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DETECTORS OF LASER RADIATION ON THE BASIS OF GaSe AND InSe CRYSTALS

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The opportunity of manufacturing of detectors of laser radiation on a basis diod structures Pt - p-GaSe and Pt - n-InSe with the fast channel recombinationis shown. Sensitivity of detectors made 0,25 мкА/мкV at length of a wave of falling radiation λ =600 nanometers. Comparison of the investigated detectors with silicon detectors, now in use for registration of laser pulses have shown, that in the same experimental conditions (length of a wave, intensity, duration of laser radiation, loading resistance and the enclosed voltage) these detectors show almost identical characteristics.

Registration of laser impulses at room temperature is one of pressing questions of laser technics [1-3]. Nowadays, there are several types of devices, allowing to register impulses of lasers. So, for example, for this purpose a vacuum photocell is used with the external photoeffect, distinguished by complexity of a design. Besides, the high voltage of a feed of this device demands the use of special high-voltage sources of a current. Well-known quick-response superficial-barrier germanium and silicon photodiodes also have very complex manufacturing techniques. On the other hand, simple on manufacturing techniques and circuits of inclusion photoresistors possess big time lag, that does not allow to use them for registration of laser impulses.

Among the new materials tested for this purpose, semiconductor crystals Gallium Selenide (GaSe) and Indium Selenide (InSe) demonstrate promising characteristics. It is known, that the crystals of A^3B^6–type compounds, in particular GaSe and InSe crystallize in a layered structure, where each layer contains two Ga(In) and two Se close-packed sublayers in the stacking sequence Se-Ga(In)-Se. The bonding between two adjacent layers is of the weak Van der Waals type, while within the layer the bonding is predominantly covalent. Existence of weak bonding between layers and absence of torn off bonding, practically excluding opportunities of formation of superficial levels, which concentration on two order is less, than in usual semiconductors, makes possible simple cleaved from the ingots manufacturing optically homogeneous samples with naturally mirror-like surfaces, with thickness down to one micron. Due to big nonlinear susceptibility, the presence of exciton absorption with rather high binding energy E_{ex}~20meV and the big variety of mechanisms of nonlinearity of a parameter of refraction and factor absorption these crystals now are widely used in quantum electronics [4-6]. Recently crystals GaSe are also an effective source of terahertz laser radiation occupying intermediate position between ranges radio - and light waves of far infra-red ranges (100 GHz - 10 ТГц) [7]. Rather small value of absorption coefficient ($\alpha \sim 10^3 cm^{-1}$) in comparison with other semiconductors (for example, $\alpha \sim 10^4$-10^5 cm^{-1} for germanium and silicon) allows deeper penetration of falling radiation into a sample that allows to create on the basis of crystals GaSe and InSe highly effective photovoltaic converters. The width of forbidden gap GaSe ($E_g \sim 2.02$ eV) and InSe ($E_g \sim 1.24$ eV) is in the field of a range of frequencies of generation of the lasers working in visible and infra-red ranges of a spectrum. And at last, rather important is presence in these crystals of the fast center recombination with the big section of capture (~ 10^{-16} sm^2), that makes possible to register on their basis short laser pulses [8]. In this paper, we present the experimental results of research of crystals GaSe and InSe for registration of laser impulses in visible and near infra-red area of an electromagnetic spectrum.

Monocrystals GaSe and InSe were grown by the Bridgman method. According to Hall measurements, specific resistance, concentration and mobility of carriers of a current in a direction parallel to an optical axis "c" made ρ = (0.8-0.3) Ом·см, n=10^{16}см$^{-3}$, μ_n=700 cm^{2}V^{-1}c^{-1} for n-InSe and ρ=(23÷30) Ом·см, p=10^{15}см$^{-3}$, μ_p = (20÷30) см^{2}V^{-1}c^{-1} for p-GaSe.

Plates with thickness 15÷80 μm have been made by way of cleaving of large ingots, a semi-transparent layer from Pt, forming with investigated crystals the barrier Shottki has been put on fresh-knocked surface of a sample in vacuum by a method of thermal evaporation Thickness of layer Pt got out so that transmission a similar layer on glass made 60÷80 %. Atop of layer Pt the gold contact comb, which incorporated in a circuit to the help of silver paste was rendered. In served as back ohmic contact. As ohmic contact transparent layers of In_2O_3 also have been used. Transparent and conducting layers In_2O_3 have been received by evaporation of a mix of powder In_2O_3 (90 %) and India (10 %). Evaporation was carried out under pressure of oxygen - $8 \cdot 10^{-5}$ of mm рт. a column. Speed of sedimentation пленок made ~ 20 $\overset{0}{A}$/minutes. Thickness of layer In_2O_3 has been measured by interference microscope and made 650÷1200 $\overset{0}{A}$. Layers In_2O_3 with the same thickness on a glass substrate possessed following transport parameters: ρ = (02÷7)10^{-3} Ом·см, n = (1÷2,6) 10^{20} sm^{-3}, μ = (4÷12) см^2 V^{-1}c^{-1}.

As an excitation source, a YAK:Nd^{3+} the laser (λ =10.600нм) and Rhodamine 6G dye laser (PRA, LN-107) pumped by the output of a N_2-laser (PRA, LN-1000), tuned through the regions (594-643)nm and (641-687)nm with a repetition frequency of 10Hz and a impulse width of 10 ns was used. By means of a lens the falling laser beam has been focused on a surface of a sample with diameter of a stain ~ 1.0 mm. The maximal power of a impulse made 12MВт/sm^2. Lower excitation intensity was obtained by means of suitable calibrated neutral filters. The falling laser beam and the enclosed electric field were perpendicular to a surface of layers of a crystal (parallel axes "c"). The output signals were fed into a chart recorder (HP-7475 A) through a storage oscilloscope (Le-Croy 9400) (Fig. 1).

Spectra of photosensitivity of structures Pt-n-InSe, Pt-p-GaSe at illumination on the part of a semi-transparent layer are submitted on Fig.2 a,b. As it is seen from the figure, spectra of photosensitivity of the investigated crystals cover a wide energy interval (1,2-3,6) эВ, from infra-red up to ultra-violet ranges of a spectrum. In spectra it is observed exciton absorption with maxima

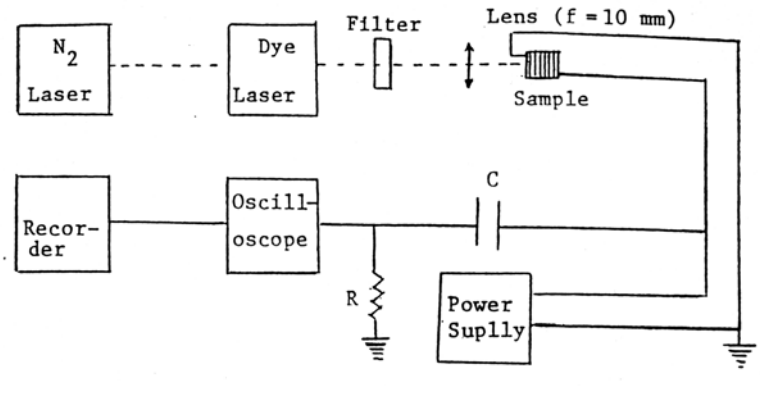

Fig. 1. The block diagramm of measuring installation

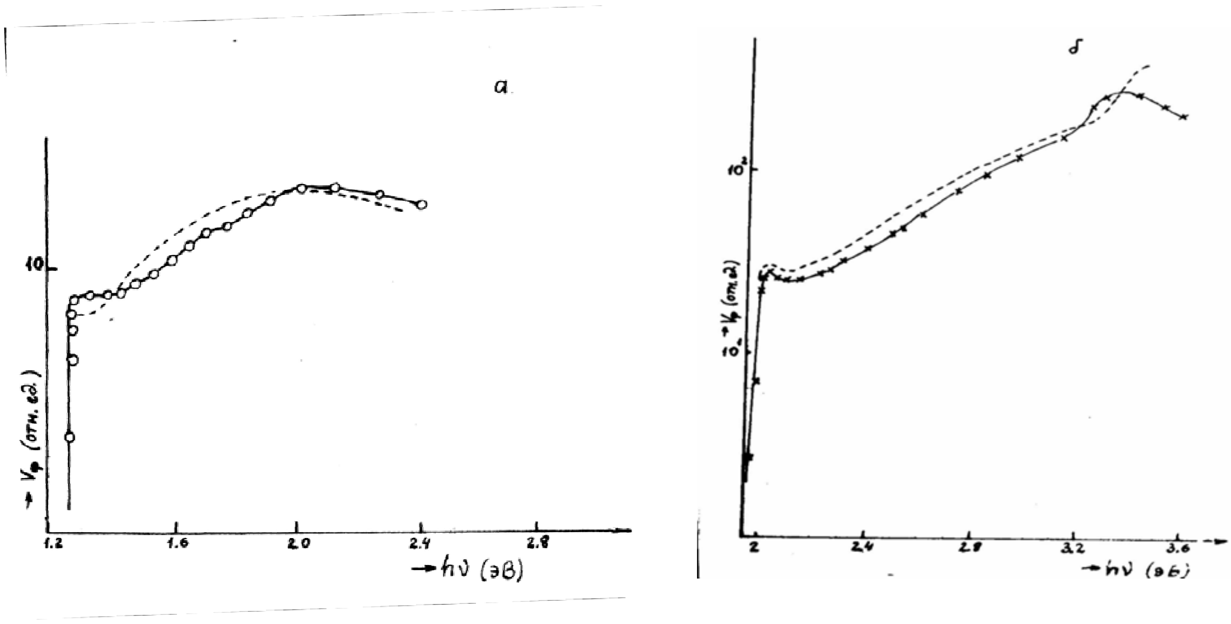

Fig. 2. Spectra of photosensivity of structures Pt-n-InSe (a) and Pt-p-GaSe (б).

1,25eV and 2,01eV for Pt-n-InSe and Pt-p-GaSe, respectively [9-12]. Comparison of experimental curves with theoretical dependence was carried out under the formula brought in the work [13]

$$I=q\Phi_0\left(1-e^{-\alpha W}+e^{-\alpha W}\frac{\alpha Ln}{\alpha Ln+1}\right)$$

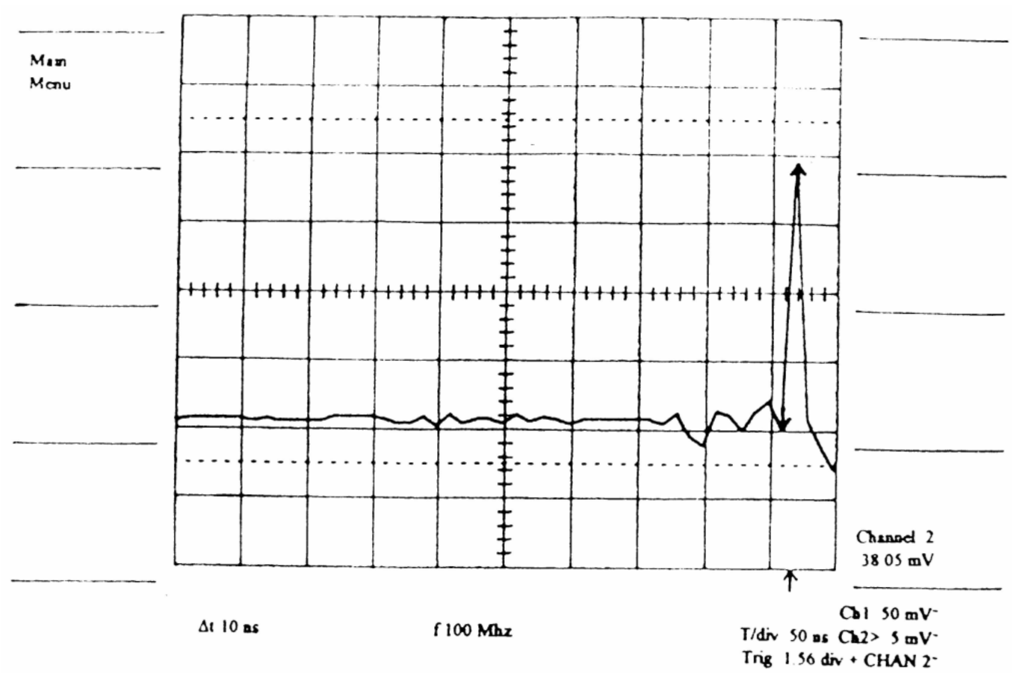

Fig. 3. The oscillogram of photosensivity of structure Pt-p-GaSe.

where α-coefficient of absorption, W-thickness of a layer of a volumetric charge, L_n- length diffusion of minor carriers, Φ_0-intensity of falling light. It is established, that settlement curves is in agreement with experimental at W=1,2μm, L_n=12 μm for InSe and W=0,4 μm , L_n=1.2 μm for GaSe

The time response curve of a Pt-p-GaSe detector at 300 K is given in Fig.3. As it is clear from the figure, the typical rise and fall time value for this detector is about 10ns. A dark current lower than $6x10^{-6}$A can be achieved with a bias voltage of 1 volt, showing a sensitivity of about 0.25 μA/μV at 0.6 μm for λ =600нм. The variation of a circulating current versus the applied bias voltage in a typical sample at the maximum incident laser intensity remains quite linear up to 30 vols (Fig.4).

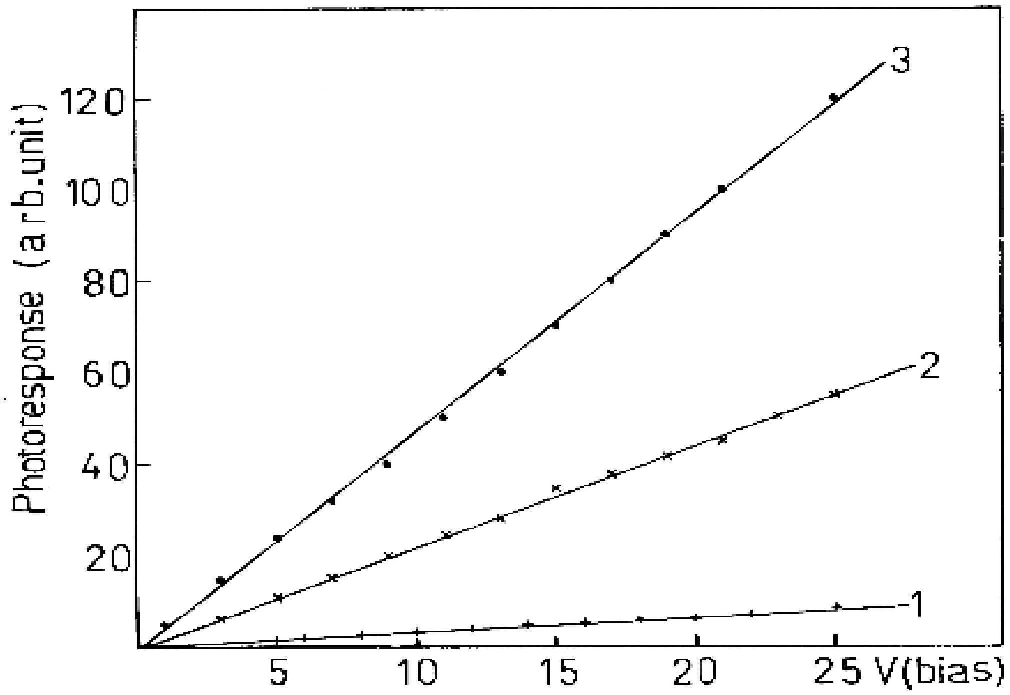

Fig. 4. Dependence of a photocurrent on the enclosed voltage in monocrystals InSe at various intensity falling laser radiation (intensity of laser radiation increases with growth of number of curves).

The comparison of the Pt-p-GaSe and Pt-n-InSe detectors with the presently used silicon photodiode, which are commonly used to detect this kind of laser, shows that at the same experimental condition both detectors exhibit nearly the same characteristics.

As a conclusion, it should be mentioned that, due to their ease of preparation, absence of junction, simple structure, high sensitivity and speed of response, Pt-p-GaSe and Pt-n-InSe detectors can be successfully used as detectors for laser impulses.

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GaSe VƏ InSe KRİSTALLARI ƏSASINDA LAZER ŞÜALARI ÜÇÜN DETEKTORLAR

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Rt - r-GaSe və Rt - n-InSe diod quruluşları əsasında lazer şüaları üçün sürətli rekombinasiya kanalına malik olan detektorların hazırlanma mümkünlüyü göstərilmişdir. λ=600 nm dalğa uzunluğunda detektorların həssaslığı 0,25 mkA/mkV təşkil edir. Tədqiq olunan detektorların hazırda lazer şüalarının qeyd edilməsi üçün istifadə edilən silikonlu detektorlarla müqayisəsi göstərir ki, eyni təcrübi şəraitdə (dalğa uzunluğu, intensivlik, lazer şüasının sürəkliliyi, yük müqavimətinin və tətbiq olunan gərginliyin qiyməti) bu detektorlar təqribən eyni xarakteristikalara malikdirlər.

ДЕТЕКТОРЫ ЛАЗЕРНОГО ИЗЛУЧЕНИЯ НА ОСНОВЕ КРИСТАЛЛОВ GaSe и InSe

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Показана возможность изготовления детекторов лазерного излучения на основе диодных структур Pt - p-GaSe и Pt - n-InSe с быстрым каналом рекомбинации. Чувствительность детекторов составляла 0,25 мкА/мкВ при длине волны падающего излучения λ=600 нм. Сравнение исследованных детекторов с силиконовыми детекторами, используемые в настоящее время для регистрации лазерных импульсов, показали, что в одних и тех же экспериментальных условиях (длина волны, интенсивности, длительности лазерного излучения, величины нагрузочного сопротивления и приложенного напряжения) эти детекторы показывают почти одинаковые характеристики.