

## STARK STATE STRUCTURE ${}^4I_{9/2}$ OF $\text{Nd}^{3+}$ ION IN $\gamma\text{-La}_2\text{S}_3$ CRYSTAL AT SELECTIVE LASER EXCITATION

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The luminescence spectrums of  $\text{Nd}^{3+}$  ions in  $\gamma\text{-La}_2\text{S}_3$  crystal have been investigated with the application of selective resonance laser excitation at helium temperature and diagram of Stark splittings of main state is constructed.

Nowadays crystals with disordered structure, activated by rare-earth ions, are the ones from the prevailing active mediums for solid-state lasers. The spectral bands of activator in these mediums are characterized by considerable heterogeneous widening. The physical nature of such widening is that different activator centers are in disordered matrix in inequivalent positions and static crystal fields influence on them.

$\gamma\text{-La}_{2-2x}\text{Nd}_{2x}\text{S}_3$  crystal is related to disordered structures of  $\text{Th}_3\text{P}_4$  type. Each Th atom in structure of thorium phosphide is surrounded by eight P atoms, being from it on equal distances and forming "twisted normal eight-top wood" of  $\text{ThP}_8$  symmetry ( $\bar{4} - S_4$ ). Six Th atoms surround P atoms, forming strained (twisted) octahedron  $[\text{PTh}_6]$  of  $3 - C_3$  symmetry. The lanthanide atoms take positions of thorium atoms in  $\text{Ln}_2\text{X}_3$  chalcogenides, and atoms of sulfur, selenium and tellurium take positions of P atoms. The coordination polyhedron of Th(Ln) atom can be presented as it would be formed by two penetrating tetrahedrons. The one third of cation knots in elementary cell in  $\gamma\text{-La}_{2-2x}\text{Nd}_{2x}\text{S}_3$  crystal is vacant one (the cell consists of four formula units) and these vacancies have irregular distribution on crystal volume. Thus, irregularly distributed vacancies distort the crystal field, influencing on ions, being near them. There is no such division even at very low temperatures and their spectrums are characterized by wide bands, presenting themselves the superpositions of variety of lines unlike simple many-centered crystals in optical centers of which the clearly resolved peaks are belonged to each center. The contours of absorption and luminescence bands of activator ions in disordered crystals are heterogeneously widened at any temperature. This circumstance is revealed in absorption and luminescence bands of neodymium ions in  $\gamma\text{-La}_2\text{S}_3$  crystals, recorded at  $T=4,2\text{K}$ . The spectral lines are nonelementary ones that makes the scheme construction of Stark splitting difficult.

The absorption and luminescence spectrums  $\gamma\text{-La}_{2-2x}\text{Nd}_{2x}\text{S}_3$  had been studied earlier in [1,2]. The authors of [1] relate  $\gamma\text{-La}_{2-2x}\text{Nd}_{2x}\text{S}_3$  crystal to type of mixed ones with the one activator quazicenter. The conception of activator quazicenter, which later isn't justify itself at spectrum investigation, has been proposed at study of luminescence property of big series of disordered laser crystals with  $\text{Nd}^{3+}$  ions in [3]. The some conceivable static construction which generalizes the properties of variety of elementary centers, differing by structure, but having nearest Stark splitting of energy states is understood as quazicenter. It is clear that construction of Stark splitting without taking into consideration the heterogeneous widening of absorption and

luminescence band (at stationary excitation) in the conception limits of quazicenter is wrong. That's why the investigation necessity of spectrum thin structure of neodymium ions in  $\gamma\text{-La}_2\text{S}_3$  crystal arises. These investigations have been carried out with the application of method of selective resonance laser excitation and spectroscopy of time resolution.

The selective luminescence spectrums and diagram of Stark splittings of  $\text{Nd}^{3+}$  ions in  $\gamma\text{-La}_2\text{S}_3$  crystal are presented on the fig.1.

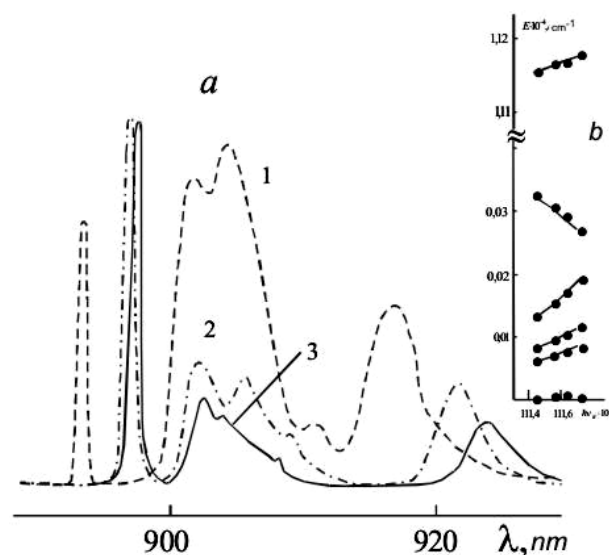


Fig.1. The selective luminescence spectrums (a) taken in 25 mcs time after finishing of light exciting impulse action at helium temperature: 1- $\lambda_{exc}=895,4\text{ nm}$ ; 2- $\lambda_{exc}=896,4\text{ nm}$ ; 3- $\lambda_{exc}=897,4\text{ nm}$ ; and diagram of Stark splittings (b) of  $\text{Nd}^{3+}$  ions in  $\gamma\text{-La}_2\text{S}_3$  ions.

The weak structure of  ${}^4F_{3/2} \rightarrow {}^4I_{9/2}$  transition reveals in luminescence spectrums at excitation of absorption band, corresponding to  ${}^4I_{9/2} \rightarrow {}^4F_{3/2}$  transition in short-wave side. That's why it is established to excite the short-wave side of absorption band (from wave length 893 nm up to 897,4 nm with step 1 nm). The thin structure in best form (fig.1a, spectrum-3) reveals at light excitation of wave length  $\lambda_w=897,4\text{ nm}$  in luminescence spectrums (fig.1,a) taken at helium temperature. The thin structure also reveals in luminescence spectrum at shift 1nm to short-wave side, i.e. at light excitation with wave length  $\lambda_w=896,4\text{ nm}$  (fig.1a, spectrum-2), but moreover maximums of luminescence bands shift to spectrum different sides. The bands with

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corresponding transitions between Stark components  ${}^4F_{3/2}$  and  ${}^4I_{9/2}$  multiplets heterogeneously widen in luminescence spectrums at further shift 1 nm to short-wave side of absorption spectrum at light excitation with wave length  $\lambda_w=895,4$  nm (fig.1a, spectrum-1). Thus, luminescence spectrum analysis obtained at selective resonance laser excitation shows that they essentially differ from spectrums at nonselective excitation and strongly depend on excitation wave length.

Taking into consideration the value of transition energy  ${}^4I_{9/2} \rightarrow {}^4F_{3/2}$  as index of ligand field force, the scheme of

Stark splittings of  ${}^4I_{9/2}$  multiplet in different optical centers in matrix (fig.1,b) is constructed in the dependence on this parameter. The definition of level energies is carried out on maximum positions in luminescence spectrums beginning from low Stark component of main state  ${}^4I_{9/2}$ .

The given diagram shows the connection between energies of different Stark levels of  ${}^4F_{3/2}$  and  ${}^4I_{9/2}$ , their correlated changes and quantitative values of Stark splittings of  ${}^4I_{9/2}$  multiplet in different centers.

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### **$\gamma$ - $La_2S_3$ KRİSTALLARINDA SELEKTİV LAZER HƏYƏCANLAŞMASINDA $Nd^{3+}$ İONLARININ ${}^4I_{9/2}$ HALININ ŞTARK STRUKTURU**

Helium temperaturunda rezonans lazer həyəcənlaşma metodunu tətbiq etməklə  $\gamma$ - $La_2S_3$  kristallarında  $Nd^{3+}$  ionlarının lyuminessensiya spektrləri tədqiq edilmiş və əsas halın ştark parşalanmasının diaqramı qurulmuşdur.

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### **ШТАРКОВСКАЯ СТРУКТУРА СОСТОЯНИЯ ${}^4I_{9/2}$ ИОНА $Nd^{3+}$ В КРИСТАЛЛЕ $\gamma$ - $La_2S_3$ ПРИ СЕЛЕКТИВНОМ ЛАЗЕРНОМ ВОЗБУЖДЕНИИ**

При гелиевой температуре, с применением метода селективного резонансного лазерного возбуждения исследованы спектры люминесценции ионов  $Nd^{3+}$  в кристалле  $\gamma$ - $La_2S_3$  и построена диаграмма штарковских расщеплений основного состояния.

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