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Photoluminescence properties of Nd3+ activated novel CdO-ZnO-V2O5-B2O3 glasses for NIR laser applications

There is a growing interest in the search for inverted glasses [1], which exhibit a low density of high-energy phonons. Due to the high energy phonons are the main source of non-radiative relaxations of lanthanide ions embedded in glasses, inverted glasses might show superior photoluminescence performance. Based on this issue, the present work aims to prepare and analyze the photoluminescence properties of inverted CdO-ZnO-V2O5-B2O3 glasses activated with Nd3+ ions. The glasses were prepared by melt-quenching method at 1200 ℃ for one hour. The glass host composition was 80, 5.0, 2.5, and 12.5 mol% of CdO, V2O5, ZnO, and B2O3, whereas the Nd3+ doping content was changed from 0.0 to 4.0 mol% regarding the host composition. The emission spectra under Nd3+ excitation at 808 nm displayed the Nd3+ emission bands at 880, 1060, and 1332 nm, associated with the 4F3/2 ⟶ 4I9/2, 11/2, 13/2 transitions, respectively, being that at 1060 nm the most suitable for NIR laser applications. The optimum emission was attained at 2.8 mol% of Nd3+. Beyond this concentration, the emission is quenched, as a consequence of cross-relaxation among Nd ions, dominated by an electric dipole-dipole interaction. The Judd-Ofelt (JO) theory was applied to the optimum emitting sample to evaluate laser parameters. The JO Ωi=2,4,6 parameters resulted to be Ω2 = 5.31×10-20, Ω4 = 2.81×10-20 and Ω6 =3.34×10-20 cm2, which lead to stimulated cross-section peak (σp) values of σp= 1.21×10-21 cm2(4F3/2 ⟶ 4I9/2) and σp= 3.50×10-20 cm2(4F3/2 ⟶ 4I11/2). The calculated quantum yield was 0.49. The Bandwidth (σem×Δλem) and optical gain (σem×τR), calculated from the 4F3/2 ⟶ 4I11/2 emission cross-section peak, resulted to be 165×10-27 cm3 and 37×10-25 cm2s. Such values were better than some reported in phosphate and borate-based glasses.

Keywords

Inverted glasses, NIR laser applications, Judd-Ofelt theory

Reference

[1] Ahmed H.Hammad, Essam B.Moustafa, Ahmed R. Wassel, Emphasis of some physicaland dynamical properties of inverted barium phosphate base glass, J. Mater. Res. Tech. 15 (2021) 4813. https://doi.org/10.1016/j.jmrt.2021.10.113

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