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Title of the thesis: *Study of ZnO nanocomposites as a luminescent material for optoelectronic applications*

Abstract

Due to the growing demands and increased costs, there is a significant focus on energy conservation and solid-state lighting devices, particularly light emitting diodes (LEDs). Zinc oxide is a low-cost environmentally friendly phosphor with good chemical and thermal stability and with exciton binding energy of 60 meV. It has been widely used in the nanostructure as well as thin film forms for photonic and optical applications due to these unique properties and has allured interest for phosphor-converted (pc)-LEDs due to their broad and strong absorption in the near UV region. Also, due to various intrinsic defects, it has wide emission spectrum. It is feasible to tune the emission colour due to change in the intensities of blue, green and orange emission by controlling the concentrations of various defects in ZnO. To achieve superior performance, improved properties, high luminance, and desirable chemical stability while managing costs, it is crucial to explore alternative red and green-emitting phosphor and oxides-based nanocomposite systems suitable for W-LEDs. This thesis explores various strategies aimed at enhancing the color rendering index (CRI), color correlated temperature (CCT), and color purity of ZnO based nanocomposites that can be employed as a phosphor for W-LEDs. The effectiveness of these measures in improving the CRI, CCT and non-toxic and energy-efficient materials for solid-state lighting is discussed. Moreover, this research provides valuable insights into the practical application of luminescent materials in everyday life, benefiting both researchers and industries working in the field of solid-state lighting.

We have synthesized ternary nanocomposites of NiO/ZnO/Fe_2O_3 with various molar ratios, namely (1:1:1), (2:1:1), (3:1:1), and (4:1:1) by co-precipitation method. This study explores how the morphological, structural, optical, and photoluminescence properties of NiO/ZnO/Fe_2O_3 ternary nanocomposites are affected by increasing the concentration of nickel. Remarkably, all the ternary nanocomposites synthesized exhibit white light emission. The significance of this study lies in the fact that the NiO/ZnO/Fe2O3 nanocomposites exhibit exceptional suitability as phosphors for solid-state white light sources. The introduction of graphene into ZnO displayed a blue emission, unlike ZnO, owing to the emergence of various defect states. The ZnO-graphene nanocomposite exhibited a robust blue emission and a relatively high color rendering index (CRI) of 87, setting a noteworthy achievement for a single system employing ZnO-graphene phosphor. Consequently, it establishes the nanocomposite as a highly suitable candidate as blue phosphor. We have successfully investigated the structural, thermal behavior, morphology, and optical characteristics of ZnO, ZnO/Ag_2O, ZnO/MnO_2, and ZnO/Ag_2O/MnO_2 nanomaterials. By combining ZnO with Ag_2O and MnO_2, we demonstrate that the resulting nanocomposites exhibit exceptional tunability in luminosity, as evidenced by their photoluminescence properties. The estimated Commission Internationale de l'Eclairage (CIE) color coordinates indicate that ZnO, originally a blue phosphor, can be adjusted to emit orange-red light (ZnO/Ag_2O and ZnO/MnO_2), and when combined with Ag_2O and MnO_2, can emit white light (ZnO/Ag_2O/MnO_2), while maintaining a reasonably high color rendering index (CRI) of 84. These nanocomposites (ZnO/Ag_2O, ZnO/MnO_2, and ZnO/Ag_2O/MnO_2) possess great potential for application as phosphor materials in warm white LED lighting due to their high purity, robust stability, and adjustable emission colors. Our findings establish a novel phosphors exhibiting tunable luminescent colors for solid-state lighting applications. Also, in this study we have explored the structural and optical properties of ZnO/CQDs nanocomposite. This material exhibits a vibrant emission in the yellow-orange range, characterized by chromaticity coordinates of (0.51, 0.47) and a remarkable color purity (CP) value of 94.3%. The colorimetric properties reveals that the work introduces an exciting opportunity for utilizing the as-produced nanocomposite as phosphor, thus paving the way for its potential application in future lighting and display technologies.

Keywords: Nanocomposites, ZnO, Photoluminescence, phosphors, white LEDs.