LONG-TIME RELAXATION OF A PHOTOCURRENT IN $TlGaSe_2<Li^+>$ SINGLE CRYSTALS

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It is established, that intercalation of $TlGaSe_2$ single crystals by lithium ions leads to the essential increase of a photo and roentgen sensitivity of these crystals, promotes slowing down of a kinetics of a photocurrent in them, and also leads to the derivation in samples internal electromotive force (EMF). It was possible to control the value of EMF by various wavelengths of visible range.

The photoelectric properties of $TlGaSe_2$ single crystals are investigated in a lot of papers [1-3]. Particularly, the relaxation of an intrinsic photo current at 77 K is investigated and the availability of two recombination levels with lie depth 1,2 and 0,95 eV [3] is revealed. In [4] the relaxation of a dark current in $TlGaSe_2$ single crystals is investigated.

In the present work the results of study of long-time relaxation of photocurrent in both intercalated with lithium ions and nonintercalated $TlGaSe_2$ single crystals are indicated. Intercalation of layered $TlGaSe_2$ single crystals realized by a method of drift electric field explicitly described in [5]. The intercalation degree of crystals with lithium ions was 15÷20 Coulomb·sm^{-2}.

Samples for researches had thickness L=65÷400 microns. For electrodes to $TlGaSe_2$ crystals was eutectic alloy In-Ga, put on side end faces of a sample of $TlGaSe_2$ so, that the electric field was applied along natural layers of crystals, and light dropped perpendicularly to layers. In a number of samples contacts were put on a surface of layers, i.e. samples had a planar structure.Distance between electrodes was 0,2÷0,4 sm. Specific dark resistance of the $TlGaSe_2$ single crystals along layers was ~ $2\cdot10^7$ Ohm·sm for room temperature and after intercalation with lithium ions was not changed almost. However, after intercalation the spectral photosensitivity of $TlGaSe_2$ was essentially increased: so, if $(R_d\backslash R_l)_{nonint}$=2 before the intercalation, after intercalation $(R_d\backslash R_l)_{int}$=8, where R_d - dark resistance, R_l - resistance of a sample illuminated by intrinsic light ($h\nu$~2,0 eV) with intensity 200 lux. Even more photosensitivity was changing lighting the samples by the white light: so at T = 300 K $(R_d\backslash R_l)_{nonint}$=2,5 and after intercalation this one reached the value of $1{,}4\cdot10^2$ (L = 400 lux).

After intercalation with lithium ions the value of the coefficient of integrated sensitivity of photoresistors grew in appropriate way and reached value $1{,}2\div1{,}5\cdot10^3$ mcA/LmV against the 100 mcA/LmV value for photoresistors from nonintercalated $TlGaSe_2$ single crystals [3]. The ratio of coefficients of roentgen sensitivity after and before the intercalation was 2,8÷5,7. Intercalation of $TlGaSe_2$ single crystals with lithium ions also essentially influenced region of their spectral sensitivity.

In a fig.1 the spectral dependence (indicated to unit) of photoconductivity of a $TlGaSe_2$ single crystals before (dashed curve 1) and after intercalation with lithium ions (curve 2) are represented. As follows from their matching, intercalation with lithium ions essentially increased spectral photosensitivity of $TlGaSe_2$ single crystals in the range of short lengths of waves.

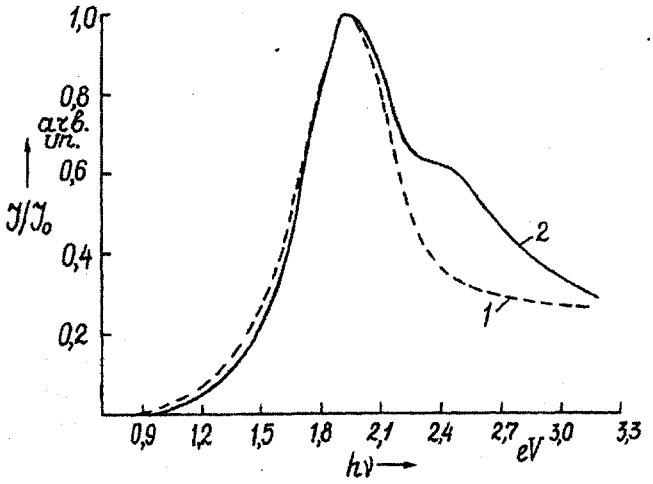

Fig.1. The spectral distributions (indicated to unit) of a photo current in $TlGaSe_2$ single crystals before (dashed curve 1) and after intercalation (curve 2) with lithium ions.

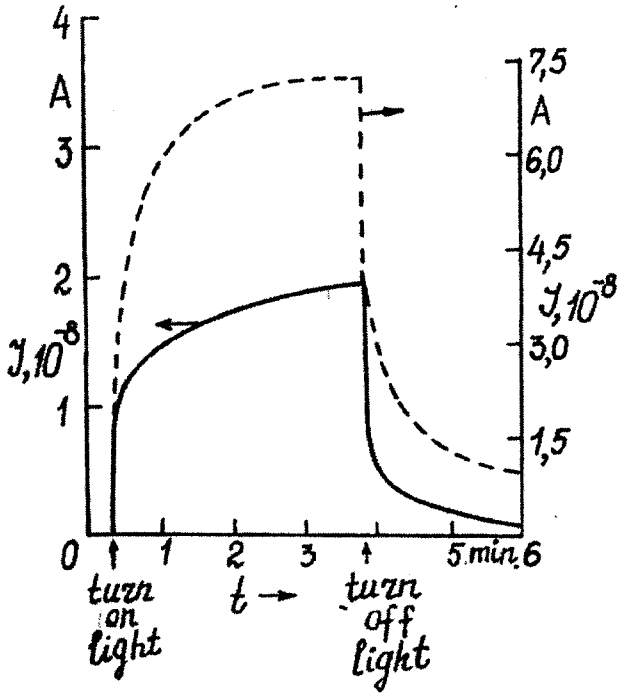

Fig.2. Kinetics of a photocurrent in $TlGaSe_2$ single crystals in a weak electrical field (F=1 V/sm) before (continuous curve) and after (dashed line) intercalation with lithium ions (T=300 K).

Intercalation with lithium ions essentially influenced relaxation curves of a photocurrent in $TlGaSe_2$ single crystals. The characteristic relaxation curves of a photocurrent before and after intercalation are indicated in fig.2. As it is visible from fig.2, in the result of giving of monochromatic light with energy of quantum appropriate to a maximum of intrinsic photoconductivity of the crystal $TlGaSe_2$ ($h\nu$~2,0 eV) a long (about several minute) process of growing of a photocurrent happened. For both sample - nonintercalated (continuous curve) and intercalated (dashed curve) constant of time of increase of a photocurrent t=12 sec and approximately in 4 minutes the stationary level of a photo current was established. After switching off the light the photocurrent in nonintercalated crystals $TlGaSe_2$ damped faster, than in intercalated. The falling branch of a photocurrent in both cases had fast (t_1) and slow (t_2) component. For nonintercalated sample $TlGaSe_2$ t_1=3 s, t_2=150 s and for $TlGaSe_2$<Li^+> t_1=15 s, t_2=400 s, i.e. the time constants of decreasing of a photocurrent in intercalated crystals in some times exceeded t_1 and t_2 in nonintercalated $TlGaSe_2$. The same ratio between them was observed both during lighting of crystals of quantum with energy $h\nu<E_g$, and at low temperatures (T=130 K).

It is possible to explain slower recession of a photo current in $TlGaSe_2$<Li^+> by presence of lithium ions, which create discontinuities in a crystal, thereby slowing recombination process [6], i.e. result in increasing of a life time of the charge carriers, excited by light, in absence of photocarriers generation.

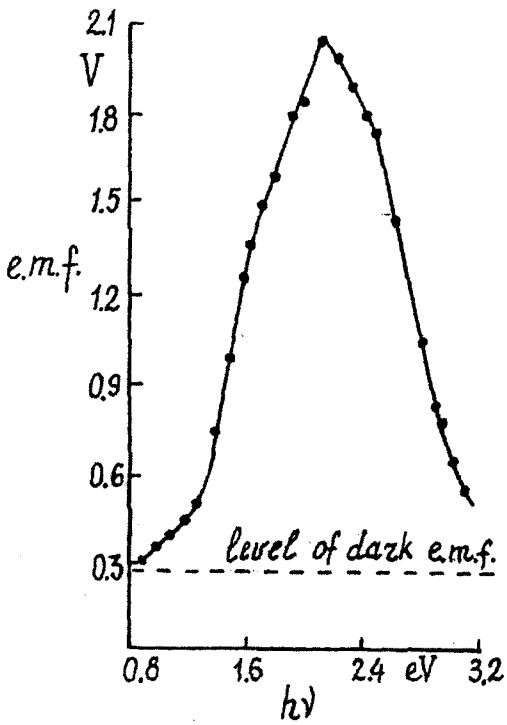

Fig.3. Spectral dependence of internal EMF for $TlGaSe_2$<Li^+> sample (width L=0,04 sm and distance between electrodes 0,2 sm) at T=300 K.

As was noted in [7], at applying constant electric field to samples $TlGaSe_2$<Li^+> there was the relaxation of a current, in result of which there was an internal electric field in a sample with opposite polarity in relation to external. Dark EMF about 500 mV also was detected in InSe single crystals intercalated with iodine [8], and also in GaSe<Li^+> [9]. In $TlGaSe_2$<Li^+> single crystals the value of internal EMF without illumination was 270mV and was sensitive to light. Under illumination of $TlGaSe_2$<Li^+> samples with various lengths of waves the value of this EMF changed (fig.3), reaching maximum value 2,1 V under the illumination of a sample by intrinsic light.

The derivation of an internal electric field in a sample influenced spectra of a photocurrent in these samples at various electric fields. The dependence of an intrinsic photocurrent of the value of the enclosed electric power in $TlGaSe_2$ samples intercalated with lithium ions had interesting features. If in nonintercalated $TlGaSe_2$ this dependence carried a linear character, in $TlGaSe_2$<Li^+> in the same range of electrical powers and at other equal conditions dependence of intrinsic photocurrent on electrical power was characterized by a short linear site (I_{ph}~V), rather continuous quadratic site (I_{ph}~V^2) and very steep site I_{ph}~V^{12} (fig.4). The range of investigated powers was 0,4÷2,2 V, i.e. was commensurable with the value of an internal photo - EMF (2,1 V).

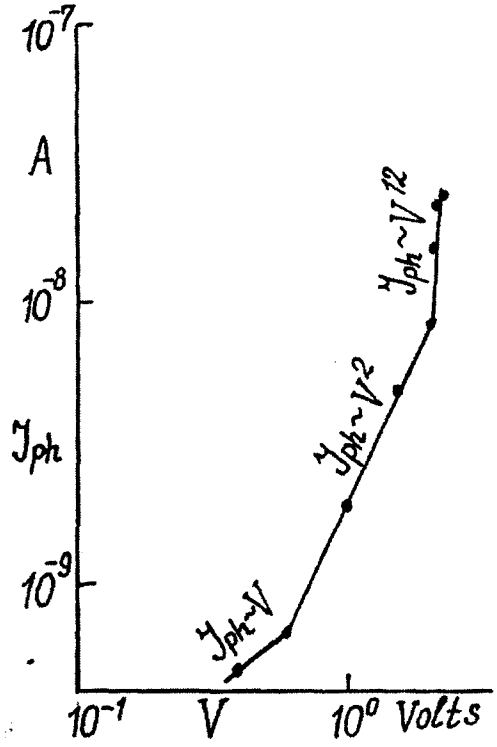

Fig.4. Peak dependence of an intrinsic photocurrent in $TlGaSe_2$<Li^+> single crystals (T=300 K).

As is known [6], on relaxation of photoconductivity the capture of carrier of a charge by levels of an adhesion influences. Under strong filling of levels of an adhesion the "nonlinear processes" of relaxation take place. The phenomena connected to "nonlinear" filling of local levels in process of recombination and an adhesion of non-equilibrium carrier plays a noticeable role in the mechanism of photoconductivity of semiconductors and, particularly, can present a basis for interpretation of superlinearity of a photocurrent observed in $TlGaSe_2$<Li^+>.

In summary it is possible to tell, that the introduction of lithium ions in interlayer space of $TlGaSe_2$ single crystals resulted in essential increase of photosensitivity of these

crystals, promoted slowing down of a kinetic of a photocurrent in them, and also resulted in formation of internal EMF in samples, controlled by various wave lengths of visible range.

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$TlGaSe_2<Li^+>$ MONOKRİSTALINDA FOTOCƏRƏYANIN UZUNMÜDDƏTLİ RELAKSASİYASI

Müəyyən edilmişdir ki, $TlGaSe_2$ monokristalını Li ionları ilə interkalyasiya edəndə, onun foto, rentgen həsasslığı nəzərə çarpacaq dərəcədə artır, onlarda fotocərəyanın kinetikasının zəifləməsinə səbəb olur, həmçinin nümunələrdə daxili e.h.q.-i əmələ gəlməsinə səbəb olur. E.H.Q.-nin qiymətini görünən oblastda müxtəlif dalğa uzunluqları ilə idarə etmək olar.

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ДОЛГОВРЕМЕННАЯ РЕЛАКСАЦИЯ ФОТОТОКА В МОНОКРИСТАЛЛАХ $TlGaSe_2<Li^+>$

Установлено, что интеркалирование монокристаллов $TlGaSe_2$ ионами лития приводит к существенному увеличению фото- и рентгеночувствительности этих кристаллов, способствует замедлению кинетики фототока в них, а также приводит к образованию в образцах внутренней э.д.с.. Величиной э.д.с. можно было управлять различными длинами волн видимого диапазона.

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