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PHOTOVOLTAIC AND PHOTOREFRACTIVE EFFECT IN CUBIC PIEZOELECTRIC ZnS

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Abstrac: In this work was considered photovoltaic effect in cubuc piezoelectric crystals ZnS. Some experimental and physical bases of photovoltaic effect have been discussed.

Key words: crystals ZnS, photovoltaic effect, tensor, crystal without the centre of symmetry, generates

Photovoltaic effect in cubic crystals ZnS

The anomalous photovoltaic effect observed for the first time for ferroelectrics is a particular case of a more general photovoltaic effect described for crystals without a center of symmetry by the third-rank tensor α_{ijk}.

$$J_i = \alpha_{ijk} E_j E_k^* \quad (1)$$

The components of tensor are distinct from zero for 20 acentric groups of symmetry. At presence of the centre of symmetry α_{ijk}=0.

The photovoltaic effect for the first time was found experimentally out in ferroelectrics [1,2], and also in piezoelectrics [3,4,9]. The consecutive theory of this effect was advanced in [5], where was shown, that it is connected to purchase nonequilibrium electron of a superfluous pulse in a zone of conductivity, which size and direction are defined by asymmetry of excitation, recombination and dispersion of the carrier in a noncentro-symmetrical crystal.

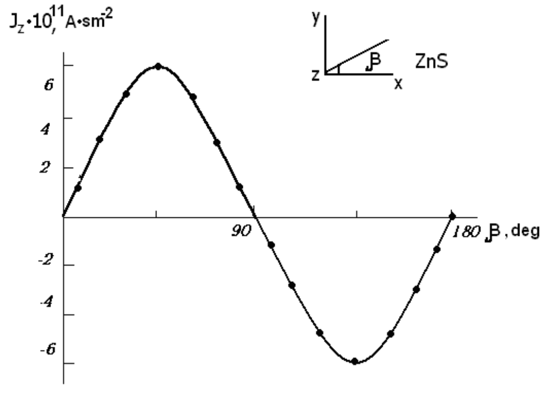
According to (1) at uniform illumination by the linearly polarized light of a homogeneous crystal without the centre of symmetry in it arises a photovoltaic current J_i. The mark and size of photovoltaic current J_i depends on orientation of a vector of polarization of light with components E_j and E_k^*. If electrodes of a crystal to open, the photovoltaic current J_i generates the photovoltage $V_i = \frac{J_i}{\sigma_T + \sigma_\phi} l$ where σ_T and σ_ϕ accordingly dark and photoconductivity, l distance between electrodes. Generated photovoltage about 10^3-10^5В, exceeding, thus, size of width of forbidden zone

Eg on two - four order. According to (1) and symmetry of dot group it is possible to write expressions for the photovoltaic current J_i . The comparison of experimental angular dependence with J_i (β) allows to define photovoltaic tensor α_{ijk} or photovoltaic factor $K_{ijk} = \frac{1}{\alpha^*}\alpha_{ijk}$ (here α* - factor of absorption of light). By us it has been discovered and investigated volumetric photovoltaic effect in piezoelectric crystals ZnS, belonging to cubic dot group $\bar{4}3$m. As against ferroelectrics [4] the photovoltaic effect in ZnS it is possible to observe only in polarized light. According to (1) and symmetry of dot group at illumination of a crystal in z direction of an axis 4 order (axis z) the expression for a photovoltaic current in a direction z looks like:

$$J_Z = \frac{1}{2}\alpha^* K_{14} I \sin 2\beta \qquad (2)$$

where β - corner between a plane of polarization of light and axis x.
In the given work is resulted, results of research of cubic crystals ZnS, grown by a hydrothermal method in solutions H_3PO_4 and KOH [6]. From crystals were cut out parallelepipeds by the size 5×5x1mm^3. The measurement of a photovoltaic current *J* and field $\breve{E} = \frac{J}{\sigma_\phi}$, generated by it ($\sigma_\phi$- photoconductivity) was made by a way taken the stationary volt - ampere characteristics [4]. In a fig. 1 is submitted a orientation dependence $J_z=J_z(\beta)$, taken at T=143K at illumination by light from a long wave λ=500 *nm* (α^*=5 sm^{-1}) and intensity $I = 2{,}3\cdot 10^{-3} Vt\cdot sm^{-2}$. The comparison of this angular dependence with (2) gives $K_{14} = 5\cdot 10^{-9} A\cdot sm\cdot (Vt)^{-1}$. Thus, the value of the module K_{14} in the crystals, investigated by us, ZnS is much higher, than at known ferroelectrics and piezoelectrics [4] in an interval T=140-300K the module K_{14} finds out weak temperature dependence. Due to this, and also because of strong temperature dependence of photoconductivity σ_f, generated in a direction of an axis z the field $\breve{E} = \frac{J}{\sigma_f}$ changed in limits from $1V\cdot sm^{-1}$ (T=300K) till $40V\cdot sm^{-1}$ (T=143 K) and did not depend on intensity of light *I*.

In crystals ZnS, grown by a hydrothermal method the photovoltaic effect has basically impurity character. It is shown in the fig. 2 where the spectral distributions of photoconductivity σ_f (1) of photovoltaic current (2), referred to unit of falling energy and edge of optical absorption (3) are submitted. The impurity strip in spectral distribution *J* takes place nearby λ=500 *nm*. There is located a impurity maximum of photoconductivity. For the crystals which have been grown, in acid or



alkaline environment the impurity maximum has a different situation and is moved limits of 450-500 nm.

Fig. 1. The orientation dependence of density of a photovoltaic current J_z in a direction [001]. The crystal is shined plainly by polarized light in a direction [001]. T=143K, I=2,3·10^{-3} $Vt{\cdot}sm^{-2}$, λ =500 nm.

The APh effect in crystals without the centre of symmetry also can be applied as a new type of elements - photovoltaic transformers of energy. The coefficient of efficiency of transformation of light energy in electrical on a basis of photovoltaic effect while low (0,1 %). However, ferroelectric and piezoelectrics can be used for generation of basic voltage of low capacity. Thus the spectral sensitivity of these elements varies in wide area: from vacuum ultra-violet till red seen area.

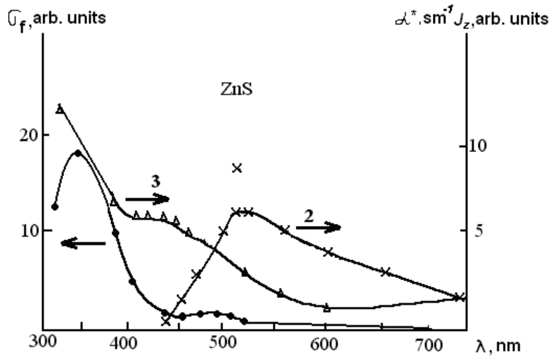


Fig. 2. The spectral distributions of a photovoltaic current J_z (2), photoconductivity σ_f (1) and optical absorption $\alpha*$ (3) at T=143K. β =45^0.

There are opportunities of application of these processes in nonsilver photo and vidicons and also in nanotechnology as the power supply.

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