

Study of the spectral and kinetic characteristics of the Er^{3+} ion in $\text{BaY}_{1.8}\text{Lu}_{0.2}\text{F}_8$ mixed crystals to assess the possibility of continuous laser oscillation at a wavelength of $2.7\ \mu\text{m}$

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Abstract— Here we present the spectral and kinetic characteristics of Er^{3+} ions in the heavily doped $\text{BaY}_{1.8}\text{Lu}_{0.2}\text{F}_8$ mixed crystals and evaluate the possibility of continuous laser oscillation at a wavelength of $2.7\ \mu\text{m}$.

Keywords— fluorides, erbium ions, optical spectroscopy, IR laser, Judd-Ofelt theory

I. INTRODUCTION

The method of differential optical absorption spectroscopy is used to determine the concentration of greenhouse gases and water vapor in the atmosphere. Laser gas analyzers based on lasers emitting in the infrared range of the spectrum are used for this purpose [1]. The Er^{3+} ion oscillations emitting at the wavelengths of 1.5 and $2.7\ \mu\text{m}$ are the same with the absorption lines of carbon dioxide and water [2]. The transparency from ultraviolet (UV) to infrared (IR) spectral regions and low phonon energy are the advantage of using fluorides as an active laser medium over other crystalline matrices [3].

A wide gain bandwidth allows wavelength tunability or the generation of ultrashort laser pulses, which is necessary for many applications. To broaden the spectral lines of transitions the Lu^{3+} ions were included in the matrix cations. So, the growth of $\text{BaY}_{1-x}\text{Lu}_x\text{F}_8$ mixed crystals is considered as one of the ways to broaden the spectral lines of transitions [4].

II. RESULTS

The study of the spectral and kinetic characteristics in the IR region of the spectrum of $\text{BaY}_{1.8}\text{Lu}_{0.2}\text{F}_8$ crystals activated by Er^{3+} ions with concentrations of 20.0 and $30.0\ \text{at.}\%$ was presented in this work. Our experimental data allowed us to make calculations according to the Judd-Ofelt theory. This work presents the calculated values of the radiative lifetimes of the ${}^4\text{I}_{11/2} \rightarrow {}^4\text{I}_{15/2}$ and ${}^4\text{I}_{13/2} \rightarrow {}^4\text{I}_{15/2}$ transitions and branching ratios of the ${}^4\text{I}_{11/2}$ level. The experimentally estimated values of the radiative lifetimes of the ${}^4\text{I}_{11/2}$ and ${}^4\text{I}_{13/2}$ states showed deviations from the results calculated by the Judd-Ofelt theory, which can be explained by the presence of cross-relaxation processes.

The lifetimes of the ${}^4\text{I}_{11/2}$ and ${}^4\text{I}_{13/2}$ states were also determined from the experiment for a series of samples of $\text{BaY}_{1.8}\text{Lu}_{0.2}\text{F}_8$ crystals with different concentrations of Er^{3+}

ions. It has been shown that at high concentrations of Er^{3+} ions (20.0 and $30.0\ \text{at.}\%$) the lifetime of the upper laser level ${}^4\text{I}_{11/2}$ becomes longer than the lifetime of the lower laser level ${}^4\text{I}_{13/2}$, which indicates the possibility of efficient laser oscillation in a continuous mode at a wavelength of $2.7\ \mu\text{m}$.

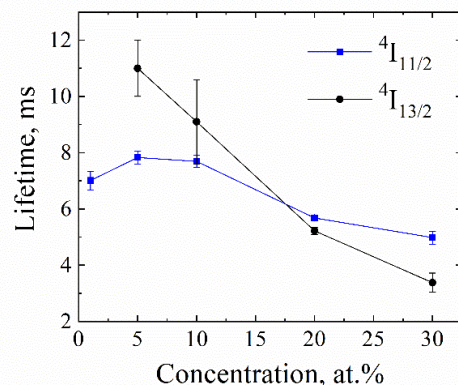


Fig. 1. Dependence of the lifetime of ${}^4\text{I}_{11/2}$ and ${}^4\text{I}_{13/2}$ manifolds on Er^{3+} ion in $\text{BaY}_{1.8}\text{Lu}_{0.2}\text{F}_8$ crystals.

The results of experiments on obtaining laser oscillation in $\text{BaY}_{1.8}\text{Lu}_{0.2}\text{F}_8$ crystals at a wavelength of $2.7\ \mu\text{m}$ are also discussed in this work.

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