ROENTGENDETECTORS ON THE BASE OF $TlInSe_2<LI^+>$

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High sensitive and durable roentgen-detectors were created on the basic of semiconductor crystals $TlInSe_2$. The dose sensitivity of created roentgen-detectors was $1.1\cdot10^{-10}\div5.9\cdot10^{-9}$ A/R·min·V in the range of the measured power E=0.75÷78.0R/min. The registered range of the X-rays energy was 10÷50keV. The detectors delay time was 3÷5s and the working voltage is 10÷20V. The ratio of coefficients of roentgenosensitivity after and prior to lithium intercalation amounts to 2÷4. It was shown that dependence of roentgenocurrent ΔI_r on radiation dose E is described as: $\Delta I_r \sim E^{\alpha}$, where α = 0.5÷1.1 at 25÷50 keV for pure $TlInSe_2$ and α = 0.65÷1.5 for $TlInSe_2$ $<Li^+>$.

The research of electric; photoelectric and roentgen-dozimetric characteristics of semiconductive single crystals $TlInSe_2$, belonging to material class of $TlMeX^6_2$ (Me-In, Ga; X-S, Se, Te) [1-9], showed; that they have a high sensitivity to the X-ray irradiation.

Single crystals $TlInSe_2$ were obtained by the following way [10]. Thallium; indium and selenium; taken in the stechiometric ratio 1:1:2 were charged in the quartz ampoule by the diameter 16 mm and the length 100mm (the selenium excess from stechiometric made 0,4 mass %). The ampoule is pumped out up to the pressure $1.3\cdot10^{-3}$ Pa and is soldered.

The compound $TlInSe_2$ was synthesized by the direct melting of initial components by the method of the double-temperature synthesis with the use of the vibrating mixing at the temperature on 50-70° higher than the fusing temperature (T_{fus}=1040K) during 3-4 hours. For the homogenizing obtained alloys were annealed at the temperature, equal to 2/3 of the fusing temperature T_{an}=693K during 200 hours. The single-phasing of obtained alloys was controlled by the method of diffirentional-thermal (DTA) and roentgenophase analysises (RPA).

DTA was carried out on the device NTR-92, allowing to fix the temperature of phase transformations with accuracy ±3÷5K. The heating rate made 2-4K/min. The temperature was controlled by the thermocouple *Pt-Pt/Rh*; graduated by the reference substance in the range 472-1560K DTA results showed; that the compound $TlInSe_2$ melts congruently at 1040K. Thermodynamic parameters of the compound $TlInSe_2$ were determined by the measurements data of EMF concentration chains, composed of alloys of Tl-In-Se system: Gibs standard free energy of the formation ΔG^o_{298}=-180 kJoule/mole; standard enthalpy of the compound formation: ΔH^o_{298} =-190 kJoule/mole; the enthalpy of the compound melting: ΔH_m =40 kJoule/mole. The RPA was realized on the device DRON-3 at the radiation CuK_α. RPA results shows, that $TlInSe_2$ crystallizes in the tetragonal lattice of TlSe (space group 14/mcm) with parameters: a=8.002Å; b=7.015Å; z=4.

For the growth of large single crystals obtained polycrystals $TlInSe_2$ were plunged into the special ampoule, pumped out up to 10^{-3}Pa and placed in the double-chamber furnace. Single crystals were grown by Bridgemen method from the melt at the rate of the crystallization front transformation 0.6 mm/hour with the following cooling of obtained crystals with the rate 5K/min.

Samples of sizes $(2.0x0.8x0.2)mm^3$ were prepared on the base of obtained chained single crystals $TlInSe_2$, which were split off along the direction [001].

Contacts to them were applied by indium melting on the crystal surface and provided by the ohmity of voltampere characteristics (VAC) up to the electric intensity ≤200V/cm. The electric field was applied along the direction [001], and the X-ray radiation was directed perpendicularly to the crystal surface. Measurements were carried out at 300K; and the voltage was taken in limits of the linear part of VAC. The device URS-55A with the tube BSV-2 served the X-rays source.

X-rays intensity was registered at the measurement by means of the current variation on the tube at each given value of the accelerating potential on it. Absolute values of X-rays doses were measured by the crystal dosimeter of DRGZ-02 type.

The detector roentgenosensitivity was determined by the formula:

$$k = \frac{\Delta J_r}{V_s \cdot E} ,$$

where $\Delta J_r = J_r - J_d$;

J_d is the dark current; J_r is the current in the sample at the X-ray irradiation; E is the X-ray power; V_s is the supply voltage (the working voltage).

The dose sensitivity of studied detectors on the base of crystals $TlInSe_2$ made $1.1\cdot10^{-10}\div5.9\cdot10^{-9}$Amin/R·V in the range of the measured power E=0.75÷78.0R/min. The registered range of the X-rays energy made 10÷50keV. The detectors delay time made 3÷5s; and the working voltage V_s=10÷20Volt.

Suggested by us X-rays detectors on the base of crystals $TlInSe_2$ yield in the sensitivy to the detectors on the base of single crystals CdS (approximately on one order); but they have a number of advantages. Firstly; at low dose rate studied detectors had much lesser time of response, than CdS. Secondly; saturation sings up to dose rates in 100R/min and the fatigue effect are absent in our detectors.

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So, *X*-rays detectors on the base of $TlInSe_2$ is quick-response, miniature; uncooled (works at the room temperature) crystal detector with the stable and reproducing dosimetric characteristics.

Preliminary researches showed, that doping of $TlInSe_2$ crystals in some cases leads to the considerable improvement of operating characteristics of roentgen-detectors. Thus the task of the gain in the roentgen-detectors sensitivity by means of intercalation of single crystals $TlInSe_2$ is put in the present work.

The sampler $TlInSe_2$ were intercalated with lithium ions by the method of pulling electric field. The intercalation degree j.t. (*j* is the current density, t is the intercalated time) amounted to 15-20 Coulomb·cm^{-2}.

Roentgendosimetric characteristics of the pure and lithium-intercalated $TlInSe_2$ single crystals were investigated. Electric field was applied along [110] -direction and amounted to 10 Volts. Compared to pure single crystal, this intercalated single crystal is more sensitive to roentgen radiation. The ratio of coefficients of roentgenocurrent (*K*) after and prior to intercalation to 2÷4.

Dependence of roentgen current on dose rate at various *X*-radiation hardnesses (from 25 to 50 keV) was interesting in $TlInSe_2$ and $TlInSe_2$ <Li^+> single crystals. It was shown that dependence of roentgenocurrent ΔJ_r on radiation dose *E* is described as:

$$\Delta J_r \sim E^{\alpha}$$

where α=0.5÷1.1 at 25÷50keV for pure $TlInSe_2$ and α=0.65÷1.5 for lithium-intercalated single crystal.

The operation by the roentgendosimetric parameters of the studied ternary single crystals due to intercalation gives perspective for the use of these objects as sensitive roentgendetectors.

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РЕНГЕНОДЕТЕКТОРЫ НА ОСНОВЕ $TlInSe_2$ <Li^+>

На основе полупроводниковых кристаллов $TlInSe_2$ sozdanı высокочувствительные рентгенодетекторы. Дозовая чувствительность созданных рентгенодетекторов составляла

$1.1 \cdot 10^{-10} \div 5.9 \cdot 10^{-9}$ А/Р·мин·В при дозах облучения Е = 0.75÷78.0 Р/мин. Энергия рентгеновского излучения составляла 10÷50 кэВ. Инерционность детекторов составляла 3÷5 с, а рабочее напряжение 10÷20 В. Отношение коэффициентов рентгеночувствительности после и до интеркалирования литием составляло 2÷4. Показано, что зависимость рентгенотока ΔI_r от дозы облучения Е носила степенной характер: $\Delta I_r \sim E^{\alpha}$, где α=0.5÷1.1 при 25÷50 кэВ для $TlInSe_2$ и α= 0.65÷1.5 для $TlInSe_2 <Li^+>$.

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$TlInSe_2 <Li^+>$ ƏSASINDA RENTQENDETEKTORLAR

Yarımkeçiriji $TlInSe_2$ kristalları əsasında yüksək həsaslığa malik olan rentqen detektorları hazırlanmışdır. Şüalanma dozası E=0.75÷78.0 R/dəq olduqda rentqendetektorların doza həsaslığı $1.1 \cdot 10^{-10} \div 5.9 \cdot 10^{-9}$ A/R·dəq·V olmuşdur. Rentqen şüalanmasının enercisi 10÷50 keV-dir. Bu detektorların ətalətliliyi 3÷5 s, işçi gərginliyi isə 10÷20 V – dir. $TlInSe_2$ kristallarının litium ionları ilə interkalyasiyasından sonra və əvvəl rentqen həssaslığının əmsallarının nisbəti 2÷4 olmuşdur. Təyin edilmişdir ki, rentqen jərəyanının ΔI_r şüalanma dozasından E asıllığı üstlü funksiya ilə xarakterizə olunur :

$\Delta I_r \sim E^{\alpha}$, burada $TlInSe_2$ üçün 25÷50 kgV- də α =0.5÷1.1 və $TlInSe_2 <Li^+>$ üçün isə α =0.65÷1.5 olmuşdur.