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Enhanced near-infrared luminescence at 1.07 µm of Nd^{3+} doped $PbCl_2$–$Li_2B_4O_7$ glasses for solid state laser and optical fiber amplifier applications

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Abstract

Nd^{3+} doped $PbCl_2$–$Li_2B_4O_7$ glasses have been synthesized using melt quenching technique. XRD spectra reveals the signature of non-crystalline behavior of synthesized glasses. DSC studies reveal glass transition temperature and thermal stability parameter (ΔT) exhibit composition dependent trends and ΔT is as high as 114 °C. UV–Vis spectra contain eleven well-defined absorption peaks with five intense absorption bands centered at 527, 586, 750, 806 and 876 nm which are assigned to transitions from $^4I_{9/2} \rightarrow {}^4G_{7/2}$, [$^4G_{5/2}$,$^2G_{7/2}$], [$^4F_{7/2}$, $^4S_{3/2}$], [$^4F_{5/2}$, $^2H_{9/2}$] and $^4F_{3/2}$ respectively. The maximum absorption cross section 1.139×10−20 cm^2 of 806 nm pump level transition $^4I_{9/2} \rightarrow$ [$^4F_{5/2}$, $^2H_{9/2}$] is comparable with maximum absorption cross section 1.149×10−20 cm^2 of 586 nm hypersensitive transition $^4I_{9/2} \rightarrow$ [$^4G_{5/2}$, $^2G_{7/2}$]. Near infrared emission spectra exhibit very high emission intensity at 1070 nm for $^4F_{3/2} \rightarrow {}^4I_{11/2}$ transition along with two dominant emission bands at 904 and 1340 nm corresponding to $^4F_{3/2} \rightarrow {}^4I_{9/2}$ and $^4F_{3/2} \rightarrow {}^4I_{13/2}$ transitions. This high absorption and emission intensities are attributed to high degree of covalent environment of ligands surrounding Nd^{3+} ions. Bonding parameter, δ increase with Nd_2O_3 content which suggests dominance of covalency between Nd^{3+} ion and ligands. ^{11}B MAS NMR studies reveal that, the addition of Nd_2O_3 to $Li_2B_4O_7$ converts diborate units into chain-like network structures such as charged trigonal borate units which is further supported by FTIR study. Two photon absorption coefficient shows linear relationship with optical band gap energy. Hence Nd^{3+} doped $PbCl_2$–$Li_2B_4O_7$ glasses with superior absorption and emission properties are found to be potential candidates for near-infrared solid state laser and optical fiber amplifier applications.

Keywords:

Thermal stability, Near-infrared luminescence, Metallization, Spectroscopy, ^{11}B MAS NMR,

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