# THE STIMULATION OF MULTIPLICITY OF THE LIGHT TO DARK CURRENTS RATIO IN $PbGa_2Se_4$ SINGLE CRYSTAL

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The volt-amperecharacteristic of $PbGa_2Se_4$ single crystals in the darkness and under the illumination 200 lx has been investigated in the broad interval of electric fields.

The stimulation of multiplicity the light to dark currents ratio at 200 lx has been revealed. It has been established that deep levels of the crystal are filled with the illumination increase, in the consequence of what the height maximum in dependences of the light to dark current ratio multiplicity on voltage ($k \sim U$) reduces.

The family of triple chalcogenide compounds, with the common formula $A^{II}B_2^{III}C_4^{VI}$ (where A-M, Pb; B-Ga, In; C-Se, S) belongs to the perspective semiconductive materials, which at present has studied in details in physics and technology of semiconductors.

Crystals on the base of above-mentioned compounds, possessing expressive photoconductive properties, are the perfect base for the creation of light-emitting and electro-photographic devices, solar elements and other converters.

$PbGa_2Se_4$ compound, belonging to this family, is photosensitive in the broad spectrum region (0.400÷1.200μm). Photoconductivity (PC) spectra at various applied electric fields, the temperature blacking of the photocurrent (TBP), PC kinetics and etc. [1] have been investigated in $PbGa_2Se_4$ crystals in works published earlier.

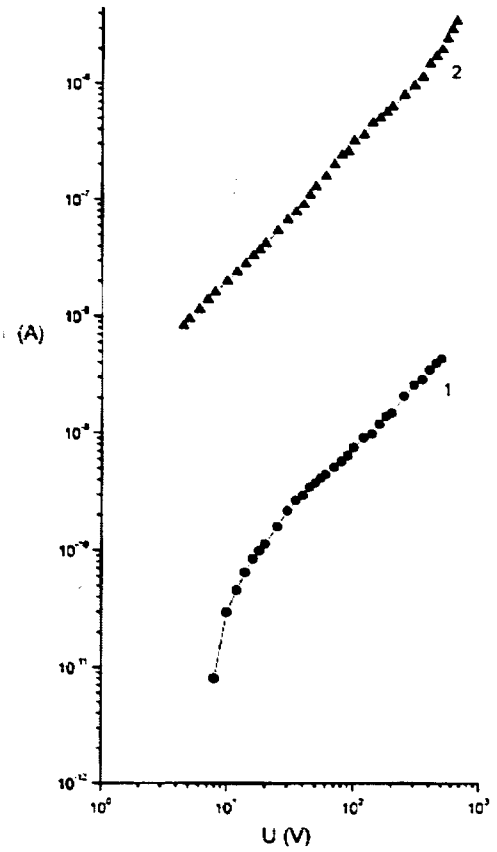


*Fig.1.* Volt-ampere characteristic of $PbGa_2Se_4$ single crystal in the darkness (1) and under the illumination 200 lx (2).

$PbGa_2Se_4$ single crystals, obtained by the Bridgman-Stockbarger method, are high-ohmic semiconductors ($\rho \sim 10^{10} \div 10^{11}$ ohm·cm). Direct and indirect optical transitions of $E_{gr}$=2.28eV and $E_{gd}$ =2.35eV energies corresponding to 300 lx [2] have been revealed as a result of optic research in the interval of the photon energy 2.24÷2.46eV.

As it is known, the multiplicity of light to dark currents ratio is one of the main characteristics of photosensitive crystals. Authors of works [3-5] have worked out the theoretically based methods of experimental photocurrent curves analysis, based on approximations in the constant field regime.

Experimental research has been carried out on the device, assembled in monochromator MDR-12 base. Samples have been illuminated by the filament lamp.

Volt-ampere characteristics (VAC) of $PbGa_2Se_4$ in the darkness and by illuminations 200 lx are presented on fig.1. As it is seen from the fig., the dark current grows sharply in weak electric fields and the linear part is observed on VAC by the illumination at the same field values. The sharp increase of the dark current up to $10^{-10}$A is connected with the contact surface barrier creation in the sample, included in the locking direction. The barrier breakdown in the consequence of the impact ionization in the volume charge region occurs as a result of the linear increase and electrons are injected into the space from the contact.

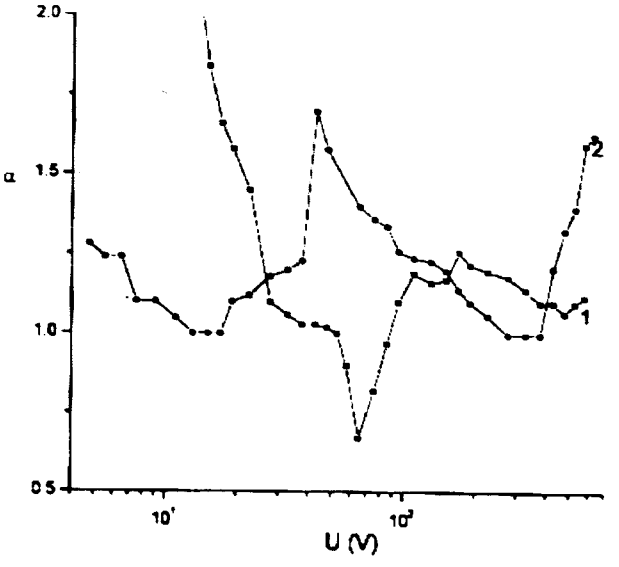


*Fig.2.* The dependence α on U in the darkness (1) and by the light 200 lx (2). (1) – $n_{t0} = 6 \cdot 10^6$ cm$^{-3}$ : $D_t^* = 6 \cdot 10^{-3}$ : $d_k = 1.1 \cdot 10^{-7}$ cm; $\Delta\varepsilon = 0.78$eV; $n_{k_{max}} = 2.6 \cdot 10^6$ cm$^{-3}$; (1)- $n_{t0} = 6 \cdot 10^6$ cm$^{-3}$ ; $D_t^* = 6 \cdot 10^{-3}$ ; $d_k = 1.1 \cdot 10^{-7}$ cm; $\Delta\varepsilon = 0.78$eV; $n_{k_{max}} = 2.6 \cdot 10^6$cm$^{-3}$; $I_{k_{max}} = 1.22 \cdot 10^{-9}$A; $\rho_k/e = 3.88 \cdot 10^{11}$cm$^{-3}$; (2) - $n_i = 2.24 \cdot 10^9$ cm$^{-3}$.

The sublinear part with the degree value $0<\alpha_m<1$, which characterizes the constant field regime on the intercontact layer, is observed on the curve at the further voltage increase (fig.2, curve 1). Using the minimal value $\alpha_m$ =0.67, the initial contact concentration $n_{k0}$, the effective transparency of contact barrier $D_k^*$, contact barrier $d_k$ width have been found [6,7]:

$$\Delta\varepsilon = kT\ ln\frac{N_c}{n_{k0}} \qquad (1)$$

where

$$N_c = 2\left(\frac{2\pi m_n kT}{h^2}\right)^{3/2} \approx 10^{19} cm^{-3}\cdot\left(\frac{m_n}{m}\frac{T}{300K}\right)^{3/2}$$

is the effective density of states in the conduction band.

The minimum possible contact concentration and the current intensity determining the decay limits of the contact emission in the monopole injection regime, are calculated by formulae:

$$(n_k)_{min} = \left(2-\frac{\alpha_m}{1-\sqrt{1-\alpha_m}}\right)exp\left(\sqrt{1-\alpha_m}\right)\frac{I_m L}{e\mu S V_m} \qquad (2)$$

$$I_{min} = \left(2-\sqrt{1-\alpha_m}\right)exp\left(\sqrt{1-\alpha_m}\right)I_m \qquad (3)$$

A junction from the linear part to the sublinear allows to estimate the contact density of the spatial charge $|\rho_k|$:

$$|\rho_k| = \frac{\varepsilon V_1}{2\pi L^2} \qquad (4)$$

Here $V_1$ is the initial value of the voltage of $\alpha(V)$ function decay point from the unit. The jump ($\alpha_{max}$=1.7, $U_{max}$=42.5V, $I_{max}$=1·10$^{-7}$A), is observed on the light in dependences $\alpha$~$U$ (fig.2, curve 2); and current increase with the voltage occurs in strong fields. The maximal value $\alpha_{max}$ has allowed to determine some important crystal parameters [8], including anode concentration – $n_k$

$$nk = 2\frac{\alpha_m^2}{\alpha_m+1}\cdot\frac{I_m L}{e\mu V_m S} \qquad (5)$$

The stimulation character of the dependence of the light to dark currents ratio multiplicity on the applied voltage is perfectly illustrated on fig 3. The multiplicity reaches $K_{max}$ =5·10$^2$ by the light 200 lx. Deep levels of the crystal are filled with the illumination increase and by this the maximum height decreases:

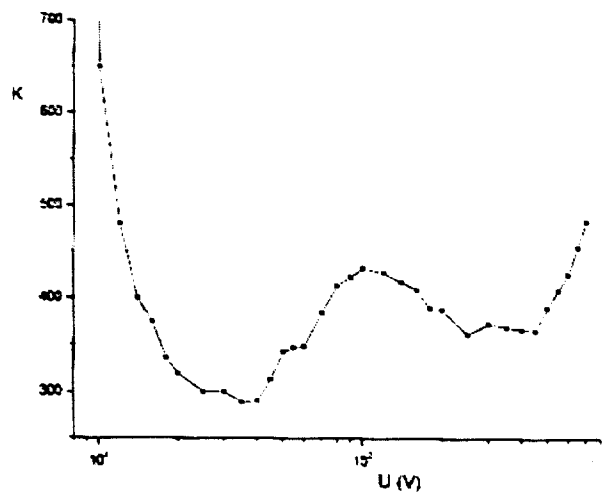


*Fig.3* The dependence $K$ on $U$.


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## $PbGa_2Se_4$ MONOKRİSTALLARINDA İŞIQ CƏRƏYANLARININ QARANLIQ CƏRƏYANA NİSBƏTƏN TƏRTİBİNİN STİMULLAŞMASI


$PbGa_2Se_4$ monokristakllarının qaranlıqda və 200 lk işıqda və geniş elektrik sahə intervalında volt-amper xarakteristikaları tədqiq olunmuşdur.

İşiq cərəyanın qaranlıq cərəyana nisbətən tərtibinin stimulyasiyası 200 lk-da müşahidə olunmuşdur. Müəyyən olunmuşdur ki, işıqlanmanın artması ilə kristalın dərin səviyyələri dolur, nəticədə isə işıq cərəyanının qaranlıq cərəyana nisbətən tərtibinin gərginlikdən asılılığında ($k$~$U$) maksimumun hündürlüyü azalır.

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# СТИМУЛЯЦИЯ КРАТНОСТИ ОТНОШЕНИЯ СВЕТОВОГО ТОКА К ТЕМНОВОМУ В МОНОКРИСТАЛЛЕ $PbGa_2Se_4$

Исследована вольтамперная характеристика монокристаллов $PbGa_2Se_4$ в темноте при освещенности 200 лк в широком интервале электрических полей.

Обнаружена стимуляция кратности светового тока к темновому при 200 лк. Установлено, что с увеличением освещенности глубокие уровни кристалла заполняются, в результате чего уменьшается высота максимума на зависимости кратности отношения светового тока к темновому от напряжения ($k \sim U$).

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