-6}$ T on heated amorphous substrates of PM-1 polyamide tape. Crushed *n*-PbTe crystals produced by zone recrystallization were used as the charge. The initial charge material was doped with PbJ_2.

The thermoelectric and galvanomagnetic properties of PbTe films are affected to the largest extent by T_c. In searching for the optimum technological regime of condensation of *n*-PbTe films with high thermoelectric parameters, we varied T_c within 300–600 K.

The produced PbTe films condensed at $T_c < 445$ K possess hole (*p*-type) conductivity at room temperature, while the films condensed at $T_c > 470$ K possess electronic (*n*-type) conductivity.

Figure 1 shows experimental dependences of the kinetic coefficients of the *n*-PbTe films condensed on the PM-1 substrate in the interval of T_c from room temperature to 660 K. In the investigations carried out, the highest values of σ, $R_H\sigma$, and n_H were observed in the films produced at T_c = 620–640 K. It is clear from the figure that an increase in T_c leads to a continuous increase in the coefficient of thermoelectric power $\alpha^2\sigma$ of the *n*-PbTe films; at $T_c = (630 \pm 10)$ K, the films possess a maximum $\alpha^2\sigma$ whose value is 45–50 μW/(K$^2\cdot$cm). The dependences of $\alpha^2\sigma$, the conductivity σ, and the Hall concentration of the electrons n_H on T_c have a narrow maximum near 620 K.

At arbitrary condensation temperatures, the concentration of the charge carriers in the films determined by a Hall measurement is lower than the concentration in the initial charge, while at $T_c \approx 620$ K they approach each other closely.

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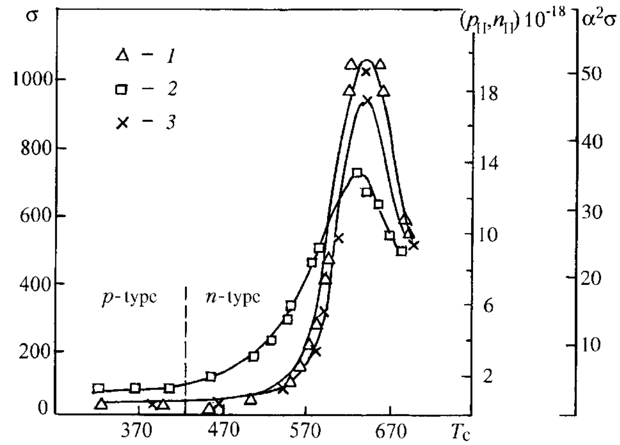

Fig. 1. Electrical conductivity, Hall concentration of the charge carriers, and thermoelectric-power coefficient in *n*-PbTe films vs. condensation temperature: 1) electrical conductivity; 2) Hall concentrations of the holes and the electrons; 3) thermoelectric-power coefficient. T_c, K; $\alpha^2\sigma$, μW/(K^2·cm); σ, $\Omega^{-1}\cdot$cm^{-1}; p_H and n_H, cm^{-3}.

TABLE 1. Dependences of the Kinetic Coefficients of *n*-PbTe films on T_c

T_c	α	σ	$\alpha^2\sigma$	$n_H \cdot 10^{-18}$	$R_H\sigma$
590	225	100	5	5.0	130
610	220	250	12	7.1	250
620	215	986	45.6	13.2	461
630	220	1010	49	12.2	511
640	200	950	38	12.0	450
660	195	576	22	9.0	400

The results obtained show that there is an unambiguous correlation between the structural perfections of *n*-PbTe films and their thermoelectric properties: the most perfect structure [3, 4] and the largest coefficient of thermoelectric power are ensured in the narrow interval of condensation temperatures T_c = 620–640 K, i.e., the highest thermoelectric properties correspond to structurally ordered films.

More detailed data on the kinetic properties of such films as functions of the condensation temperature have been tabulated (Table 1); some of them are presented in Fig. 1. It is clear from the table that *n*-PbTe films in which T_c is equal to 620 and 630 K have good thermoelectric properties.

NOTATION

T_c, condensation temperature, K; $\alpha^2\sigma$, thermoelectric-power coefficient, μW/(K^2·cm); σ, electrical conductivity of the semiconductor film, $\Omega^{-1}\cdot$cm^{-1}; $R_H\sigma$, Hall electron mobility, cm^2/(V·sec); α, thermoelectric coefficient, μV/K; *z*, thermoelectric efficiency, K^{-1}; χ, thermal conductivity, W/(K·cm^2); *p* and *n*, Hall concentrations of the holes and the electrons, cm^{-3}. Subscripts: c, condensation; H, Hall.

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