Área: Química de Materiais (MAT)

Persistent luminescence in doped Lu_2O_2S materials: structural analysis and optical investigation

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Highlights

- Doped lutetium oxysulfides are versatile and highly efficient phosphors, with great thermal and chemical stability, and also of easy color tunability.

- Applications of Lu_2O_2S-based materials include X-rays scintillator screens, field emission displays, and advances in medical and industrial areas.

- The effect of doping on the structure and optical behavior of Lu_2O_2S materials was investigated through X-ray diffraction and spectroscopic techniques.

Resumo/Abstract

Rare earth oxysulfides (RE_2O_2S, RE^{3+}: Y, La, Gd, Lu) are suitable matrices for luminescent materials, which is due to their high thermal and chemical stability, low cost, and suitable sensitization of trivalent lanthanide ions, resulting in high luminescent efficiency [1]. Lutetium oxysulfide (Lu_2O_2S) has been widely investigated as the host material for three-dimensional plasma display panels, field emission displays and light-emitting diodes [2]. $Lu_2O_2S:Eu^{3+}$ is a persistent luminescent material in which Eu^{3+} efficiently emits red light, while $Lu_2O_2S:Ti^{3+/4+}$ presents a wide band in the orange region, related to titanium. The duration of these emissions after the irradiation removal can be increased by the insertion of Mg^{2+}, with the purpose of creating charge compensation defects and allowing energy storage in trap levels.

In this work, crystalline structure, optical absorptions, and persistent luminescence behavior of Lu_2O_2S, $Lu_2O_2S:Eu^{3+}$, $Lu_2O_2S:Ti^{3+/4+}$ and $Lu_2O_2S:Mg^{2+}$ were investigated. The effect of co-doping was also studied in $Lu_2O_2S:Eu^{3+},Ti^{3+/4+}$, $Lu_2O_2S:Eu^{3+},Mg^{2+}$, $Lu_2O_2S:Ti^{3+/4+},Mg^{2+}$ and $Lu_2O_2S:Eu^{3+},Ti^{3+/4+},Mg^{2+}$ materials.

Lu_2O_2S materials were obtained by a rapid and energy-saving microwave-assisted solid-state synthesis. Phase purity and crystal parameters were obtained through X-ray diffraction (XRD) with Rietveld refinements. The incorporation of Eu^{3+}, $Ti^{3+/4+}$ and Mg^{2+} ions in Lu_2O_2S host was evaluated, along with structural changes.

Optical absorptions were measured through diffuse reflectance spectroscopy (DRS), which also enabled the calculation of Lu_2O_2S band gap energy with Kubelka-Munk theory. Eu^{3+} 4f-4f transitions and ligand-to-metal charge transfer (LMCT) transitions were observed in the 200-700 nm region of the spectra. The presence of $O^{2-}/S^{2-} \rightarrow Eu^{3+}$ and/or $O^{2-}/S^{2-} \rightarrow Ti^{3+/4+}$ bands proved to be correlated with luminescence mechanism in these materials.

Photoluminescence spectroscopy studies and persistent luminescence measurements demonstrated the effect of the incorporation of activator ions (Eu^{3+} and/or $Ti^{3+/4+}$), as well as an optically inactive co-dopant (Mg^{2+}), into Lu_2O_2S structure. Emissions in the visible region, excited by UV or X-ray irradiation, and the high storage capability of these materials provide several applications in dosimetry, bioimaging and optoelectronic devices [1,2].

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