Prospective visible laser active media based on disordered fluorite-type structure crystals

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Abstract. The synthesis conditions and the results of spectral-kinetic studies of disordered crystals series CaF_2-LaF_3-PrF_3 with variable chemical composition are presented. The prospects of using these crystals as active media for the visible spectral range DPSS laser pumped by InGaN (GaN) laser diodes and operating on 4f-4f transitions of Pr^{3+} ions are discussed.

The development of biosensor and biomedical applications causes a steady interest in visible DPSS (diode pumped solid-state) lasers [1]. Visible range laser action is realized at 4f-4f transitions of Pr^{3+}, Tb^{3+}, Sm^{3+}, Eu^{3+} ions in crystals and glasses pumped by InGaN (GaN) laser diodes (LD) [2]. The most promising of active media are the Pr^{3+} ion doped fluoride crystals demonstrating highest output properties [3-5]. However, the expansion of these DPSS lasers is limited by a narrow absorption spectral line width of dopants to compare with the LD emission spectra. It requires the enhanced selection of LD according to central emission wavelength. Using of disordered crystalline matrices can solve this problem.

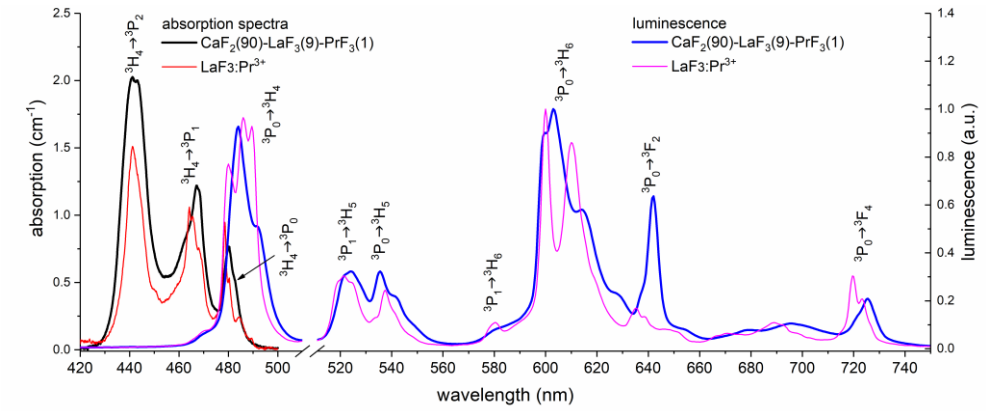

Fig. 1. Absorption and luminescence spectra of CaF_2(90)-LaF_3(9)-PrF_3(x=1) and LaF_3:Pr^{3+} (C_{pr}=1 at.%).

The report provides growing conditions and spectral-kinetic studies of disordered crystals series CaF_2-LaF_3-PrF_3 with variable chemical composition. The prospects of using these

crystals as active media for the visible spectral range DPSS laser pumped by InGaN (GaN) LD are discussed.

Single crystals of $CaF_2(90)$-$LaF_3(10-x)$-$PrF_3(x)$ solid solutions ($0.5\% < x < 8\%$) were grown by the Bridgman technique in graphite crucibles in high-purity Ar + CF_4 atmosphere. The obtained crystals have the length of 40 mm and diameter of 10 mm. Absorption and fluorescence spectra were recorded using the MDR-23 monochromator with attached FEU-100 photomultiplier. Fluorescence of the samples was excited by pulsed radiation of the optical parametric oscillator laser system (LT-2215LC) from JV LOTIS TII. The luminescence energy yield (LQY) was studied in the integrating sphere IS200 (Thorlabs). The experimental results at room temperature are presented in Fig. 1 and summarized in table 1.

Table 1. Effective lifetimes, luminescence energy yield (LEY) and luminescence quantum yield of Pr^{3+} ions $^3P_0 \rightarrow {}^3H_j$, ^3F_j transitions in $CaF_2(90)$ -$LaF_3(10-x)$ -$PrF_3(x)$ disordered crystals.

Sample Composition	τ, us	LEY,%	LQY,%
CaF2(90)-LaF3(9.5)-PrF3(0.5)	38	40 ±3	95 ±4
CaF2(90)-LaF3(9)-PrF3(1)	26	20 ±3	49 ±4
CaF2(90)-LaF3(8.5)-PrF3(1.5)	19	12 ±3	29 ±4
CaF2(90)-LaF3(8)-PrF3(2)	14	7 ±1	16 ±2
CaF2(90)-LaF3(6)-PrF3(4)	5	1 ±0.3	2 ±0.5
CaF2(90)-LaF3(2)-PrF3(8)	0.9	0.1 ±0.1	0.2 ±0.2

It was found that the $^3H_4$-^3P_j absorption spectrum lines of disordered $CaF_2(90)$-$LaF_3(10-x)$-$PrF_3(x)$ crystals are noticeably broader than the similar ones of LaF_3:Pr^{3+} crystal. For instance, the $^3H_4$-$^3P_2$ transition has the absorption bandwidth (FWHM) approximately 7.6 nm for LaF_3:Pr^{3+} sample and 10.2 nm for the $CaF_2(90)$-$LaF_3(9)$-$PrF_3(x=1)$ sample. Thus, following data of table 1 and ref.6, the disordered CaF_2-LaF_3-PrF_3 crystals look a promising active media for visible-range DPSS.

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