

ABSTRACT:

Co-Doped Lead Bismuth Borate Glass for Enhancement of Solar Cell Efficiency

Muhammad Yasir Ilyasa, *, Maria José V. Bella, Virgílio de C. dos Anjosa

aGrupo de Engenharia e Espectroscopia de Materiais – GE2M,

Departamento de Física – ICE, Universidade Federal de Juiz de Fora - UFJF,

36036-330, Brazil.

*e-mail: myasir.ciit@gmail.com

In this study, lead–bismuth–borate (BBP) glasses co-doped with a fixed concentration of 0.75 mol% Tm^{3+} and varying concentrations of Yb^{3+} were synthesized by the melt-quenching technique to investigate their potential as spectral-conversion materials for next-generation photovoltaic applications. The structural and optical properties of the prepared glasses were systematically investigated using Raman spectroscopy, UV– visible absorption spectroscopy, FT-MIR spectroscopy, and photoluminescence (PL) measurements. Raman and FT-MIR spectra revealed the characteristic vibrational features of the borate-based glass network and indicated modifications in the local structural environment with increasing Yb^{3+} concentration. The UV– visible spectra exhibited characteristic absorption bands associated with Tm^{3+} ions, confirming their incorporation into the BBP host and providing an excitation pathway under 463 nm radiation. Under 463 nm excitation, the PL spectra exhibited pronounced near-infrared emission in the ~980–1050 nm region, with the dominant emission around ~980 nm assigned to the $2F\ 5/2 \rightarrow 2F\ 7/2$ transition of Yb^{3+} . The observation of Yb^{3+} -associated NIR emission under Tm^{3+} -selective excitation suggests Tm^{3+} -mediated sensitization of Yb^{3+} and efficient spectral down-shifting from the blue region toward the near-infrared. The NIR emission exhibits a strong dependence on Yb^{3+} concentration, indicating an optimum dopant concentration for maximizing the spectral-conversion response, while the reduction at higher Yb^{3+} content suggests the onset of concentration-quenching effects. The pronounced NIR luminescence and concentration-dependent optical response demonstrate the potential of these $\text{Tm}^{3+}/\text{Yb}^{3+}$ -codoped BBP glasses as rare-earth-based spectral- conversion layers for improved utilization and spectral management of solar radiation in next-generation photovoltaic devices.

Keywords: Lead, bismuth, borate glass, up- conversion, ytterbium, and thulium ions.

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