ORIGINAL PAPER

PHOTOCURRENT SPECTRA AND CONDUCTIVITY OF SOLID SOLUTIONS $Tl(InS_2)_{1-X}$ $(FeSe_2)_X$ NEAR THE PHASE TRANSITIONS

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Abstract. *It is found that in Tl $(InS_2)_{1-x}$ $(FeSe_2)_x$ crystals and it is characteristic sequence of phase transitions, for $TlInS_2$, manifested in the form of anomalies in the temperature dependences of $\delta = f(T)$ and $\varepsilon = f(T)$. It is shown that as the values of x laver, the phase transition temperatures decrease, and the temperature range for the existence of an incommensurate phase a bit increases. Information has been was obtained on the temperature dependence of δ (T), the width of the forbidden band from the spectral distribution of intrinsic photoconductivity, and the magnitude of maximum spectral photo sensitivity σ_c^{max}/σ_T for the samples studied.*

Keywords: *photocurrent spectra, conductivity, phase transitions.*

1. INTRODUCTION

There are many works devoted to the study and creation of a terahertz Bloch generator based on semiconductor superlattices [1-4]. The possibility of creating a generator for Bloch oscillations of electrons on superlattices of semiconductor crystals in the terahertz frequency range is shown. It is established that the Bloch oscillations that arise on superlattices can produce effective generation of terahertz radiation in pulsed electric fields. Therefore, the possibility of developing a terahertz Bloch generator on the basis of disordered layered crystals is of definite interest [4-6]. From this point, the study of the electrophysical properties of crystals of the family $A^{III}B^{III}X_2$ is very important.

2. RESULTS AND DISCUSSION

Triple analogues of TlSe type $A^{III}B^{III}X_2$ are mainly crystallized in three structural types -TlSe, MoS_2, $TIGaSe_2$. For $TlInS_2$, a low-temperature monoclinic modification of the $TIGaSe_2$ type and a high-temperature hexagonal phase with a structure of the MoS_2 type are installed. The basis of the structure of $TlInS_2$ (monoclinic) [4] like $TIGaSe_2$ must constitute tetrahedral construction In_4S_{10} of during joining that form longitudinal prismatic "channels" filled with TI atoms. Because of the larger size of the TI atoms, compared with the Ga atoms in tetrahedras, some stresses are created, due to the structure becomes less stable and turns out to be dimorphic. As it is known, there is no polymorphic modification for $TIGaSe_2$. The key structural unit is formed by purely tetrahedral Ga atoms, but, as indicated in [5], due tu the shift of packets, all possible polytypes are formed, up to incommensurate phases [6].

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In order to obtain the monoclinic phase of $TlInS_2$ and to study the electrical and photoelectric properties of the solid solutions of Tl $(InS_2)_{1-x}$ $(FeSe_2)_x$, by Bridgman-Stockbarger method their single crystals have been ground. As a result of X-ray analysis it has been determined that grown monocrystals have a monoclinic structure of the $TIGaSe_2$ type.

Figure 1. X-ray patterns of the oscillation around the axes a (a) and b (b) of Tl(InS_2) single crystals 0.985 ($FeSe_2$) 0.015

Fig. 1 (a, b) shows the x-ray patterns swinging around the axes a and b of the crystal. The calculated lattice parameters are as follows: a = 10.926 Å, b = 10.923 Å, c = 15.09, β = 100^0 , z = 16, pr.gr C_c > (C_c^4) [4]. In order to determine the amount of Fe and Se atoms entering into the structure on the Camebax micro analyzer, all the studies compositions have been analyzed. The detection limit was not worse than 10^{-3}.

Single crystals of Tl $(InS_2)_{1-x}$ $(FeSe_2)_x$ below 220K undergo several successive phase changes from the paraelectric to the ferroelectric phase. The electric and photoelectric properties of TlInS2 crystals near phase transitions have not been sufficiently studied [8], and the photoelectric properties of solid solutions based on them are less studies. In [9], the results of a studying of the dependency of the electrical conductivity and dielectric permeability of Tl $(InS_2)_{1-x}$ $(FeSe_2)_x$ crystals on composition and temperature are presented. It is established that by increasing the x the value of permeability decreases, and the electrical conductivity increases. It is found that in Tl $(InS_2)_{1-x}$ $(FeSe_2)_x$ crystals consistence of phase transitions is characteristic for $TlInS_2$, manifested as anomalies in the temperature dependences $\delta = f(T)$ and $\varepsilon = f(T)$. It is shown that with the of x values increase, the phase transition temperatures decrease, and the temperature range for the existence of an incommensurate phase slightly increases.

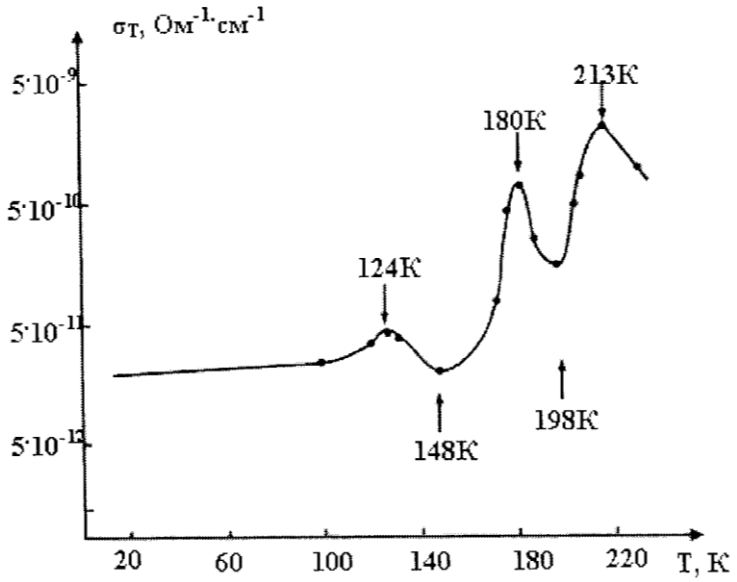

Figure 2. Temperature dependence of the dark electrical conductivity σ_T of single crystals of Tl $(InS_2)_{1-x}$ $(FeSe_2)_x$ at x = 0.005.

Information on the temperature dependence of $\delta_T(T)$ (Fig. 2), the width of the forbidden band from the spectral distribution of intrinsic photoconductivity (Fig. 3), and the magnitude of the maximum spectral photo sensitivity ($\sigma_c^{max}/\ \sigma_T$) for the samples studied is obtained in this paper.

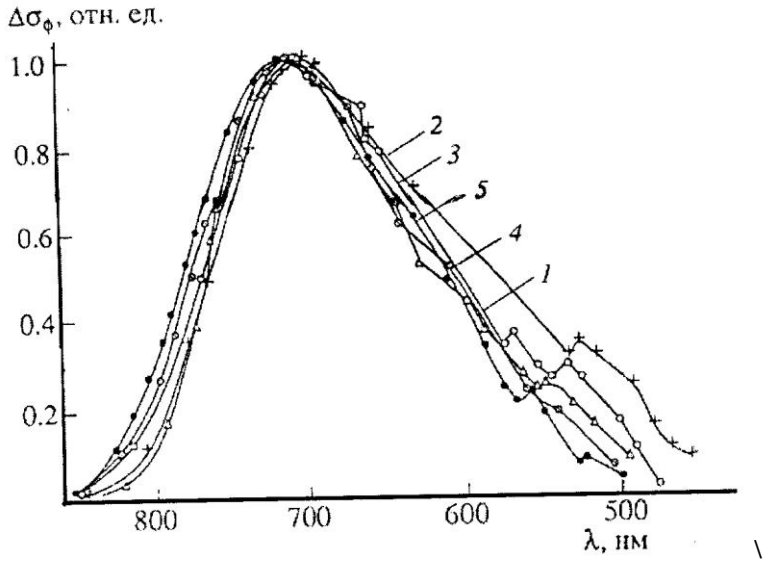

Figure 3. Spectral dependencies of the photoconductivity of Tl (InS_2) 0.995 ($FeSe_2$) 0.005 single crystals at temperatures of 50 (1) K, 150 (2) K, 175 (3) K, 200 (4) K, 250 (5) K.

The effect of $FeSe_2$ has a particularly strong effect on the temperature dependence of the width of the forbidden zone (Fig. 4).

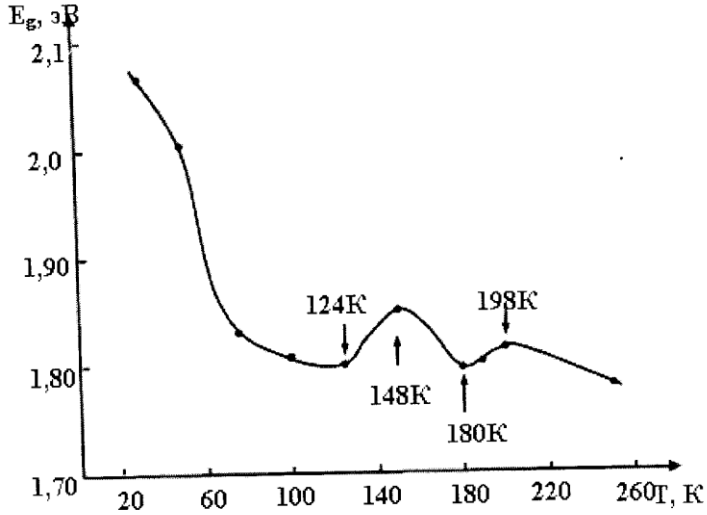

Figure 4. Temperature dependence of width of forbidden zone E_g in Tl $(InS_2)_{1-x}$ $(FeSe_2)_x$ single crystals at x = 0.005.

In this experiments, E_g was determined from the curves of the spectral distribution of photoconductivity. In this case, the value of the photon energy corresponding to the half-fall of the maximum photocurrent at the long-wavelength edge was taken as the value of E_g. The characteristic anomalies of the $E_g(T)$ curve at 124K, 148K, 180K, and 198K correlate with the anomalies of the curve $\sigma_T(T)$ (Fig. 2).

3. CONCLUSION

Thus, it was found that, in Tl $(InS_2)_{1-x}$ $(FeSe_2)_x$ crystals, a sequence of phase transitions characteristic of $Tl(InS_2)$ occurs, manifested as an anomaly in temperature dependences. The temperature dependence of the dark electrical conductivity, the width of the forbidden band, and the spectral dependence of the photoconductivity were studied.

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