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Research Article

High sensitivity transparent glass ceramic systems development based on $MgSO_4$:Dy_2O_3–B_2O_3 and $MgSO_4$:Dy_2O_3–B_2O_3:ZnO:An investigation of FT-IR and thermal properties for thermoluminescence dosimeter applications

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ABSTRACT

The demand for highly sensitive radiation dosimeters is increasing. Recent research underscores the effectiveness of $MgSO_4$:Dy_2O_3–B_2O_3 and $MgSO_4$:Dy_2O_3–B_2O_3:ZnO as new thermoluminescence dosimeters (TLDs) in comparison to the commercial TLD-100. Two series of glass ceramics, $[(MgSO_4)_{86}(Dy_2O_3)_{14}]_x[B_2O_3]_{1-x}$ with x = 0.1, 0.2, 0.3, 0.4, 0.5 and $[MgSO_4\text{-}Dy_2O_3\text{–}B_2O_3]_{0.2}[ZnO]_x$ with x = 0.05, 0.1, 0.15, 0.2, were successfully prepared using the melt quenching technique. The synthesized samples were characterized using X-ray diffraction (XRD), Fourier-transform infrared spectroscopy (FTIR), field emission scanning electron microscopy (FE-SEM), and differential thermal analysis (DTA). The XRD pattern confirmed the transparent ceramic nature of the samples, while DTA revealed their thermal stability. FTIR analysis identified the expected composition and vibrational bonds. Upon irradiation, the samples MSDB0.2 and MSDBZ0.05 exhibited the highest sensitivity and dose response, with TLD readings of 1278.84 nC and 3262.63 nC, respectively, compared to the TLD-100 reading of 213.45 nC. This enhanced sensitivity is attributed to $MgSO_4$:Dy_2O_3 and ZnO, which facilitate charge carrier movement and effective trapping and release of charges in borate glass ceramics. The increase in sensitivity indicates improved accuracy, highlighting the potential of these materials as high performance radiation dosimeters for environmental and medical applications.

1. Introduction

Ionizing radiation can have various biological consequences, including chromosomal abnormalities, carcinogenesis, mutations, and cell death. Common exposure scenarios include space flight, nuclear work environments, and medical diagnostics or therapies. Monitoring dosages with accurate, high performing equipment and robust analytical techniques is crucial to mitigating overexposure. One of the significant

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