

Spectroscopy of the Nd-doped and Ag-Nd co-doped lithium tetraborate glasses

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Spectroscopic and luminescent properties of the Nd-doped and Nd-Ag co-doped borate glasses with $\text{Li}_2\text{B}_4\text{O}_7$ ($\text{Li}_2\text{O}-2\text{B}_2\text{O}_3$) basic composition are presented and analysed using experimental results of optical absorption, electron paramagnetic resonance (EPR), photoluminescence (excitation, emission, decay kinetics) and Judd-Ofelt theory. Technology, local structure, spectroscopic and luminescent properties of the $\text{Li}_2\text{B}_4\text{O}_7:\text{Nd}$ and $\text{Li}_2\text{B}_4\text{O}_7:\text{Nd,Ag}$ glasses containing 0.5 and 1.0 mol.% Nd_2O_3 and 2.0 mol.% AgNO_3 doping impurities firstly were presented in articles [1,2]. EPR and optical spectroscopy show that Nd impurity is incorporated into the $\text{Li}_2\text{B}_4\text{O}_7:\text{Nd}$ and $\text{Li}_2\text{B}_4\text{O}_7:\text{Nd,Ag}$ glasses network as Nd^{3+} ($4f^3$, $^4I_{9/2}$) ions, exclusively. Optical absorption, photoluminescence, and decay kinetics of Nd^{3+} centers were detailed studied. Experimental and theoretical oscillator strengths (f_{exp} and f_{theor}), phenomenological Judd-Ofelt intensity parameters (Ω_2 , Ω_4 , Ω_6), and important to laser applications parameters such as radiative transitions rates (W_r), probabilities of radiative transitions (A_{rad}), branching ratios (β), radiative lifetimes (τ_{rad}), emission cross-sections (σ_{em}), and quantum efficiency (η) of the Nd^{3+} luminescence centers in the $\text{Li}_2\text{B}_4\text{O}_7:\text{Nd}$ [1] and $\text{Li}_2\text{B}_4\text{O}_7:\text{Nd,Ag}$ [2] glasses have been calculated and analyzed. In the $\text{Li}_2\text{B}_4\text{O}_7:\text{Nd,Ag}$ glass optical absorption band of surface plasmon resonance (SPR) related to silver nanoparticles was observed. Presence of the Ag^{2+} ($4d^9$, $^2D_{5/2}$) paramagnetic centers and small non-plasmonic Ag aggregates or nanoclusters in the $\text{Li}_2\text{B}_4\text{O}_7:\text{Nd,Ag}$ glass was confirmed by EPR spectroscopy [2]. Enhancement of the Nd^{3+} emission intensity in 1.3 and 20 times was observed in the $\text{Li}_2\text{B}_4\text{O}_7:\text{Nd,Ag}$ glass under excitation at 585 nm and 350 nm, respectively. The observed luminescence enhancement is assigned to energy transfer from Ag^+ isolated ions and Ag aggregates to the Nd^{3+} ions as well as local field effects induced by the SPR of Ag nanoparticles. The Ag co-doping is a promising approach for improving of luminescent and laser properties of the Nd^{3+} ions in borate glasses.

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[1] Padlyak B.V., Lisiecki R., Padlyak T.B., et al. (2018) J. Lumin. 198, 183–192.

[2] Kindrat I.I., Padlyak B.V., Lisiecki R., et al. (2021) J. Alloys Comp. 853, 157321.

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