Polarization sensitivity of ZnSe single crystals based structures

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Abstract. The work is devoted to study of polarization photosensitivity of structure on the basis of ZnSe single crystals. To produce such photosensitive structure we used heat treatment of ZnSe substrates on dry air. The polarization photosensitivity was detected and studied in relation to their manufacturing conditions and photoregistration configuration. We conclude that such photosensitive structure can be used as polarimetric short wavelength photodetector.

1. Introduction
The compound of ZnSe is among promising II-VI compounds and is widely used in developing short wavelength semiconductor electronic devices and also as data displaying systems [1, 2, 3]. Moreover, ZnSe is one of the typical materials of phases of variable composition; therefore, its properties “keep track” of thermodynamic equilibrium parameters, which requires precise control of the material existence conditions during growth. In the present work we report the initial results of an experimental study of the photoelectric structures based on ZnSe single crystals in linearly polarized light, which have allowed us to draw conclusions regarding their potential for application in polarization photonics.

2. The method
To date, growth methods from vapor have been applied to grow high-quality crystals. However, growth method from melt has attracted attention because it is more suitable to obtain large bulk crystals for relatively short growth duration. AIBVI single crystals have a number of unique properties which significantly depend on nano-scale defect type and concentration. Native point defects generating as a result of deviation from stoichiometric composition influence on luminescence, conductivity, and other structure sensitive properties similar to dopants. Electrical and optical properties of ZnSe crystals are affected by deviations from stoichiometry [4] which can varied within the homogeneity limits of ZnSe. ZnSe is II-VI Semiconductors with zinc-blende structure straight-band semiconductors forming tetrahedrally directed covalent bonds from hybridized s and p atomic orbitals. In an elementary unit cell containing one anion and a cation, the diatomic basis contains a cation at and the anion at relative to the lattice point (Fig. 1). Zinc selenide (ZnSe) is an intrinsic semiconductor yellow color (Fig. 2) with a band gap of about 2.72 eV at 300 K.

Photosensitive structures were derived from n-ZnSe single crystals grown from a melt with the composition close to the stoichiometry of the compound. Single crystals has a sphalerite structure and a lattice parameter the corresponding value [4].
Figure 1. Crystal structure of ZnSe lattice.

To produce the photosensitive structures of the n-type single crystals substrates via crystallographic plane of splitting (100) with average dimensions of $5 \times 4 \times 2 \text{ mm}^3$ were subjected for heat treatment at a temperature of 723 K in dry air. As the result reproduces the colored p-type layer. It was observed that the heat treatment of ZnSe single crystals on dry air lead to the change of color in ZnSe with a sub-surface region. So such changes during heat treatment in the air seems to be related to interference of the formed oxide layers. We used the well-known method of polarization photoabsorption spectroscopy to evaluate the quality of the frontal plane of such photosensitive structures and their possible application in polarization photonics.

3. Results and discussion

The photovoltaic effect was detected in all the studied structures. Linearly polarized light along the normal to the photodetector surface the photosensitivity of Schottky barriers as well as type structures A and B are practically independent of the spatial orientation of the electric field vector of the light wave $E$ relative to crystallographic axes in a crystal substrates. This fact corresponds to the isotropic nature of the photoactive absorption in the substrates ZnSe having a sphalerite structure. Therefore, natural photopleochroism in structures based on ZnSe not observed [10].

In all structures derived from n-ZnSe, only “induced photopleochroism” is detected when angle of incidence of linearly polarized radiation at the surface becomes different from 0 degree [11].

Figure 2. The external form of ZnSe crystal.
**Figure 3.** Induced photopleochroism coefficient spectras for different structure basen on ZnSe with different time of treatment ( curve 1- 7 min, curve 2- 10 min, curve 3 -20 min).

Only induced photopleochroism was detected in all photosensitive structure on the basis of ZnSe single crystals. This type of photopleochroism observed when the angle of incidence of linearly polarized light different from 0.

When structures illuminated along (001), the photocurrent is polarization –independent, such n-p transitions corresponding functionally to GaAs diodes. Zn Se structures prepared on (100) plates exhibit polarization indicatrices of photocurrent in agreement with the generalized Malius Iaw [5, 6, 7, 8, 9]. The main laws for the polarization photosensitivity investigations of such ZnSe based structures consists in following. All structures demonstrates the angular dependencies of short circuit

Changing the geometry of photodetection also affects markedly the polarization photosensitivity of such ZnSe based conversion devices. Spectral dependences of the induced polarization photosensitivity for such ZnSe structures plotted on Fig. 3. Coefficient of induced photopleochroism reach 40 % as well as the light enter to the active region of structures. This correspond to the analysis carried out in [9-21].

It was concluded ZnSe photosensitive structure based on ZnSe single crystals can be used as polarimetric photodetector for short wavelength range in polarization photonic.

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