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TRANSIENT PHOTO-INDUCED CURRENT MEASUREMENTS IN HIGH RESISTIVITY ZnSe CRYSTALS*

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Using technique of computerized signal-averaging of photocurrent transient, we have studied the details of deep level states in high resistivity ZnSe crystals. The time resolved spectra of photocurrent and four-gate PICT spectra are presented.

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Detailed investigations of photoconductivity in II–VI semiconductors have been concentrated mainly on CdS and CdSe single crystals and powders but only few [1–3] on the mechanism of photoconductivity of ZnSe single crystals. The electrical and optical properties of these compounds are often affected by the presence of some dopants or native defects which are easily introduced during the high temperature growth and sample preparation processes. In general in these compounds the photocurrent transients are non-exponential because of a non-linear multi channel recombination mechanisms. The presence of two or more deep traps with nearly equal thermal activation energies could lead to a signal comprised of two or more exponentials, one faster than the other. In order to determine the nature of the traps one has to know whether the transient current is due to electrons or holes.

In this work we have made photo-induced current transient measurements on the high resistivity ZnSe crystals. The ZnSe crystals were grown by the high pressure Bridgman method using Koch Light ZnSe powder as a source material. The

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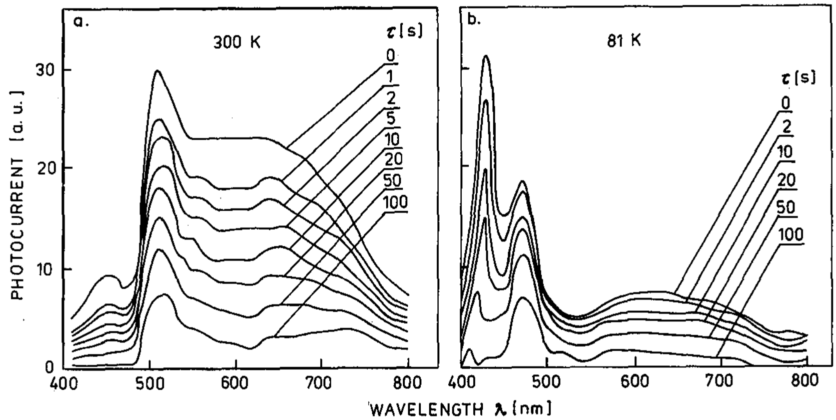

Fig. 1. Photo-induced current for ZnSe crystal at room temperature (a) and at 81 K (b) measured at different delay times after excitation light pulse.

crystal was cut onto 1 mm thick plates and annealed in liquid Zn containing 10 % of Al at a temperature of 1220 K during 70 hours. After mechanical polishing and chemical etching indium contacts were alloyed to ZnSe samples. The ZnSe crystal was attached to the cold finger of a cryostat and the temperature could be set with a precision of 0.1 K and maintained within 0.2 K of the set point for periods as long as several minutes. A constant voltage was applied across the sample, and the current was measured by monitoring the voltage across a resistor in series with the sample. Light from the halogen 50 W lamp through SPM-2 (Zeiss) monochromator was focused on the sample. We have used electromechanical shutter with the off time less than 1 ms. We use a digital approach which offers the possibility of recording and storing the entire decay PICT signals at various excitation conditions. The data can be sampled at 20 000 points with 16-bit accuracy. The stored data were analyzed using the so-called four-gate technique [4-9]. In Fig. 1. we present the results of measurements of photo-current decay after excitation of ZnSe crystals with light of different wavelengths at RT and 81 K. The spectral photoresponse for photoconductivity at 81 K exhibits three maxima at about 430, 465 and 620 nm, which correspond to the band to band, shallow and deep levels transitions, respectively. As the delay time increases the 430 nm peak shifts towards shorter wavelengths, while the 465 and 620 nm maxima remain unchanged. The time resolved spectra (TRS) have been investigated by PICT spectroscopy in high resistivity ZnSe for the first time. The obtained PICT data seem to require three or four separate exponential decays to fit the experimental results. With the use an extrinsic excitation a photoconductivity is excited by electron transitions from the acceptor level to the conduction band. As a result holes remain trapped in the acceptor level because their thermal emission into the valence band is not possible at low temperature. The relaxation process is simply determined by the capture of photoelectrons by the traps, followed by radiative recombination with the holes in the acceptor level [9].

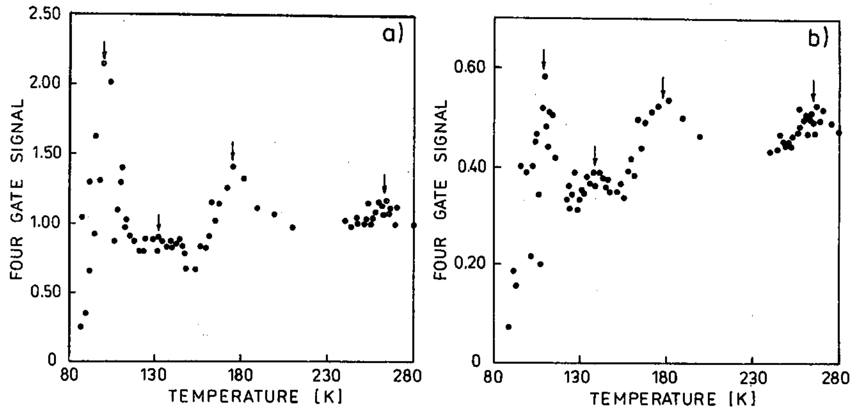

Fig. 2. Four-gate PICT spectrum for ZnSe crystal for the emission time τ_m = 15 s, t_2/t_1 = 1.5 (a), and τ_m = 23 s, t_2/t_1 = 1.5 (b).

Fig. 2a and 2b show a typical PICT spectra generated by four-gate signal processing [4, 6, 9]. Four well-separated peaks are revealed indicating the presence of four trapping levels. From a series of spectra corresponding to different values of τ_m an Arrhenius plot can be constructed for each maximum. The activation energies of carrier emission E_T of these traps were estimated as: 0.20±0.02 eV, 0.26±0.02 eV, 0.34±0.02 eV and 0.38±0.02 eV. The electron traps with the activation energies 0.38 eV are minority defects. We assume, according to the work of Heurtel et al. [10], that this level is connected with Zn which has to be stabilized in same way in the lattice or by interaction with another defect. All DLTS spectra for low resistivity ZnSe crystals which were annealed in molten Zn are often dominated by the single peak. This electron trap has the thermal activation energy of 0.34 eV [11].

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