08,09,12

Structure Analysis, Photoluminescence, and Non-linear/Linear Optical Parameters of $Li_2Ge_4O_9:Mn^{4+}$ Transparent Glass-Ceramic

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Received: January 18, 2022
Revised: January 26, 2022
Accepted: January 27, 2022

In this study, $Li_2Ge_4O_9:Mn^{4+}$ transparent glass-ceramic was prepared by conventional melt-quenching. The thermal treatment was used for the devitrification of the sample. The creation of a $Li_2Ge_4O_9$ nanocrystalline precipitated through the glass matrix was verified by X-ray diffraction and HR-TEM. Electron paramagnetic resonance spectra were employed to confirm the oxidation of Mn^{2+} to Mn^{4+} in glass-ceramic after thermal treatment. The photoluminescence spectra displayed a narrow red band centered at 668 nm ascribed to the spin-forbidden $^4E_g \rightarrow {}^4A_{2g}$ transition of Mn^{4+}. To estimate the optical parameters, UV-Vis-IR absorption spectroscopies were measured. The red shift of the direct optical band gap E_g^{opt}, from 3.81 to 2.55 eV, was observed by increasing the Mn^{4+} concentration. The dispersion parameters, refraction indices (n, n_∞), and oscillator wavelength (λ_0) were examined by using Wemple–DiDomenico single-oscillator model. The relationship between the refractive index and the energy gap has been investigated using various models such as Moss, Hervé–Vandamme, Ravindra, and Singh–Kumar. In addition, the linear and non-linear optical properties of $Li_2Ge_4O_9:Mn^{4+}$ were mentioned. The temperature-dependent luminescence intensity measurement was also carried out. The method of preparation exposed herein for the synthesis of Mn^{4+}-doped GCs might be prevailing to produce identical luminescent ceramics in accordance with the glass's devitrification.

Keywords: glass-ceramics, photoluminescence, optical properties, non-linear/linear optical, dispersion parameters, energy gap