Effect of Ag co-activation on luminescence of Dy^{3+} ions in lithium tetraborate glasses

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The spectroscopic properties of lithium tetraborate ($Li_2B_4O_7$) glasses activated with Dy and co-activated with Dy and Ag were studied using optical absorption and photoluminescence (emission, excitation, decay kinetics, quantum yield) techniques [1]. The optical absorption spectra of the $Li_2B_4O_7$:Dy and $Li_2B_4O_7$:Dy,Ag glasses exhibit several characteristic $4f$ – $4f$ transitions associated with Dy^{3+} ($4f^9$, $^6H_{15/2}$) ions.

The luminescence emission spectra of the investigated glasses upon excitation at 349 nm show two strong bands at 481 nm and 574 nm, two weaker bands at 662 nm and 753 nm corresponding to the $^4F_{9/2} \rightarrow {}^6H_{15/2}$, $^6H_{13/2}$, $^6H_{11/2}$, $^6H_{9/2}$ transitions of Dy^{3+} ions as well as a weak band at 452 nm attributed to a phonon side band of the emission at 481 nm. The luminescence excitation spectra of the $Li_2B_4O_7$:Dy and $Li_2B_4O_7$:Dy,Ag glasses exhibit numerous narrow bands corresponding to $4f$ – $4f$ transitions of Dy^{3+} ions with the most intense band at 349 nm ($^6H_{15/2} \rightarrow {}^6P_{7/2}$ transition).

The luminescence emission spectrum of the $Li_2B_4O_7$:Dy,Ag glass upon excitation at 268 nm shows that the intense Dy^{3+} emission bands are superimposed on two very broad weakly resolved bands peaking near 398 nm and 523 nm, which are attributed to isolated Ag^+ ions and small non-plasmonic molecule-like Ag nanoclusters (Ag_m^{n+} centres). The luminescence excitation spectrum also exhibit two bands related to these Ag centres.

The luminescence decay lifetime of Dy^{3+} ions in the $Li_2B_4O_7$:Dy and $Li_2B_4O_7$:Dy,Ag glasses slightly exceeds 800 μs. The luminescence decay lifetimes of Ag^+ ions and Ag nanoclusters in the $Li_2B_4O_7$:Dy,Ag glass are 63 μs and 166 μs, respectively.

Integrating-sphere measurements show that the $Li_2B_4O_7$:Dy,Ag glass exhibits a higher luminescence quantum yield than the $Li_2B_4O_7$:Dy glass as a result of the energy transfer from Ag^+ ions and Ag nanoclusters to Dy^{3+} ions. The chromaticity coordinates of the emission of the $Li_2B_4O_7$:Dy,Ag glass are (0.3341, 0.3771), which are very close to those of standard white light. The corresponding correlated colour temperature is 5442 K. The obtained results demonstrate that $Li_2B_4O_7$:Dy,Ag glass is a promising luminescent material for white light emission.

[1] Kindrat I.I., Padlyak B.V., Drzewiecki A., et al. (2024) Mater. Res. Bull., 179, 112979.

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