INFLUENCE OF HYDROSTATIC PRESSURE ON ELECTRICAL PROPERTIES OF INDIUM SELENIDE CRYSTALS

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Indium monoselenide belongs to layered semiconducting crystals A^3B^6. Crystalline structure presents a packet of layers each incluing four sequences of atomic planes Se-In-In-Se. Due to unique physical properties they are perspective for fundamental investigations and technical applications. In work [1], the anisotropy of the electrical properties of InSe monocrystals was investigated.

It has been shown, that anisotropy of electroconductivity $N = \sigma_{\perp c}/\sigma_{\parallel c}$ increases with temperature decreasing, reaching 10^5 value at $T = 80$ K. Anisotropy of kinetic properties of indium selenide crystals under pressure has not been studied.

Interest to A^3B^6 group of crystals is also stimulated since they possess polytypism, leading to perculiarities in electrophysical, optical, vibrational and other properties [2].

The present work deals with studying the kinetic and galvanomagnetic properties of layered InSe semiconductors both pure (specially undoped) and doped with tin atoms (0.2 %; 0.4 %) at room temperature and under pressure up to 10 kbar.

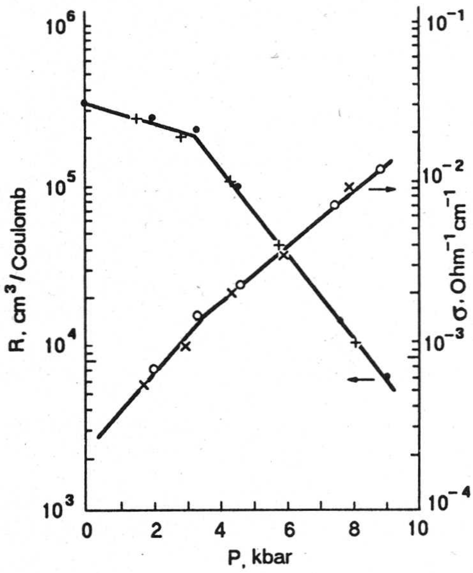
Methods of investigation of kinetic properties of crystals under pressure to 10 kbar, did not differ from that described in [3,4].

The experiments were carried out on crystals grown by Bridgman method and having hole conductivity at room temperature. Crystals, containing admixtures, had the electron conductivity [1]. Typical sizes of samples, cut out by diamond disc was of the order of $1\times2\times6$ mm^3. The optical contacts were formed by diffusional burning of indium in vacuum. When measuring the resistivity and the Hall effect (in the field of 6600 Gauss), the strength of current was limited by the ohmic region of current-voltage characteristics (CVC) and was equal to 10–15 μA.

The Hall constant of current carriers, their mobility and longitudinal resistivity ρ (in $I \perp C$) was measured.

In Fig. 1 the baric dependences of specific electroconductivity and Hall coefficient of InSe crystal are presented measured at room temperature. It is shown that with pressure increase to 10 kbar, the electroconductivity is 1.5 times increased. The increase of $\sigma(P)$ is approximately linear. Conductivity of the admixed crystals was not practically changed under pressure to 10 kbar as opposed to specially unalloyed crystals. Pressure dependence of the Hall coefficient is of complex character. Decreasing of R with pressure increase from the atmospheric one to 3.5 kbar is of linear dependence character, with the angle of slope tg $\varphi_1 = 6.6\cdot10^{-5}$. Let us denote the pressure range from the atmospheric one to ~ 3.5 kbar as region I. Sharp changing of the angle of slope of $R(\rho)$ dependence and tg $\varphi_2 = 2.8\cdot10^{-4}$ occurs at pressure over 3.5 kbar.

Analysis of the dependence shown in Fig. 1, allows to relate the change of Hall factor R with pressure, as dependent on changing of forbidden zone E_g width. Evaluation of the baric dependence of E_g in regions I and II gives values



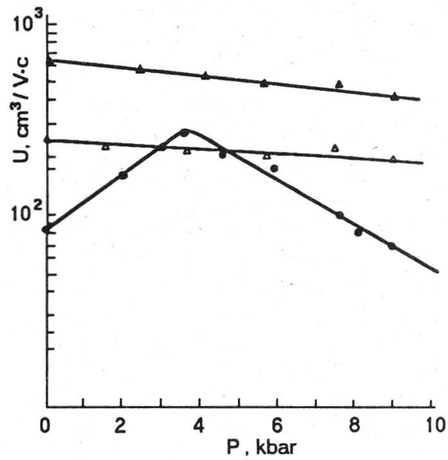


Fig. 1. Baric dependence of Hall constant and electroconductivity of InSe crystal, measured at room temperature (× — direct motion, ● — reverse motion)

Fig. 2. Pressure dependence of mobility (indium selenide crystals, measured at T = 300 °K, ⊙ — pure crystal, × — InSe < 0.2 % Sn>,O — InSe <0.4 % Sn>

$\frac{\partial E_{gl}}{\partial P} = 8 \cdot 10^{-5}$ eV/bar, $\frac{\partial E_{gl}}{\partial P} = 3 \cdot 10^{-5}$ eV/bar. Value of forbidden-zone width baric coefficient in region I is near the characteric value of coefficient of straight zone of other representatives of layered crystals A^3B^6 (GaSe; GaS etc). It differs nearly by the order of $E_g(P)$ value unstraight-zone width of InSe.

Baric dependences $R(P)$: $\sigma(P)$ of InSe crystal with forbidden-zone stright width and mobility $U(P)$ are presented in Fig. 2 for pure and alloyed Sn crystal and may be described by presentation taken in [6]. Unstraight-zone bottom is 10–15 meV above that straight zone according to [6]. Change of forbidden-zone straight width is related with changing of concentration with pressure increase in the I region. At 3.5 kbar the straight zone transfers to unstraight one (the straight zone decreases approximately by 25 meV) the rate of concentration change in II region is determined by the rate of changing of unstraight forbidden zone width. Break in the dependence of mobility on pressure for pure crystals may be explained by difference of the effective mass of carriers in straight and unstraight zones. According to [6], the effective mass of carriers in unstraight zone is higher, than in the straight one.

One of the experimental results of present work is that in alloyed crystals, carrier concentration, their mobility and electroconductivity display the baric dependence up to ~ 9 kbar.

From data of dependence $R(P)$ we can calculate the baric coefficient of chemical potential.

Let us use the expression for carrier concentration for a nondegenerate semiconductor [5];

$$P = Ne^{\xi/k_0T}, \quad (1)$$

where $N = 2(2\pi m_p k_0 T)^{3/2} h^{-3}$ density of states, ξ — chemical potential. Ignoring the pressure dependence of the density of states we can get an expression for the baric dependence of chemical potential;

$$\frac{\partial\xi}{\partial P} = \frac{k_0 T \partial \ln (P/P_0)}{\partial P} = \frac{k_0 \partial \ln (R/R_0)}{\partial P}. \quad (2)$$

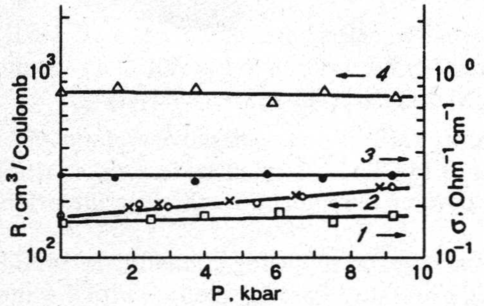


Fig. 3. Pressure dependence of Hall constant R of InSe crystals doped with <Sn> at room temperature : *1* and *2* — σ and R InSe <0.2%>; *3* and *4* — σ and R InSe <0.4%>

Calculation by using the $R(T)$ dependence is presented in Fig. 3, resulted in values of $\partial\xi/\partial P$, got from curve 2.

$$\partial\xi/\partial P = 10^{-6} \text{ eV/bar}.$$

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