

SPECTROSCOPIC PROPERTIES OF NEODYMIUM IONS IN α -Gd₂S₃ SINGLE CRYSTALS

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The radiation spectrum identification of Nd³⁺ ions has been carried out in α -Gd₂S₃ crystals on ${}^4F_{3/2} \rightarrow {}^4I_{11/2}$ transition. The energy values of Stark sublevels are defined for each of Nd³⁺ centers.

Nowadays Nd³⁺ ions are the most distributive activators for solid-state lasers. The electron configuration of free trice ionized neodymium atom is $4f^3$. The number of electrons is odd one and J values are half-integer ones. Each level of free Nd³⁺ ion is degenerate one with $2J+1$ degeneracy multiplicity. Each initially degenerated level, characterized by definite J value, splits on the series of sublevels (Stark components) under the influence of electric field, created by the ion surroundings in crystal lattice. Nd³⁺ ions, being in crystal-basis, can be in the fields with different symmetry and intensity, moreover the number of such inequivalent positions (number of centers) can change in wide range. As a result each type of Nd³⁺ optical center in the given crystal differs from other ones of the same crystal by the level scheme. The crystal optical properties in the given case present themselves the superposition of properties of separate center types. The given crystal disordered structure reveals in spectrums of absorption and luminescence Nd³⁺ in the form of heterogeneous widening and splitting of its lines. The heterogeneous widening of Nd³⁺ spectrums in several crystals is so big that it totally levels Stark splits of separate optical centers. The absence of information about structure of heterogeneously widened bands essentially makes difficult the analysis of processes taking place in excited activated medium.

The method of selective laser excitation allows us to carry out these gaps. It is based on constriction of heterogeneously widened luminescence lines at narrow-band selective excitation of separate centers.

α -Gd₂S₃ crystal is the one from few semiconductors

allowing the introduction of high concentrations of Nd³⁺ ions. This compound has orthorhombic structure in which Gd³⁺ ions are in two equivalent positions [1]. The α -Gd₂S₃ structure is formed by Gd(1)S₇ and Gd(1)S₈ polyhedrons. The coordination polyhedron Gd(1)S₇ presents itself dual trigonal prism; Gd(2) is surrounded by seven sulfur atoms, forming distorted "monocapped" trigonal prism. The coordination number of sulfur atoms in α -Gd₂S₃ is equal to 5. Nd³⁺ ions at introduction into crystal are also in inequivalent positions that reveals in their optical spectrums [2]. Thus, for example, the four well resolved peaks take place in absorption spectrum, corresponding to ${}^4I_{9/2} \rightarrow {}^4F_{3/2}$ transition at $T=4,2K$, whereas ${}^4F_{3/2}$ term should split only on two Stark components in the field of low symmetry. Thus, the task of thin structure identification of optical spectrums for which Nd³⁺ ions, being in inequivalent positions are responsible arises. This task has been solved by us by the method of resonance selective laser excitation with the record of radiation spectrums with time resolution.

The convertible laser on LiF crystal is used in the capacity of resonance selective excitation. The duration of generation impulse is ~ 15 nsec, and width of emission line is less than 5\AA . The conversion region totally recovers the neodymium absorption spectrum ${}^4I_{9/2} \rightarrow {}^4F_{3/2}$. The spectrometer SDL-1 is used as spectral device. The luminescence signal coming from radiation sensor PEM-83 is given to strobe-integrator PAR-162 and recorded by logger. The duration of strobe impulse is $\sim 0,5$ mcs, and delay time $\tau=20$ mcs. The experiments are carried out at helium temperature.

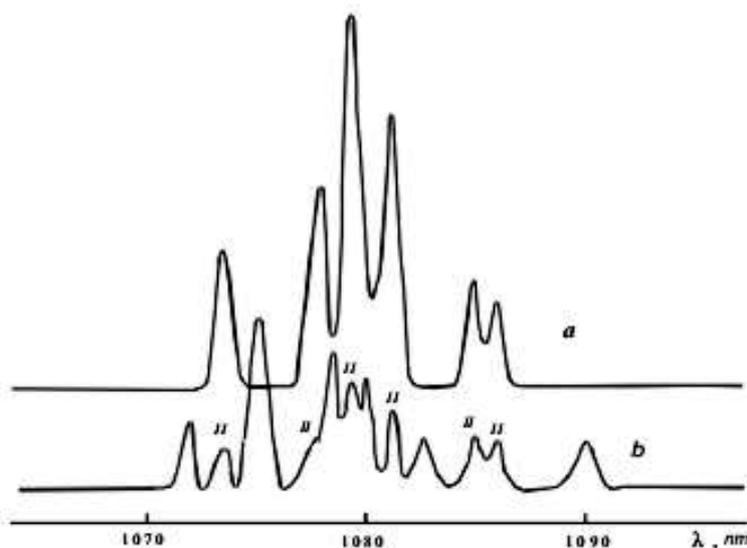


Fig.1. The luminescence spectrums ${}^4F_{3/2} \rightarrow {}^4I_{9/2}$ of Nd³⁺ ion in α -Gd₂S₃ at excitation in different absorption bands: a - $\lambda_{excit}=900.4nm$; b - $\lambda_{excit}=888.4nm$. The delay time $\tau=20mcs$.

The ${}^4F_{3/2} \rightarrow {}^4I_{9/2}$ luminescence spectrums of Nd^{3+} ion at excitation of each line in resonance absorption spectrum are identified in work [2]. The two types of centers are revealed and designated as center I and center II. The energy of low Stark component of ${}^4F_{3/2}$ level in center I exceeds the one in center II. The schemes of Stark splitting of ${}^4F_{3/2}$ and ${}^4I_{9/2}$ Nd^{3+} levels for each center have been constructed.

The scheme of Stark splitting of low laser level ${}^4I_{11/2}$ has the special significance, i.e. the wave length generacy is defined especially by energy positions of Stark sublevels ${}^4F_{3/2}$ and ${}^4I_{11/2}$. That's why luminescence spectrums ${}^4F_{3/2} \rightarrow {}^4I_{11/2}$ of neodymium ions have been investigated by us.

The luminescence spectrums ${}^4F_{3/2} \rightarrow {}^4I_{11/2}$ of Nd^{3+} ion at excitation of each line in resonance absorption spectrum are presented on the fig.1. The six lines (fig.1,a) which one can

naturally identify as ones, related to one center, called center II in work [2], are observed in luminescence spectrum in the correspondence with theory in the case of line excitation, designated in absorption spectrum as lines II.

Using the given data, it isn't difficult to define the energy values, corresponding to Stark components of ${}^4I_{11/2}$ Nd^{3+} level for center II. These values are the following: 1800 cm^{-1} ; 1868 cm^{-1} ; 1880 cm^{-1} ; 1901 cm^{-1} ; 1928 cm^{-1} ; 1936 cm^{-1} .

Such clear selection isn't observed at excitation of center I lines (fig.1,b). The lines of center II appear in luminescence center. Thus center II is excited at excitation in the absorption band of center I. Taking this into consideration, the energy values of corresponding Stark components of ${}^4I_{11/2}$ Nd^{3+} level for center I are defined. These values are: 1812 cm^{-1} ; 1840 cm^{-1} ; 1869 cm^{-1} ; 1881 cm^{-1} ; 1898 cm^{-1} ; 1960 cm^{-1} .

[1] Fizicheskiye svoystva khalkogenidov redkozemelnikh elementov. Pod.red. V.P. Juze. M. Nauka, 1973, 304s. (in Russian).

[2] A.A. Mamedov, V.A. Smirnov, I.A. Shsherbakov. FTT, 1984, № 8, s.2405-2407.(in Russian).

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α -Gd₂-S₃ MONOKRİSTALLARINDA NEODİM İONLARININ SPEKTROSKOPİK XASSƏLƏRİ

α -Gd₂-S₃ kristallarında ${}^4F_{3/2} \rightarrow {}^4I_{11/2}$ keçidində ionlarının şüalanma spektrləri identifikasiya edilmişdir. Hər bir Nd^{3+} mərkəzi üçün şark səviyyələrinin enerjiləri müəyyən edilmişdir.

A.A. Мамедов

СПЕКТРОСКОПИЧЕСКИЕ СВОЙСТВА ИОНОВ НЕОДИМА В МОНОКРИСТАЛЛАХ α -Gd₂-S₃

В кристаллах α -Gd₂-S₃ проведена идентификация спектров излучения ионов Nd^{3+} на переходе ${}^4F_{3/2} \rightarrow {}^4I_{11/2}$. Для каждого из центров Nd^{3+} определены значения энергий штарковских подуровней.

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