PARAMETERS OF ROENTGEN DETECTORS ON THE BASE OF $TlGaS_2$ <Mn, Cr> SINGLE CRYSTALS

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Bridcmen metodu ilə yetişdirilmiş $TlGaS_2$, $TlGaS_2$ <Mn> və $TlGaS_2$<Cr> monokristallarda Ga→Mn, Ga→Cr qismən əvəz olunmasının roentgen dozimetrik xarakteristikalarına təsiri tədqiq edilmişdir. Müəyyən edilmişdir ki, yetişdirilmiş monokristallarda roentgen keçiricilik əmsalı roentgen şüası dozasının gücü və enerjisinin artmasına uyğun olaraq azalır.

Изучена рентгендозиметрия монокристаллов $TlGaS_2$, $TlGaS_2$<Mn> и $TlGaS_2$<Cr>. Установлено, что коэффициент рентгенопроводимости во всех изученных монокристаллах уменьшается как с увеличением мощности дозы облучения, так и эффективной жесткости рентгеновского излучения

There have been studied the roentgendosimetry of $TlGaS_2$, $TlGaS_2$<Mn> and $TlGaS_2$<Cr> single crystals. Analysis of obtained experimental data showed that roentgenconductivity coefficient in all crystals under investigation is regularly decreased as with the rise of irradiation dose as increasing the value of accelerating voltage on X-ray tube.

$TlGaS_2$ single crystals are representatives of laminated semiconductors. These crystals are wide-band and high resistive. Dc- and ac- conductivities of $TlGaS_2$ single crystals were investigated in [1, 2]. In [3], the results of study of γ-radiation influence on ac-conductivity of $TlGaS_2$ single crystals were described. Of some interest is the study of influence of Ga partial substitution in $TlGaS_2$ for transition metals on their physical properties.

The aim of the present paper is the study of influence of partial substitution of Ga by Mn and Cr in $TlGaS_2$ single crystals, on roentgenconductivity and roentgendosimetric characteristics of these crystals.

Homogenous samples of $TlGaS_2$, $TlGaS_2$<Mn> and $TlGaS_2$<Cr> crystals at a manganese content of 3 mol % and chromium content of 0.5 mol % were synthesized directly from the initial components. Single crystals of the $TlGaS_2$, $TlGaS_2$<Mn> and $TlGaS_2$<Cr> compounds were grown by the Bridgman method. The crystal data for $TlGaS_2$, $TlGaS_2$<Mn> and $TlGaS_2$<Cr> are presented in Table.

Table.

Crystal data for $TlGaS_2$, $TlGa_{0.97}Mn_{0.03}S_2$ and $TlGa_{0.995}Mn_{0.005}S_2$ single crystals

Composition	Symmetry	*a*,Å	*b*,Å	*c*,Å	Z	Sp. gr.	ρ, g/sm^3
$TlGaS_2$	Monoclinic	10.40	10.40	15.17	16	$P2_1/n$	5.560
$TlGa_{0,995}Cr_{0,005}S_2$	Monoclinic	7.625	7.293	29.814	16	$P2_1/n$	5.181
$TlGa_{0,97}Mn_{0,03}S_2$	Tetragonal	7.266		29.94	16	*I4/mcm*	5.676

Samples from $TlGaS_2$ and $TlGaS_2$<Mn, Cr> for measurements are obtained by spalling along the C-axis of the natural spall from massive single crystals and have a thickness by 100 -500 μm order. Ohmic contacts of samples are made by Ag paste. Samples have produced in planar structure so that constant electric field applies along the layers of single crystals, and X-rays were directed along the C-axis of crystals. Distance between the indium contacts was equal to 0.10÷0.20 cm for different samples. Electric conductivity (σ) of obtained samples has been measured at 300 K. Intensity of applied constant electric field is corresponding to ohmic section on volt-ampere characteristics (VAC). For measurements the samples have been placed in screened cell.

Roentgenconductivity and roentgendosimetric characteristic measurements are carried out in low load resistance regime at 300 K. The source of roentgen radiation is the installation of X-ray diffraction analysis (URS-55a) with the tube BSV-2 (Cu). Intensity of roentgen radiation (E) is regulated by measurement with current variation in tube at each given value of accelerating potential (V_a) on it. Absolute values of roentgen radiation dose E(R/min) are measured by crystal dosimeter (DRGZ-02).

Roentgenconductivity coefficients K_σ characterizing roentgensensitivity of investigated crystals are determined as the relative change of conductivity under roentgen radiation a per dose:

$$K_\sigma = \frac{\sigma_E - \sigma_0}{\sigma_0 \cdot E} = \frac{\Delta\sigma_{E,0}}{\sigma_0 \cdot E},$$

where, σ_0 is conductivity in the absence of roentgen radiation (dark conductivity), σ_E is conductivity under the effect of radiation with the dose intensity E(R/min).

There have been determined values of characteristic coefficients of roentgenconductivity as of the initial single crystal $TlGaS_2$ as of $TlGaS_2$<Mn> and $TlGaS_2$<Cr> at different values of accelerating voltage (V_a) on the tube and corresponding doses of roentgen radiation.

In Figure there have been presented dependence of K_σ on dose intensity for $TlGaS_2$ single crystal at 300 K and electric field F = 80 V/cm (ohmic section of VAC). Curves 1 – 6 correspond to various values of accelerating voltage V_a from 25 to 50 keV (effective hardness).

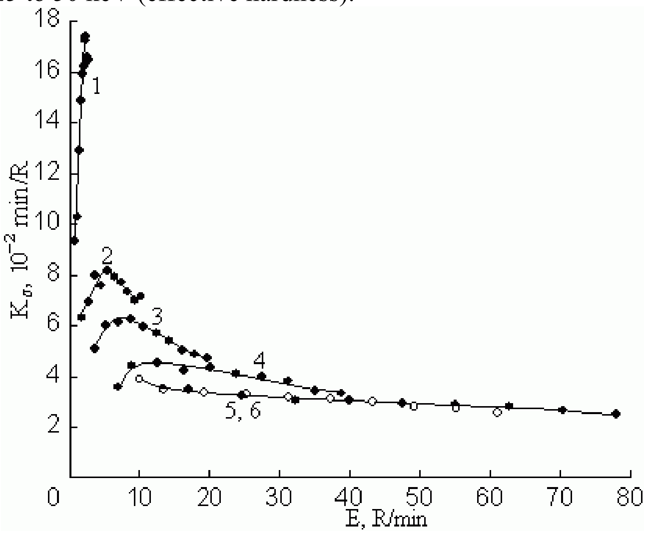

Fig.. Dependences of characteristic coefficients of roentgenconductivity on dose intensity for $TlGaS_2$ single crystal (F = 80 V/cm) at various values of accelerating voltages: 1 – 25; 2 – 30; 3 – 35; 4 – 40; 5 – 45; 6 – 50 keV and 300 K.

As it can be seen from obtained experimental results, the X-ray sensitivity of $TlGaS_2$ single crystal varies in the range 0.025 – 0.174 min/R, whereas the X-ray conductivity coefficient of the $TlGaS_2$<Cr> single crystal falls in the range 0.1 – 0.43 min/R; i.e. the X-ray conductivity coefficient of the $TlGaS_2$<Cr> single crystal is approximately 2.5 – 4.0 times greater than the coefficient K_σ of the $TlGaS_2$ single crystal. The analysis of the obtained experimental data shows that X-ray conductivity coefficient K_σ of the $TlGaS_2$ and $TlGaS_2$<Cr,Mn > single crystals regularly decreases with an increase in the dose rate E from 0.75 to 78 R/min and the accelerating voltage V_a from 25 to 50 keV.

One of the possible reason of observed regularities is that roengenconductivity in investigated crystals, especially at comparatively low accelerating voltages is predominantly due to radiation absorption in thin layer of crystal. In this case with the rise of radiation intensity there have been started to prevail the mechanism of surface quadratic recombination which leads to observed decrease of roengenconductivity. With the rise of accelerating potential effective hardness is increased owing to penetration depth into crystal is increased, as a result of which there have been taken place predominantly absorption-generation of free roentgen carriers in volume and fraction of incident radiation passing through crystal is increased.

From analyzing the current-dose characteristics of $TlGaS_2$<Cr> single crystal, it follows that the dependence of the steady-state X-ray current (I_r) on the dose rate can be adequately described by a power law: $I_r \sim E^\alpha$, where α=1.3 at low dose rates of soft X-ray (at low voltages V_a) and α = 0.7 at relatively high dose rates of hard x rays (at high voltages V_a).

Compared to pure $TlGaS_2$ single crystal and $TlGaS_2$<Cr>, doped with Mn single crystals are more sensitive to roentgen radiation. For example, the roentgen sensitivity of $TlGa_{0.97}Mn_{0.03}S_2$ single crystal changes in interval K_σ = 0.6 ÷ 0.96 min/R in the range of the measured power E = 13.5 ÷ 78.0 R/min. The registrated X-rays energy made ~ 50 keV.

Dependence of roentgen current on dose rate at various X-radiation hardnesses was investigated in $TlGaS_2$ <Mn> single crystals. It was shown that the dependence of roentgen current ΔI_r on radiation dose E is described as: $\Delta I_r \sim E^\alpha$, where α = 0.7 ÷ 1.7 in the range of the X-rays energy 25 ÷ 50 keV.

The obtained results have demonstrated that $TlGaS_2$ <Mn> and $TlGaS_2$<Cr> single crystals are characterized by a high X-ray sensitivity and can be used in the design of uncooled (operable at room temperature) X-ray detectors.

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