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EXPERIMENTAL OPTIMIZATION, DESIGN SYNTHESIS, AND UP-CONVERSION LUMINESCENCE PROPERTIES OF Y_4GeO_8: Er^{3+}/Yb^{3+} RED PHOSPHORS †

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The Er^{3+}/Yb^{3+} co-doped Y_4GeO_8 crystal powders were successfully synthesized using a high-temperature solid-phase method. The crystal structure of the obtained phosphors was confirmed to be pure Y_4GeO_8 through X-ray diffraction (XRD) analysis. A regression equation correlating Er^{3+}/Yb^{3+} doping concentrations with luminescent intensity was established based on the optimized theoretical model derived from experimental design. The optimal concentrations of Er^{3+} and Yb^{3+} under 980 nm laser excitation were determined as 7.41% and 21.34%, respectively, while under 1550 nm laser excitation, the concentrations were 2.66% and 17.42%, respectively. The fluorescence emission spectra of the up-conversion samples were measured, revealing intense green and red emissions with peaks at 542, 546, and 654 nm under 980 nm excitation, and peaks at 546, 557, and 663 nm under 1550 nm excitation. These peaks correspond to transitions from $^2H_{11/2}$ to $^4I_{15/2}$, $^4S_{3/2}$ to $^4I_{15/2}$, and $^4F_{9/2}$ to $^4I_{15/2}$ energy levels. The relationship between up-conversion luminescence and laser operating current for the optimal samples under 980 nm and 1550 nm was investigated, uncovering that up-conversion luminescence occurs through both two-photon and three-photon processes. A detailed analysis and discussion of the up-conversion luminescence mechanisms were conducted. Furthermore, the relationship between up-conversion fluorescence and temperature for the optimal samples was studied, revealing excellent temperature-sensing characteristics under 980 nm and 1550 nm laser excitations. The calculated illumination region coordinates for the optimal samples under 980 nm and 1550 nm wavelength excitations were (0.5558, 0.4362) and (0.5256, 0.4687), respectively. The research highlights the potential of rare-earth ion-doped up-conversion luminescent materials for diverse anti-counterfeiting applications. In particular, the Y_4GeO_8: Yb^{3+}/Er^{3+} phosphors, incorporating a dual-excitation mechanism, enhance the security of anti-counterfeiting strategies in multifaceted scenarios. The study underscores the promising developments in this field.

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