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Photoluminescent study of Y_2O_3: Eu^{3+} powder prepared by Microwave-Hydrothermal Method

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Abstract – Yttrium oxide doped with europium (Y_2O_3:Eu^{3+}) was prepared via microwave-hydrothermal route. X-ray diffraction (XRD), field emission scanning electron microscopy (FE-SEM) and photoluminescence study (PL) were used to characterize the crystalline, morphology and luminescence properties of the Y_2O_3:Eu^{3+} products. Pure cubic Y_2O_3:Eu^{3+} phase was formed after heat treatment in air at 500^0 C for 2h. The photoluminescence (PL) properties of Y_2O_3:Eu^{3+} were evaluated and the Eu^{3+} emissions were observed at 580, 591, 610, 651 and 695 nm under the excitation of 396 nm.

Y_2O_3:Eu^{3+} nanoparticles are one of the most promising oxide-based red phosphors systems due to its excellent luminescence efficiency, color purity, and stability. In the preparation of Y_2O_3:Eu^{3+} phosphors, many different techniques have been reported such as spray pyrolysis, chemical vapor deposition and sol–gel[1,2]. In this work, a domestic hydrothermal microwave was used in the preparation of the Y_2O_3:Eu^{3+}. A complex of polyethylene glycol (PEG), yttrium nitrate ($Y(NO_3)_3$), 1,0% of Eu_3O_2 and sodium hydroxide solution (NaOH (5 M)) was firstly crystallized in the domestic hydrothermal microwave system, and the reaction was maintained at 140°C for 40 and 80 minutes, respectively. Then, the obtained precursors were heat treated in air at 500°C for 2 h, giving rise to the Y_2O_3:Eu^{3+} powders. These materials were characterized by X-ray diffraction (XRD), field emission scanning electron microscopy (FE-SEM) and room temperature photoluminescence spectra (PL) before and after heat treatment. The luminescent properties of the Eu^{3+} ion in the Y_2O_3:Eu^{3+} materials before and after the heat treatments have been studied to get informations about the environment around this ion during the synthesis and the sintering processes. The XRD results of the samples hydrothermalized at 140°C for 40 min and heat treated at 500°C for 2 h are presented at Fig. 1 (a) and (b), respectively. The diffraction peaks corresponds to a pure cubic phase of Y_2O_3:Eu^{3+}. However, the hydrothermalized precursors without any heat treatment did not present a crystalline phase. The emission spectra of the hydrothermalized precursors and sintered samples presented at Fig. 2 show the Eu^{3+} $^5D_0 \rightarrow {}^7F_J$ (J= 0,1,2,3,4) characteristic bands at, respectively 580, 591, 610, 651, and 695 nm, under the excitation of 396 nm. It was observed that the sintering process promotes a modification in the PL emission and excitation spectra of the Eu^{3+} ion, indicating a changing in the Eu^{3+} surrounding in the Y_2O_3 matrix. The excitation spectra of the precursors samples show the most intense peak ascribed to the Eu^{3+} $^7F_0 \rightarrow {}^5L_6$ transition at 396 nm. In the heat treated samples excitation spectra it was noticed an additional broad band at around 330 nm, which probably is associated to energy transfer process from the matrix to the Eu^{3+} ion.

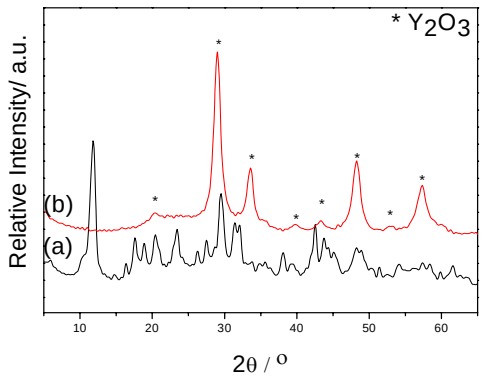

Figure 1: DRX analysis of the Y_2O_3:Eu^{3+} powders **a)** hydrothermalized for 40 min. **b)** Hydrothermalized and heat treated at 500^oC for 2 h.

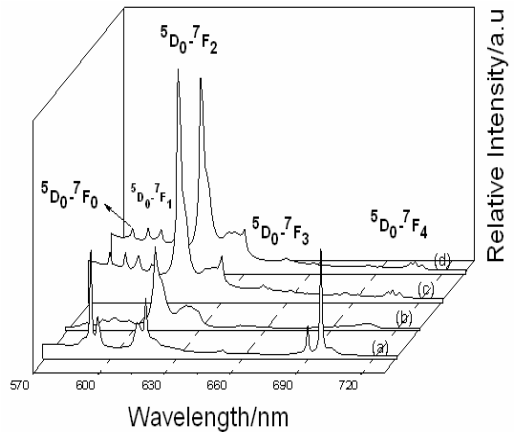

Figure 2: Emission spectra of the Y_2O_3:Eu^{3+} phosphor hydrothermalized for (a) 40 min and (b) 80 min. Hydrothermalized and heat treated at 500^oC for (c) 40min and (d) 80 min. λ_{exc}=396 nm

References

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