Optical studies on Tb3+: Dy3+ singly and doubly doped borosilicate glasses for white light and solid state lighting applications

ABSTRACT

Host (H), Singly and co-doped Dy3+/Tb3+ ions borosilicate glasses (S1-S7) were fabricated by a traditional melt-quenching-annealing method to investigate their luminescence properties as well as their suitability for the development of SSL (solid-state lighting) and W-LEDs (white light-emitting diodes). The X-ray diffraction profile indicates the amorphous structure nature of the prepared glasses. The J-O (Judd-Ofelt) intensity parameters Ωt(t=2,4,6) are evaluated for both singly Dy3+, Tb3+ doped glasses according to their absorption spectrum. The Ω2 parameter of Dy3+ ion has higher value which indicates a higher degree of Dy3+ covalency and the neighbour ligands while Tb3+ ion in a lower degree of covalency where its Ω2 has low value. Also the radiative parameters for both singly doped ions (S1 and S2) are computed like probability of transition (AT), branching ratio (βr) and radiative lifetime (τr) for different bands. Further, both singly doped glasses reflects good properties for lasing application where the 4F9/2 manifold of S1 (0.5 mol% Dy3+) has radiative lifetime (τr) value of 1376 μs and higher value of (AT:447.02 s−1) in addition to branching ration of (βr:61.5%) for the (4F9/2→9H13/2) transition (576 nm). At the same time, S2 (0.5 mol% Tb3+) glass show a higher lifetime (τr:3753) for 5D4 level and (AT: 92.94 s−1) while the branching ratio for 5D4→7F5 band at 546 nm wavelength is (βr: 34.9%). The radiative emission properties were investigated according to the Tb3+ concentration increments. The mutual energy transfer (ET) occurrence between both ions (Dy3+, Tb3+) is demonstrated through the varying of their emission intensities. Furthermore, The chromaticity (x,y) color coordinates were evaluated according to the emission spectra of aforementioned glasses under excitation of 368 nm and 348 nm were found to be located in the white light color region of the CIE chromaticity color diagram. Also, from color-coordinated the color correlated temperature (CCT) is computed were found to be at high values (>4000). Thus, the fabricated glasses are suggested as a useful luminescence material for solid-state lightening as well as cool white light applications.

Keyword: Borosilicate glass; Optical absorption; Radiative properties; Judd–Ofelt analysis; Luminescence; Energy transfer; W-LEDs