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Structural features and distribution coefficients of Pr^{3+}, Y^{3+} and Lu^{3+} ions in $LiY_{1-x}Lu_xF_4$ mixture crystals

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ABSTRACT

The spatially dependent spectral-kinetic and crystal structure properties of undoped and Pr^{3+} - doped $LiY_{1-x}Lu_xF_4$ mixed crystals grown by Bridgeman technique were studied along crystal growth direction. The distribution coefficients of Pr^{3+}, Y^{3+} and Lu^{3+} in these crystals were determined. The rise of lattice parameters with increasing of the Pr^{3+} concentration along the crystal growth direction was observed.

1. Introduction

The praseodymium doped wide-band gap dielectric crystals are well known UV and visible phosphors emitting from 220 nm to 730 nm due to inter- 4f5d → $4f^2$ and intraconfigurational $4f^2 \rightarrow 4f^2$ transitions of Pr^{3+} ions [1–4]. Laser action based on inter-configurational 4f5d → $4f^2$ transitions was not yet realized because of different photodynamic processes arising from the UV pumping. On the other hand the intraconfigurational $4f^2 \rightarrow 4f^2$ transitions of Pr^{3+} ions were successive used to obtain tunable visible laser action in several crystal hosts, for instance in Pr:$LiYF_4$ [5–17], Pr:$LiLuF_4$ [6,7,9,18], Pr:$LiGdF_4$ [7,17], Pr:KYF_4 [17], Pr:KY_3F_{10} [9,19], Pr:LaF_3 [20], Pr:BaY_2F_8 [21], Pr:$YAlO_3$ [22–24], Pr:$SrAl_{12}O_{19}$ [25] etc. The key parameter limiting output power of quantum oscillators in such systems is concentration of the dopant together with the high optical quality. Widely used $LiLuF_4$ and $LiYF_4$ laser crystals are isostructural to each other and demonstrate similar optical and kinetic properties. At the same time $LiLuF_4$ exhibit better optical quality than $LiYF_4$ crystals due to its congruent melting behavior [18,26]. From the other hand $LiLuF_4$ crystals are used rarer for laser implementations due to high cost of the lutetium compounds and lower distribution coefficient of Pr^{3+} ions than $LiYF_4$ [6]. To reach balance between these two parameters the solid solutions of $LiY_{1-x}Lu_xF_4$ can be used. Moreover, the results of [27,28] demonstrate an opportunity to significantly increase of Ce^{3+} and Nd^{3+} ions distribution coefficient in $LiY_{1-x}Lu_xF_4$ solid solutions. In the present search we check this effect with respect to Pr^{3+} ions.

The nine samples of $LiY_{1-x}Lu_xF_4$ (x = 0, 0.3, 0.5, 0.6, 0.7, 0.8, 1) mixture crystals doped by 1 at% of Pr^{3+} ions in the melt and pure $LiY_{0.3}Lu_{0.7}F_4$ and $LiYF_4$ crystals were studied in the present search. Here we present the results of spectral-kinetic investigations, energy-dispersive x-ray spectroscopy (EDS) and x-ray diffraction (XRD) analysis of these crystals along their growth direction. The distribution coefficient of Pr^{3+}, Y^{3+} and Lu^{3+} ions dependences along crystalline bulk are discussed. The crystal

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