Low Temperature Synthesis of $R_2O_3:Eu^{3+}$ (R: Y, Gd and Lu) Nanophosphor Using Trimellitic Acid Precursors

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Summary

The rare earth (R) complexes with the 1,2,4-benzenetricarboxylic acid (TLA) which present favorable thermal decomposition to prepare oxides at low temperatures were synthesized as reported previously [1]. The luminescent $R_2O_3:Eu^{3+}$ nanophosphors were obtained by annealing the complexes at 500, 600, 700, 800, 900 and 1000 °C.

Keywords

Luminescence, Rare Earths, Europium, Benzenetricarboxylate, Nanophosphor

Introduction

With improvements made lately in the nanoscience and nanotechnology, the photonic, structural and morphological properties of the $R_2O_3:Eu^{3+}$ nanomaterials (R: Y, Gd and Lu) have been widely investigated [2]. These phosphors have been prepared with various methods, *e.g.* hydrothermal, sol-gel, spray pyrolysis, combustion, chemical vapor deposition, thermolysis and coprecipitation. In the thermolysis route, it may be advantageous to use the RTLA complexes (TLA: 1,2,4-benzenetricarboxylate) as precursors to produce the cubic R_2O_3 materials. The one-step ligand decomposition starts at low temperature (below 430 °C), producing the sesquioxides with isothermal heating already at 500 °C [1]. In this work, the preparation, characterization and luminescence properties of selected $R_2O_3:Eu^{3+}$ nanomaterials are reported.

Materials, Results and Discussion

The thermal decomposition of the RTLA:Eu^{3+} complexes (R: Y, Gd and Lu; Eu^{3+} doping concentration: 0.1, 0.5, 1 and 5 mole-%) was studied by TG-DTG in air between 30 and 900 °C. The organic moiety of these complexes decomposes in a single-step from 430 to 580 °C, allowing the formation of R_2O_3 with isothermal annealing for 10 or 1 h at 500 or 600–1000 °C, respectively. The decomposition temperature decreases for all complexes with increasing Eu^{3+} concentration.

The X-ray powder diffraction patterns confirmed the formation of the cubic R_2O_3 phase, as a result of the total decomposition of the organic phase during annealing. Both the crystallinity and the crystallite sizes calculated by the Scherrer's equation of the $R_2O_3:Eu^{3+}$ phosphors increased with increasing annealing temperature between 500 and 1000 °C (Figs. 1 and 2).

The luminescent properties were investigated by the excitation and emission spectra as well as lifetime measurements of the $^5D_0$ emitting level of Eu^{3+}. The number of lines for the $^5D_0 \rightarrow {}^7F_1$ transition indicates the presence of Eu^{3+} in two sites (C_2 and S_6). The intense hypersensitive $^5D_0 \rightarrow {}^7F_2$ transition due to the non-centrosymmetric C_2 site was observed, too.

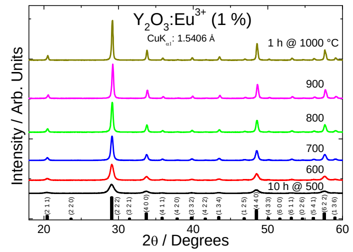

Figure 1: XRD of $Y_2O_3:Eu^{3+}$ (1 %) annealed at different temperatures.

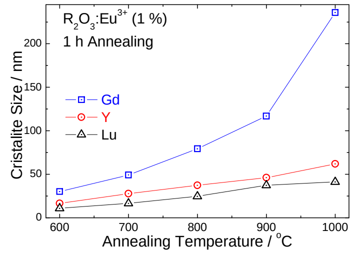

Figure 2: The crystallite size of $R_2O_3:Eu^{3+}$ (1 %) at different annealing temperatures.

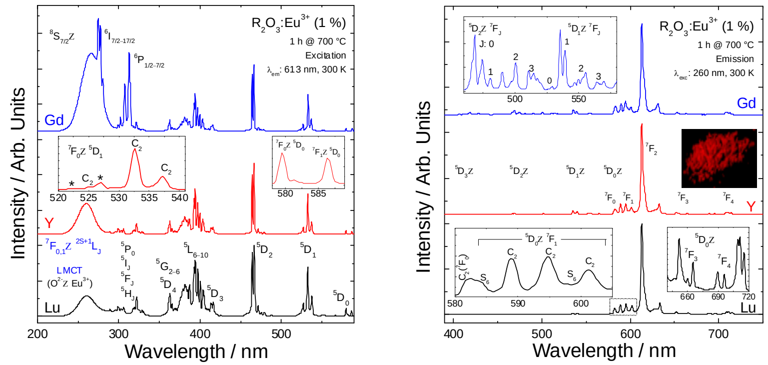

Figure 3. Excitation and emission spectra of $R_2O_3:Eu^{3+}$ (1 %) annealed at 700 °C.

Conclusions

The RTMA complexes proved to be suitable precursors for the low temperature thermolysis preparation route of high purity nanophosphors, the products yielding strong luminescence arising from the cubic phase $R_2O_3:Eu^{3+}$ sesquioxides.

References

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