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Optical and photoluminescence properties of trivalent rare earth ions doped $LiMgPO_4$

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Abstract

Trivalent rare-earth-activated luminescent materials have attracted a lot of attention due to their fascinating optical properties and broad range of applications. In this study, polycrystalline Sm and Eu-doped $LiMgPO_4$ luminescent materials were synthesized using a solid-state reaction technique. The crystalline structures, morphological features, and optical characteristics of the synthesized materials were thoroughly investigated using x-ray diffraction (XRD), Fourier Transform Infrared Spectroscopy (FTIR), Field-Emission Scanning Electron Microscopy (FE-SEM) and UV–vis spectroscopy. The Rietveld refinement analysis confirmed the phase purity of synthesized phosphors. In addition, the strain induced owing to the incorporation of trivalent rare-earth ions and crystallite sizes of each synthesized material was estimated using the Williamsons-Hall (W-H) and modified Debye-Sherrer equations. The estimated results of the microstrain were reported to be 0.0010, 0.0023 and 0.0020. Subsequently, as a consequence of distinct peak profile options, the projected average crystallite size by both approaches was distinct. The UV–vis spectroscopy analysis reveals that Sm and Eu doped materials exhibit absorption bands around 402 nm and 396 nm and depicts the declining band gap values. The Photoluminescence (PL) spectra at 402 nm and 395 nm excitation wavelengths exhibited the distinctive emissions of both Sm^{3+} ($^4G_{5/2} \rightarrow {}^6H_{7/2}$) and Eu^{3+} ($^5D_0 \rightarrow {}^7F_2$) ions emanating due to the intra-configurational f - f and 4 f − 4 f transitions. Finally, the CIE diagram explicitly demonstrates that the Sm and Eu-modified materials reveal their exceptional color purity. McCamy's approach was used to determine various parameters of trivalent rare-earth doped materials. The correlated color temperature (T_{CCT}) and their coordinates T_{CCT} (ζ, β) was found to be 2287 K, 1900 K, 0.281, 0.632, and 0.302, 0.681 respectively. Temperature-dependent emission spectra exhibit excellent color and thermal stability at high temperatures. The obtained results in this study indicate that the synthesized luminescent materials can potentially be used in white light-emitting diode applications.

1. Introduction

The digital realm faces significant energy constraints owing to advancements in technology and the inefficient use of energy resources. This presents an opportunity for the development and examination of efficient energy-saving devices [1, 2]. Due to the variety of their applications in developing domains including solid-state lighting, persistent luminescence, dosimetry, up-down conversion fluorescence and medicine, the desire for novel light-emitting materials has increased. Luminescent materials have the designation inorganic phosphors and they are made up of an activator and a host with distinct crystal structures. A growing number of rare-earth ions doped by inorganic phosphors are utilized as luminescence carriers towards white-light-emitting diodes (W-LEDs) due to their outstanding stability as well as their significant function in the production of highly sensitive thermoluminescence