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RESIDUAL PHOTOCONDUCTIVITY EFFECT IN SEMI-INSULATOR FILMS $ZnSe_xTe_{1-x}$

The features of photoconductivity in semi-insulating layers $ZnSe_xTe_{1-x}$ have been studied. The dependence of the photocurrent on applied voltage has been investigated. It is observed that the voltage under which the space-charge-limited (SCL) current flows the impurity maximum with $h\nu = 1{,}4$ *eV* appears in the spectra of photocurrent. The residual photoconductivity is observed under illumination of impurity absorption region. And the ratio of photocurrent to the dark one reaches of value 10^5. The observed phenomena are explained by space inhomogeneity of the layers.

1. Introduction

The epitaxial films $ZnSe_xTe_{1-x}$ combine the high resistivity with the high photosensitivity. However there is no complete information on photoelectric properties of solid solution in literature. Generally, the available information concerns the researches in the dependence of bandgap (Eg) on film composition [1]. In the present work the unknown effects, being discovered in the semi-insulating $ZnSe_xTe_{1-x}$ films grown on ZnSe substrate are discribed.

2. Experimental procedure

The epitaxial films of solid $ZnSe_xTe_{1-x}$ solution were produced by liquid phase epitaxy on high-resistant ZnSe (111) substrate. The growth took place under the epitaxial temperature 980—1050 K out of Bi melt. The geometry of Ohmic contacts is presented in fig. 1, insertion (*a*). The films have *p*-type conductivity and their resistivity was 10^8 *Ohm · cm*. The value of resistivity for (ZnSe) substrate are not more ($ZnSe_xTe_{1-x}$) than two or three order. The composition of solid solution $ZnSe_xTe_{1-x}$ was defined by Raman spectroscopy [1]. The value x, of growing films changes in the range 0,2—0,3, that corresponds to $E_g = 2{,}14$ *eV*. Photoconductivity spectra were measured within the wavelength range 0,4—3,0 μ*m* using DMR monochromator. The PZh-100 incandescent lamp was used as excitation source. Photoconductivity spectra were taken with constant number of light quanta being incident on the sample.

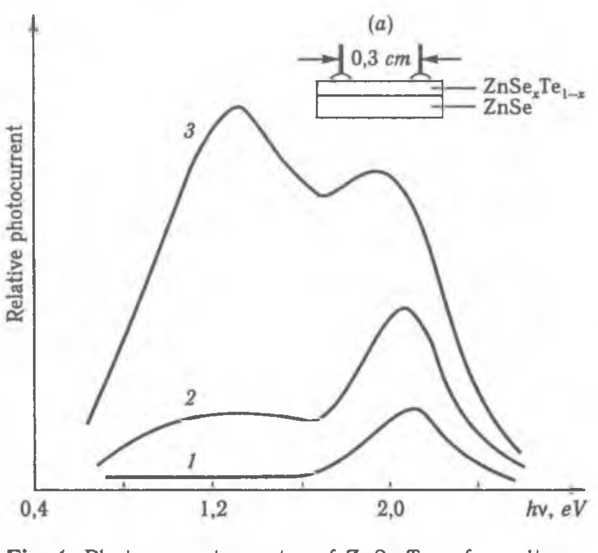

Fig. 1. Photocurrent spectra of $ZnSe_xTe_{1-x}$ for voltages 10 *V* (*1*), 20 *V* (*2*) and 30 *V* (*3*)

3. Results and Discussion

The spectral responce of photocurrent measured under the different applied voltages and at $T = 500$ K are showed on Fig. 1. Figure 1 presents one intrinsic peak with maximum $h\nu_{max} = 2{,}14$ *eV*, under low voltages (curve *1*), which corresponds to the band-to-band transitions $ZnSe_xTe_{1-x}$. The additional band with $h\nu_{max} = 1{,}4$ *eV*, corresponded to photoionization of impurity centres, appears in spectrum (curves *2*, *3*) under voltage increase, beginning from the certain critical value (U_{cr}). The induced impurity photocurrent increases with the voltage more quickly than the intrinsic peak. One more experimental fact, being observered on $ZnSe_xTe_{1-x}$ films, consists in the following, if the samples, mounted in darkness under the voltage $U < U_{cr}$, are illuminated by light with energy $h\nu = 1{,}4$ *eV*, current increases to some value, which relaxes quickly to the primary one after switching off the light. When $U > U_{cr}$ current increases slowly to its maximum value. The relaxation time depends on voltage, intensity and sample temperature. The maximum value of ratio for the impurity photocurrent to the dark one I_d was equal 10^5. When the turning off the light the impurity photocurrent slightly decreases, but the state with the large conduction is reminded for long time (10^5... 10^6 *s*). So, the phenomenon of residual photoresistivity can be observed.

The current voltage characteristics (CVC) of dark current and impurity photocurrent were measured.

Figure 2 shows, that the dark current changes, firstly, in accordance with Ohm law, and than is dis-

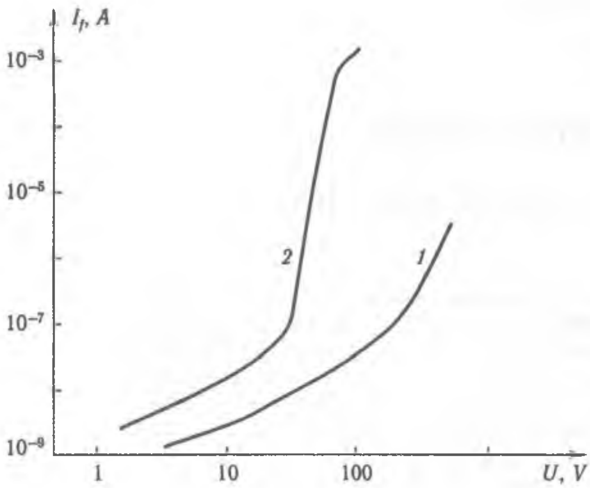

Fig. 2. CVC dark current (*1*) and impurity photocurrent (*2*)

cribed by the responce, which is characteristic law for the current-limited space (CLS). CVC of the impurity photocurrent are also discribed by the law of the monopolar injection (curve *2*). The voltage, threshold population traps V_{tpt}, equal

$$V_{tpt} = 4eN_tL^2/3\varepsilon,$$

here e — is electron charge, L — is distance between cathode and anode, ε — static dielectric constant, N_t — traps concentration. The evaluation of N_t under the given geometry of contacts shows the value $10^{15}\ m^{-3}$. However, such very low concentration is not determined by general purity of films, but it shows that in our case (SCL) flows in small regions of high resistivity and it regulates current flow in films. At voltage increase, the resistance of both regions are equalized at the expense of its injection currents. The investigations in nature of inhomogeneities showed, that it is connected with the inhomogeneity distribution of electrical defects in films volume, but not with the inhomogeneities distribution of $ZnSe_xTe_{1-x}$ composition. We suppose, that the centres of extrinsic photosensivity are in the low resistance regions. So the impurity peak appears in photocurrent spectra under the high voltage. The recombination barriers with height E_{rec}, existed on the boundary of electrical inhomogeneities and provided the space separation on nonequeilibrium carriers. Life time of nonequeilibrium carrier and relaxation time of residual conductivity (τ) are determined by the expression

$$\tau = \tau_0 \exp(E_{rec}/kT),$$

here τ_0 — time of thermal quilibrium carrier. By 300 K $\tau_0 = 10^{-4}$ C, $kT = 0{,}025\ eV$, $\tau = 10^5...10^6$ C, obtained value $E_{rec} = 0{,}5\ eV$.

4. Conclusion

The $ZnSe_xTe_{1-x}$ films of solid-solution growing on ZnSe substrates show the photosencivity inducing by electrical field and residual photoconductivity exciting by light from absorption impurity region. The investigation of mechanism of current flow in $ZnSe_xTe_{1-x}$ showed that it contained the electric inhomogeneity. The residual conductivity in films is explained the existance of recombination barriers providing the space separation of carriers on the boundary of inhomogenity. The received results in work could be practically applied in optic switching devices. To these also promote that, the effects are obsereved under the high temperature (300...350 K), have the high value and the films have of the mechanical durability and the high adhesion to substrate.

References

1. *Skobeeva V. M., Serdyuk V. V.* Application of Raman spectroscopy for investigation of solid of II—VI semiconductors // SPIE. — 1993. — V. 1983. — P. 769.