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Intracenter processes induced by electron beam and 337 nm laser light in CsI:Tl

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Investigated are the spectral-kinetic properties of the activator luminescence excited in CsI:Tl crystal by a pulsed electron beam and by a pulsed nitrogen laser at $\lambda = 337.1$ nm, that corresponds to the long-wave decline of the *A*-absorption band. It is found that the decay kinetics of 2.6 and 2.25 eV luminescence bands excited by an electron beam at 80 K is mono-exponential with the time constants $\tau = 4$ μs and $\tau = 13$ μs, respectively. The decay kinetics of each from the luminescence bands under the laser excitation is bi-exponential due to the presence of one more component with time constant $\tau = 900$ ns. This sub-microsecond component dominates in the bi-exponential kinetics, and the value of its time constant is determined by the time of the electron transfer from the metastable ψ sub-level of the excited $6^2P_{3/2}$ state to the ground $6^2P_{1/2}$ state of Tl^0 center. Phonon-assisted processes causing population of the radiative states of Tl^+ centers responsible for 3.0, 2.25 and 2.6 eV luminescence bands are discussed in detail.

Keywords: thallium doped cesium iodide, luminescence, Tl^+-perturbed exciton, decay kinetics, charge transfer.

Исследованы спектрально-кинетические свойства активаторной люминесценции, возбуждаемой в кристалле CsI:Tl импульсным электронным пучком и импульсным азотным лазером в области $\lambda = 337{,}1$ нм, что соответствует длинноволновому спаду *A*-полосы поглощения. Обнаружено, что кинетика затухания полос люминесценции с максимумами 2,6 и 2,25 эВ, возбуждаемых электронным пучком при 80 К, является моноэкспоненциальной с постоянной времени $\tau = 4$ мкс и $\tau = 13$ мкс, соответственно. Кинетика затухания каждой из полос люминесценции при лазерном возбуждении является биэкспоненциальной благодаря наличию еще одного компонента с постоянной времени $\tau = 900$ нс. Этот субмикросекундный компонент доминирует в биэкспоненциальной кинетике, и значение его постоянной времени определяется временем переноса электрона с метастабильного ψ-подуровня возбужденного состояния $6^2P_{3/2}$ в основное $6^2P_{1/2}$ состояние Tl^0 центра. Детально обсуждаются термически активированные процессы, вызывающие заселение излучающих состояний Tl^+ центров, ответственных за полосы люминесценции 3,0, 2,25 и 2,6 эВ.

Внутрішньо-центрові процеси, наведені in CsI:Tl електронним пучком та 337 нм лазерним світлом. *В.Яковлєв, Л.Трефілова, Г.Карнаухова, О.Шпилинська.*

Досліджено спектрально-кінетичні властивості активаторної люмінесценції, що збуджуються в кристалах CsI:Tl імпульсним електронним пучком та азотним лазером в

області λ = 337,1 нм, що відповідає довгохвильовому спаду *A*-смуги поглинання. Встановлено, що кінетика загасання смуг люмінесценції з максимумами 2,6 і 2,25 еВ, що збуджуються електронним пучком при 80 К, є моноекспоненційною з постійною часу τ = 4 мкс і τ = 13 мкс, відповідно. Кінетика загасання кожної з цих смуг під лазерним збудженням є біекспоненційною через наявність ще однієї компоненти з постійною часу τ = 900 нс. Цей субмікросекундний компонент домінує у біекспоненційній кінетиці, а величина його постійної часу визначається часом переносу електрона з метастабільного підрівня збудженого стану $6^2P_{3/2}$ в основний $6^2P_{1/2}$ стан Tl^0 центра. Детально обговорюються термічно-активовані процеси, що викликають заселення випромінювальних станів Tl^+ центрів, відповідальних за смуги люмінесценції з максимумами 3,0, 2,25 і 2,6 еВ.

1. Introduction

Although scintillation CsI:Tl crystal has been widely applied for over 50 years, its luminescence properties are not fully understood up to now. CsI:Tl crystal is a wide-band gap dielectric (E_g = 5.8 eV) with the concentration of cation-substituting Tl^+ ions not higher than a tenth of a percent. But it is Tl^+ ions that make CsI:Tl crystal sensitive to daylight which excites their slowly decaying luminescence (called phosphorescence). The latter blocks the scintillation process until complete radiative relaxation of the crystal been exposured to daylight. The absorption properties of Tl^+ ions in CsI were studied in detail by Masunaga et al. [1] and Stillman et al. [2], who found six and five bands, respectively, in the absorption spectra of CsI:Tl. At excitation by photons with energy of E_{ex} = 4.27 eV corresponding to the lowest-energy *A*-absorption band, there were observed luminescence bands with 3.31, 3.09, 2.55 and 2.25 eV maxima [3]. The bands with maxima at 3.31, 3.09 eV were interpreted in the scope of the Jan-Teller model [3, 4] to be due to intracenter transitions of Tl^+ ion from triplet relaxed excited state of Tl^+ center with trigonal and tetragonal symmetry, respectively; the luminescence bands with maxima at 2.55 and 2.25 eV are related to the radiative decay of triplet near-activator excitons of two different structure configurations. Excitation at lower energies with respect to the *A*-absorption band, which extends up to 3.1 eV, according to the data of [5], leads to the accumulation of energy that can be released thermally or optically to give rise to thermally- or photo-stimulated luminescence, respectively.

This study is a continuation of the series of our papers [6–8] aimed at clarification of the role of photo-induced processes of charge transfer in the formation of color and luminescence centers in CsI:Tl crystals at nitrogen laser excitation (λ_{ex} = 337 nm). The photon energy at such an excitation is about 0.6 eV lower than the photon energy from the region corresponding to *A*-absorption band. However, we found phenomena of the internal photoelectric effect and exponentially decaying photoluminescence under one-photon excitation of CsI:Tl crystal with 337 nm light in the temperature range of 80–400 K and suggested a model for description these phenomena [6]. Both bulk conduction current and exponentially decaying luminescence in the visible spectral region are characterized by a pronounced Arrhenius temperature dependence with the thermal activation energy of 0.3 eV. In the present paper, we carried out comparative studies of the spectral-kinetic properties of CsI:Tl luminescence excited by a pulsed electron beam and 337 nm laser light at room and liquid nitrogen temperatures.

2. Experimental

CsI:Tl ingots were grown by the Stockbarger technique in evacuated quartz ampoules taking into account recommendations of [9]. The samples with dimensions 8×8×2 mm^3 were cut from the ingots. Tl concentration in the samples was determined by the chemical technique [10] and given in mass %. Luminescence was excited by N_2 laser pulses (λ = 337.1 nm; $t_{1/2}$ = 5 ns; j = 1 mJ/cm^2) and electron pulses (E = 250 keV, $t_{1/2}$ = 15 ns, j = 160 mJ/cm^2). The luminescent response linearity of CsI:Tl crystal to the density of 337 nm laser beam was verified experimentally. The luminescence pulses were registered by an optical spectrometer consisting of an MDR-3 monochromator, an FEU-106 photomultiplier and a 350 MHz oscilloscope LeCroy WR 6030A. The oscillogram family for the luminescence pulses was obtained for a certain wavelength within 250÷1100 nm range at temperatures of 80 K and 295 K. Then the oscillograms were converted into luminescence kinetic curves in order to determine the kinetic parameters of the luminescence pulses and to plot the time resolved luminescence spectra with 7 ns time resolution for any time delay. The cathodoluminescence kinetics for

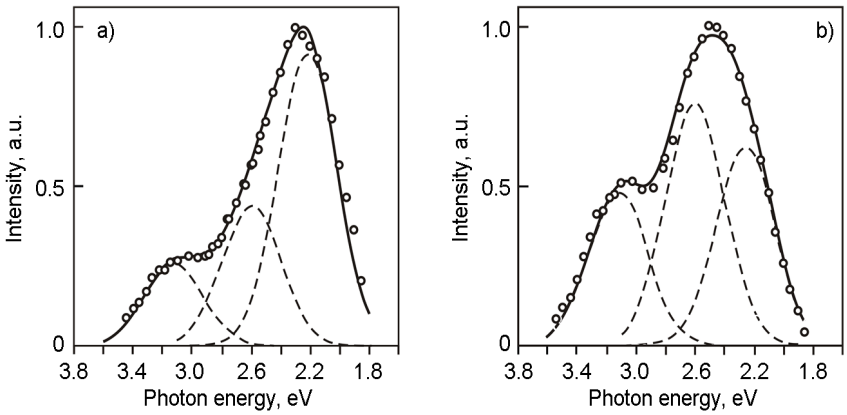

Fig. 1. Luminescence spectra of CsI:0.043%Tl excited by 337 nm laser pulse (a) and electron pulse (b) at T = 295 K. Empty circles are experimental data; dashed lines are fitting curves; solid lines are the sum of the fitting curves.

CsI:Tl at room temperature has a sub-microsecond rise stage after irradiation pulse [11, 12]. Therefore, all the spectra presented in the study were obtained with 200 ns time delay corresponding to the rise time of the cathodoluminescence pulse intensity up to its maximum value. The luminescence spectra are corrected for the spectral response of the monochromator and the photomultiplier.

3. Results and discussion

Fig. 1 shows the luminescence spectra of CsI:0.043 %Tl crystal excited by a laser pulse at 337 nm and by an electron pulse at room temperature. The sum of three Gaussians with parameters not depending from the excitation method fits both spectra. The fitting results are presented by the solid line in Fig. 1. Table 1 contains the parameters of the fitting bands and the ratio of their maximum intensities for CsI:Tl with different Tl concentration. It is seen that the only difference between the photo- and cathodoluminescence spectra is a little "red" shift of the longwave fitting band characteristic of the two samples with 0.043 and 0.52 % of Tl. It should be noted that the observed difference in the luminescence spectrum shape for the crystals with different thallium concentration is due to redistribution of the contribution of each of the three fitting bands to the total spectrum.

At both excitation methods, the luminescence intensity decreases uniformly for the whole spectrum after depletion of the exci-

Table 1. Parameters of the best Gaussian fit for the luminescence spectra of CsI:Tl crystals at 295 K

Tl, mass.%	Excitation by	E_{m1}, eV	FWHM, eV	E_{m2}, eV	FWHM, eV	E_{m3}, eV	FWHM, eV	$I_{m1}/I_{m2}/I_{m3}$
0.018	e-beam	3.12	0.47	2.6	0.47	2.25	0.47	0.24/0.66/0.62
	337 nm light	3.12	0.47	2.6	0.47	2.25	0.47	0.21/0.33/0.62
0.043	e-beam	3.12	0.47	2.6	0.47	2.25	0.47	0.48/0.76/0.62
	337 nm light	3.12	0.47	2.6	0.47	2.22	0.47	0.26/0.44/0.92
0.14	e-beam	3.12	0.47	2.6	0.47	2.25	0.47	0.35/0.41/0.6
	337 nm light	3.12	0.47	2.6	0.47	2.25	0.47	0.33/0.55/0.78
0.47	e-beam	3.12	0.47	2.6	0.47	2.25	0.47	0.2/0.43/0.49
	337 nm light	3.12	0.47	2.6	0.47	2.25	0.47	0.22/0.28/0.87
0.52	e-beam	3.12	0.47	2.6	0.47	2.25	0.47	0.35/0.67/0.65
	337 nm light	3.12	0.47	2.6	0.47	2.2	0.47	0.055/0.11/0.95

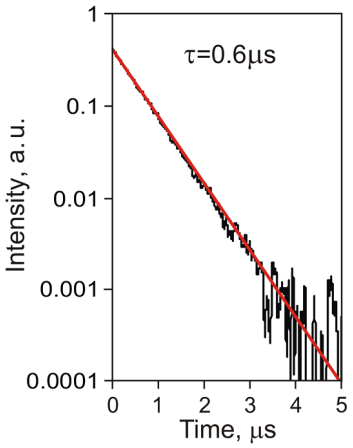

Fig. 2. (Color online) Photoluminescence oscillogram of CsI:0.043%Tl at 337 nm laser excitation at T = 295 K. The broken line is experimental data, the red solid line is the fitting curve.

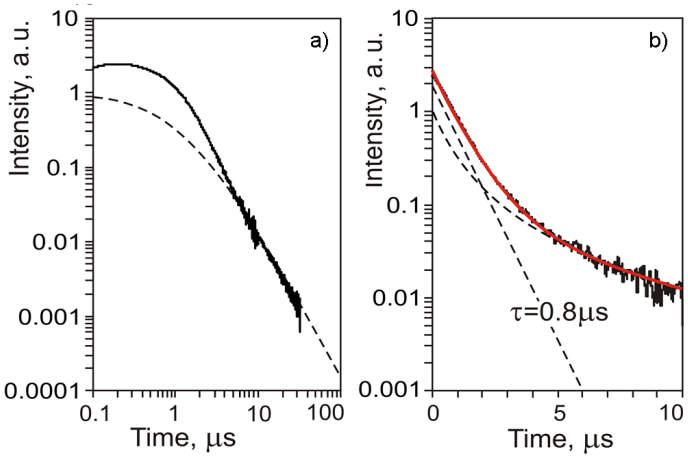

Fig. 3. (Color online) Cathodoluminescence oscillogram of CsI:0.47%Tl in log-log scale (a) and log-scale (b) at T = 295 K. Broken lines are experimental data, dashed lines are fitting curves, the red solid line is the sum of the fitting curves.

tation pulse. The luminescence pulse oscillogram in semi-logarithmic scale shows that under the optical excitation a luminescence pulse of CsI:Tl has mono-exponential decay (Fig. 2). The values of the decay constant for all the samples are almost the same and amount to 0.6±0.05 μs. Figure 3 (a, b) presents the cathodoluminescence oscillogram of CsI:0.47%Tl in logarithmic scale (a) and semi-logarithmic scale (b). The scintillation decay curves are often approximated by the sum of two, three or more exponential components [13 and references therein]. Analysis of the literature data shows, however, that such a representation is an oversimplification of physical reality. Indeed, the results obtained by Brecher et al. [14] directly show that under lattice excitation the intensity of CsI:Tl luminescence pulse decreases hyperbolically by nine orders within the time range $10^{-7} \div 10^{-1}$ s. It means that the kinetics of higher-order reactions fits the scintillation pulse decay kinetics, and therefore the latter should not be described by the sum of several exponentials. But anyway, many researchers [11–13, 15, 16] regard Tl^+ center luminescence to be due to recombination of Tl^0 and V_k centers. At room temperature the centers of both types produced by ionizing radiation in equal amounts are thermally unstable [17, 18]. Therefore, on the base of physical considerations [19], it seems appropriate to express the decay kinetics of the cathodoluminescence pulse by a second-order hyperbola:

$$I(t) = \frac{I_0}{(1 + \alpha \cdot t)^2} \qquad (1)$$

The fitting results of the slow decay component by the hyperbola are shown in Fig. 3a by a dashed line. The sum of the hyperbolic and exponential components fits the experimental decay curve in Fig. 3b. The best fitting results are obtained with $\alpha = 0.8 \cdot 10^6$ s^{-1} and the time constant of the cathodoluminescence exponential decay τ = 0.8 μs which is close to the time constant of the photoluminescence decay. Note, that the exponential component with τ = 0.8 μs is present in the decay kinetics of all the studied samples. Its contribution to the cathodoluminescence decay kinetics at room temperature is dominant, ranging from 70 to 85 percent of the initial intensity.

The spectra and the decay curves of luminescence induced by electron beam and UV laser light in CsI:Tl at liquid nitrogen temperature are shown in Fig. 4 and Fig. 5, respectively. The luminescence spectra are the superposition of two Gaussian-shaped bands with the parameters close for both excitation methods (Fig. 4a, 5a and Table 2). It should be noted that at 80 K the intensity of photo-induced luminescence is by a factor of several tens lower than the one observed at room temperature. Therefore, the samples with high thallium concentrations are used for measurements at 80 K. The decay kinetics of cathodoluminescence registered for 2.25 and 2.6 eV bands at 80 K contains exponential stages with time constants equal to 13 and 4 μs, respectively (Fig. 4b

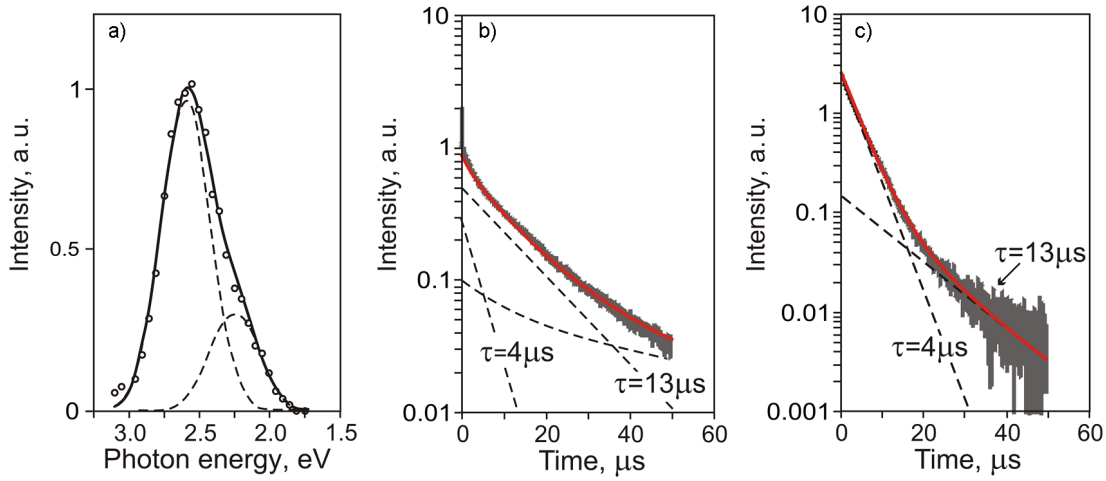

Fig. 4. (Color online) Spectrum (a) and oscillograms (b,c) of catholuminescence registered for CsI:0.47 % Tl at 2.25 eV (b) and 2.6 eV (c). T = 80 K. Empty circles and the broken lines are experimental data, dashed lines are fitting curves; solid lines are the sum of the fitting curves.

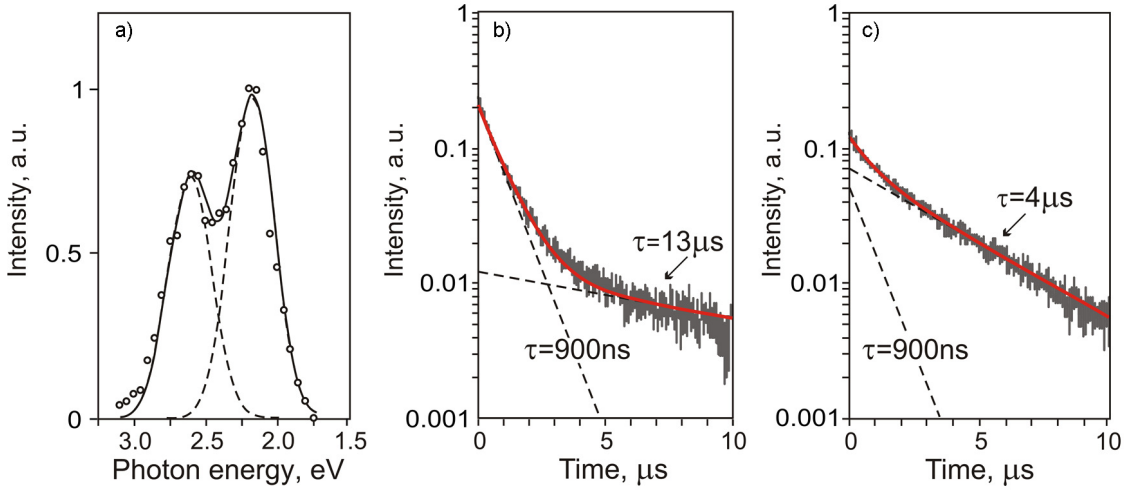

Fig. 5. (Color online) Spectrum (a) and oscillograms (b,c) of photoluminescence registered for CsI:0.47%Tl at 2.25 eV (b) and 2.6 eV (c). T = 80 K. Empty circles and broken lines are experimental data, dash lines are fitting curves; solid lines are the sum of the fitting curves.

and 4c). For the optical excitation, the sum of two exponential components — relatively fast and slow — fits the decay kinetics for each of the luminescence bands excited by 337 nm laser pulse at 80 K (Fig. 5b and 5c). The fast decay component for both bands is characterized by the same time constant τ_{fast} = 900 ns; those of the slow exponential decay components being 13 μs and 4 μs for the 2.25 eV and 2.6 eV band, respectively. This completely coincides with the time constants of exponential decay for the same luminescence bands excited by an electron pulse.

The above experimental results show that the excitation by near UV-light with the photon energy by a factor of about 1.5 lesser than the width of the band gap and the excitation by ionizing radiation produce the same luminescence centers in CsI:Tl. The

Table 2. Parameters of the best Gaussian fit for the luminescence spectra of CsI:0.47 %Tl at 80 K

Type of luminescence	E_{m1}, eV	FWHM, eV	E_{m2}, eV	FWHM, eV
Photoluminescence	2.18	0.35	2.61	0.35
Cathodoluminescence	2.25	0.35	2.6	0.35

elementary bands with maxima at 3.12, 2.6, and 2.25 eV in the photo and cathodoluminescence spectra shown in Fig. 1 correspond very closely to the luminescence bands with maxima at 3.09, 2.55 and 2.25 eV, respectively, observed under *A*-band excitation [3]. Following V.Nagirnyi et al. [3], we consider the 3.12 eV band to be due to the Tl^+ intracenter radiative transition, and 2.6 and 2.25 eV bands to be bound up with radiative annihilation of Tl-perturbed excitons $(I_2^- e^-)^*$ with "weak" and "strong" off-center structure configuration, respectively. As shown above, the slow exponential decay of cathodoluminescence in 2.6 eV and 2.25 eV bands at 80 K is characterized by the time constants equal to 4 μs and 13 μs, respectively (Fig. 4b and 4c), which coincide with the data of [20]. The nature of these exponential stages is considered to be defined by the lifetime of Tl-perturbed excitons of two types in the lowest relaxed state [3]. In our opinion [11], these stages are bound up with the lifetimes in the pairs of $[Tl^0 V_k]$ centers located in the neighbouring lattice sites prior to their tunnel radiative recharge. The issue of the origin of the slow exponential stages is fundamentally significant, since according to the obtained results, it is the fast exponential component with $\tau = 900$ ns that dominates in the decay kinetics of both 2.25 eV and 2.6 eV bands of Tl^+-center luminescence excited by near UV-light at 80 K (Fig. 5b and 5c). This strongly suggests that the lifetime of Tl^+-perturbed excitons in the lowest relaxed state at 80 K does not exceed 900 ns.

Consider the following luminescence features revealed in this study by different excitation methods.

– The exponential decay of luminescence in the sub-microsecond scale under excitation by UV light at both liquid nitrogen temperature and room temperature.

– The presence of the slow exponential components in the decay kinetics of photoluminescence at 80 K characterized by the time constants equal to those of cathodoluminescence.

– The presence of sub-microsecond exponential component in the cathodoluminescence decay kinetics at room temperature, characterized by the time constant whose value is close to that of the photoluminescence.

Synchronous decay of all the three luminescence bands at both excitation methods at temperatures close to room temperature proves the existence of a common mechanism for population of the radiative states of the luminescence centers responsible for these bands.

The model of excitation mechanism of CsI:Tl luminescence induced by near-UV light was discussed in our earlier paper [6]. Developing ideas presented in [6], we consider the exponential decay component of Tl^+-center luminescence to be due to photo-induced transfer of valence electrons from the anions surrounding a thallium ion to the thallium levels with subsequent formation of $[(Tl^0)^* V_k]$ complexes with the populated ψ-sublevel of $6^2P_{3/2}$ excited state of Tl^0 center. De-excitation of $[(Tl^0)^* V_k]$ complexes may occur in two ways. At first, the capture of electrons from the ψ-sublevel by $[Tl^+ V_k]$ complexes called V_{kA} centers results in Tl^+-perturbed excitons of two different configurations according to reaction (2):

$$h\nu_{exc} + [\,I^- Tl^+ I^-\,] \rightarrow [Tl^0)^* V_k] \rightarrow [Tl^+ (V_k e^-)^*] \rightarrow \rightarrow Tl^+ + h\nu_{2.25eV;2,6eV} \quad (2)$$

The probability of the population of the radiative state of Tl^+-perturbed excitons whose luminescence decays exponentially ($\tau_d = 900$ ns at 80 K and $\tau_d = 600$ ns at 295 K), is determined by the probability of the thermal ionization of $(Tl^0)^*$ centers with the populated metastable ψ sub-level.

The other way for de-excitation of $[(Tl^0)^* V_k]$ complexes is the electron transition from the ψ- to the φ sub-level of Tl^0 center (the transition is shown by the arrow ν_i in Fig. 6). This transition gives rise to the pairs of color centers V_k and Tl^0 in $6^2P_{1/2}$ ground state, which are located in neighbouring lattice sites.

$$[(Tl^0)^* V_k] \xrightarrow{\Psi \rightarrow \varphi} [(Tl^0) V_k] \quad (3)$$

According to [11], the destruction of such pairs by the mechanism of tunnel recombination at 80 K is accompanied with slow-decaying luminescence with the time constants equal to 4 μs for 2.6 eV band and 13 μs for 2.25 eV band (see also Fig. 4b and 4c). Therefore, we consider the presence of these slow exponential components in the photoluminescence decay kinetics at 80 K (Fig. 5b and 5c) to be due to the formation of excitons in the process of tunnel radiative recharge of $[Tl^0 V_k]$ pairs (the inclined line in Fig. 6) in according to reaction (4):

$$[Tl^0 V_k] \xrightarrow{tunneling} [Tl^+ (V_k e^-)^*] \rightarrow \rightarrow Tl^+ + h\nu_{2.25eV;2,6eV} \quad (4)$$

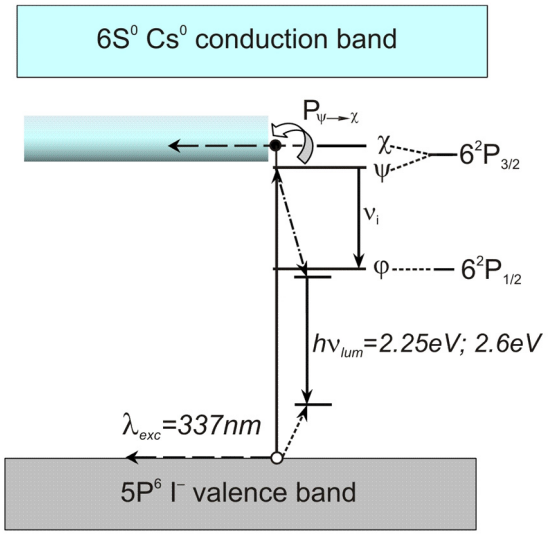

Fig. 6. Scheme of photo-induced electron transitions in CsI:Tl crystal.

At temperatures close to room temperature, the phonon assisted electron transition from the ψ sub-level of $6^2P_{3/2}$ excited state to χ-sub-level which forms impurity conduction sub-band of CsI:Tl [6], has a decisive influence on the luminescent properties. The phonon assisted electron transfer from the ψ-sub-level of Tl^0 center state to the impurity conduction sub-band ($P_{\psi\to\chi}$ transition in Fig. 6) leads to disintegration of $[(Tl^0)^*V_k]$ complex, and intracenter luminescence process is being replaced by the recombination luminescence process:

$$[(Tl^0)^*V_k] \xrightarrow{\psi\to\chi} e^- + [Tl^+V_k] \qquad (5)$$

$[Tl^+V_k]$ complexes are thermally unstable at room temperature, and the electron transfer from the ψ sub-level of $6^2P_{3/2}$ state of Tl^0 center to the impurity conduction sub-band leads, in fact, to the formation of mobile charge carriers of both signs. This is shown in Fig. 6 by horizontal dotted arrows in the corresponding bands. Arising together with free electrons, the holes of the valence band (or mobile V_k centers) in CsI:Tl can be captured by thallium ions with subsequent formation of either Tl^{2+} or V_{kA} centers. At the same time recombination of the conduction electrons with Tl^{2+} centers causes the intracenter transition in Tl^+ ions, which is responsible for the luminescence band with maxima at 3.12 eV:

$$e^- + \ldots + Tl^{2+} \to (Tl^+)^* \to Tl^+ + h\nu_{3.12eV} \qquad (6)$$

Recombination of the conduction electrons with V_{kA} centers results in $[Tl^0V_k]$ complexes which are decomposed with the formation of excitons of two different configurations (reaction 4). In our opinion, synchronous decay of all the three luminescence bands evidences that the duration of recharge in $[Tl^0V_k]$ pairs at room temperature does not exceed the lifetime of Tl^0 center in the excited metastable state. This assumption is consistent with the highlights of the classical theory for the elementary act of recharge of defects in solids [21]. Thus, the features of luminescence excited in CsI:Tl by UV laser emission are consistently described in scope of the proposed model for the mechanism of luminescence center formation under near-UV light.

The presence of the sub-microsecond exponential component in the cathodo-luminescence decay kinetics with the time constant close to that of the photoluminescence testifies to the existence of an effective mechanism for the formation of complexes $[(Tl^0)^*V_k]$ under ionizing radiation at room temperature. According to the data of optical absorption measurements [11, 22, 23], under non-selective band to band excitation, in the CsI:Tl there are formed primary defects such as self-trapped holes (V_k color centers) and Tl^0 centers in $6^2P_{1/2}$ ground state. The creation time for these centers does not exceed 5 ps [22, 23]. Recombination of thermally unstable V_k and Tl^0 centers at room temperature gives rise to luminescence of Tl^+ centers. The dominant contribution to the cathodoluminescence decay kinetics at room temperature belongs to the exponential component whose time constant corresponds to the transition time of Tl^0 center from the excited metastable to the ground state. Therefore, it is reasonable to conclude that the stage of $[(Tl^0)^*V_k]$ complexes formation precedes the creation of Tl^+-perturbed excitons in the process of Tl^0–V_k center recombination. The general scheme of the recombination process is described by reaction:

$$V_k + .,, + Tl^0 \to [Tl^0)^*V_k] \to \qquad (7)$$
$$\to [Tl^+(V_ke^-)^*] \to Tl^+ + h\nu_{2.25eV;2.6eV}$$

According to the model of inter-impurity radiative recombination [24], at electron tunneling from a donor to an acceptor there arises Coulomb interaction. Due to this interaction, the process of electron tunneling from Tl^0 to the nearby V_k center in $[Tl^0V_k]$ complexes seems to include an intermediate stage of electron transition from the level

of the ground state to the sub-level of the metastable of Tl^0 center state. The probability of this transition defines athermal behavior of the exponential decay constant of Tl-perturbed exciton luminescence at temperatures below 20 K [3,20]. The transition of Tl^0 centers to the metastable state becomes assisted by phonons at temperatures above 20 K, therefore the exponential decay constant of Tl-perturbed exciton luminescence becomes temperature-dependent.

Thus, the luminescence lifetime of Tl^+-perturbed excitons arising under a pulsed electron beam or UV laser light in CsI:Tl crystal is defined by the lifetime of Tl^0 centers in the metastable excited state. This could be just the factor that limits the fast response of CsI:Tl scintillator.

4. Conclusions

The main results of this study are summarized as follows:

At single-photon absorption of 337 nm light of a nitrogen laser in CsI:Tl crystals with different activator concentration, there is excited luminescence of Tl^+-perturbed excitons of two structure configuration and Tl^+ intracenter luminescence.

The lifetime of Tl^+-perturbed excitons in the lowest relaxed state at 80 K is shown not to exceed 900 ns. The excitons arise due to the recharge of $[(Tl^0)^*V_k]$ complexes consisting of Tl^0 center in the excited metastable state and V_k center which are located in neighbouring lattice sites.

Recombination of electrons from impurity conduction band with hole centers arising due to disintegration of $[(Tl^0)^*V_k]$ complexes with the populated ψ sub-level of $6^2P_{3/2}$ excited state of Tl^0 centers is considered to be the basic mechanism for creation of luminescence centers under both excitation method at room temperature. The mechanism explains the appearance not only of the exciton luminescence, but also of luminescence caused by the intracenter transition in Tl^+ ions.

It is shown that the major contribution to the cathodoluminescence decay kinetics at room temperature is made by the exponential component with the decay time corresponding to the time of Tl^0 center transition from the excited metastable to the ground state. Recombination of Tl^0 with V_k centers is always accompanied with the creation of $[(Tl^0)^*V_k]$ complexes with the populated ψ-sublevel of $6^2P_{3/2}$ excited state of Tl^0 centers. The lower limit of the decay time of the activator luminescence for CsI:Tl crystal is defined by the lifetime of Tl^0 center in the metastable excited state.

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