Ultraviolet Photoluminescence of the Gd^{3+} Centres in Borate Glasses

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The Gd-doped borate glasses of high optical quality with $Li_2B_4O_7$, CaB_4O_7, $LiCaBO_3$ basic compositions have been investigated in details using electron paramagnetic resonance (EPR) and optical spectroscopy techniques. The $Li_2B_4O_7$:Gd, CaB_4O_7:Gd, and $LiCaBO_3$:Gd glasses were obtained by standard glass synthesis method using technological conditions described in [1]. The Gd impurity was introduced into the glass compositions as Gd_2O_3 compound in amounts 0.5 and 1.0 mol. %. In all obtained Gd-doped borate glasses has been observed at room temperature characteristic EPR spectrum of the paramagnetic Gd^{3+} ($^8S_{7/2}$, $4f^7$) ions. The observed EPR spectrum of the Gd^{3+} centres practically is independent of the basic glass compositions and is typical for glassy (vitreous) materials [2,3].

The optical absorption and photoluminescence (emission and excitation) spectra as well as luminescence decay curves of the $Li_2B_4O_7$:Gd, CaB_4O_7:Gd, and $LiCaBO_3$:Gd glasses were registered and analysed. In all investigated Gd-doped borate glasses at room temperature is observed the strong and sharp UV emission band at 311 nm under excitation with 273 nm and 252 nm. The emission band at 311 nm is extremely efficient at excitation with 273 nm. Analysis of electronic levels of the rare-earth ions and referenced data [4,5] clearly shows that the emission band at 311 nm corresponds to the $^6P_{7/2} \rightarrow {}^8S_{7/2}$ intraconfiguration $4f - 4f$ transition of the Gd^{3+} ions. Observed in emission spectrum weak band at 305 nm belongs to the $^6P_{5/2} \rightarrow {}^8S_{7/2}$ transition of the Gd^{3+} ions, whereas the weak band around 325 nm most probably is related to the vibronic sideband. In the photoluminescence excitation spectrum of the Gd^{3+} centres are well observed three characteristic groups of bands, which correspond to transitions from the ground state to higher excited states: $^8S_{7/2} \rightarrow {}^6P_J$, ^6I_J, and ^6D_J [4,5]. The emission band at 311 nm is dominant under the excitation with 273 nm ($^8S_{7/2} \rightarrow {}^6I_{7/2}$ transition) and 252 nm ($^8S_{7/2} \rightarrow {}^6D_{9/2}$ transition). The observed excitation bands show good correlation with the Gd^{3+} absorption bands, which are revealed as weak features on the background of the fundamental absorption edge of the glass host.

Luminescence decay curves of the Gd^{3+} emission band at 311 nm in the investigated glasses have been described in the framework of single exponential approximation with lifetimes ~ 4 ms. The obtained results show that the investigated borate glasses, activated with Gd^{3+} ions, are very promising materials for sources of UV radiation including solid-state UV lasers with working wavelength 311 nm ($^6P_{7/2} \rightarrow {}^8S_{7/2}$ channel).

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