

RAPID MICROWAVE PREPARATION OF Ti³⁺ DOPED Lu₂O₃ PERSISTENT LUMINESCENCE MATERIALS

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Highlights

Non-rare earth persistent luminescence materials based on Ti³⁺ were prepared by fast, energy saving microwave method.

Abstract

Fluctuation in the price of rare earth oxides as well as challenging purification of these elements can be an issue in the research, manufacture and application of some strategically important materials. The most important and commercially available luminescence materials are based on the rare earths, e.g. Y₃Al₅O₁₂:Ce³⁺, SrAl₂O₄:Eu²⁺;Dy³⁺. Thus, novel non-rare earth doped materials are needed as alternative phosphors. The most common non-rare earth doped materials cited in the literature use Ti³⁺, Mn²⁺ and Cr³⁺ as activators.

The rapid microwave preparation [1] of the Ti doped Lu₂O₃ yields a very crystalline and phase pure material (Fig.; left) in about 20 minutes with power between 800-920 W. The Rietveld refinements show that the formed material is a solid solution of cubic Lu_{2-x-y}Ti_xMg_yO₃ (x: 0.002 - 0.030; y: 0.00 - 0.09) (space group: Ia $\bar{3}$) and no phase segregation was observed. According to the Rietveld refinements, Ti is substituting for Lu³⁺ in both the C₂ and S₆ sites. The valence of Ti is more likely to be three due to the reducing atmosphere generated by heating carbon inside the synthesis crucible. Furthermore, Ti³⁺ allows electroneutrality and the ionic radius is suitable according to Vegard's law. The Ti^{IV} presence in Lu₂O₃ materials cannot be ruled out specially with high Mg²⁺ amounts, however.

The intense broad emission band centred at 19300 cm⁻¹ (518 nm) is attributed to the 3d-3d transition of Ti³⁺ (Fig.; top right). The band is composed of three Gaussians as showed by deconvolution, and it is probably due to the emission of Ti³⁺ in different sites. Persistent luminescence is slightly blue-shifted from 19300 to 21000 cm⁻¹ (476 nm) and mainly composed of the bands at 20500 (487) and 24000 cm⁻¹ (416 nm). The material shows persistent luminescence even for hours after ceasing the excitation (Fig.; right, inset). Thermoluminescence and isothermal decay curves will be discussed as well as the mechanism of persistent luminescence.

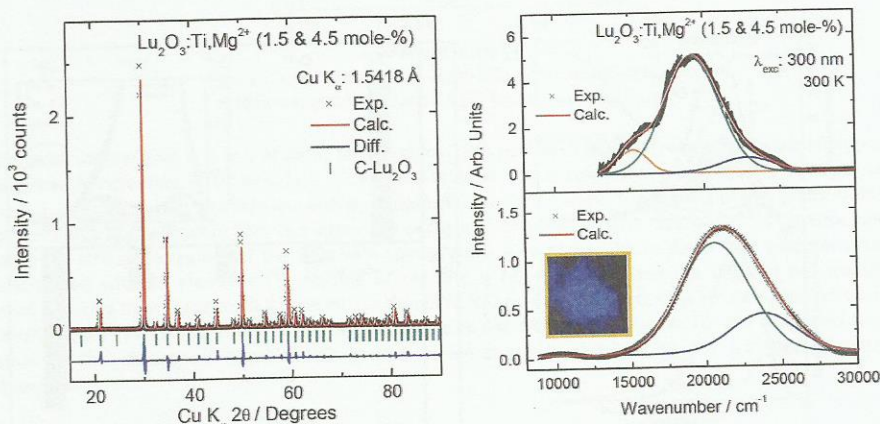


Figure. XPD pattern of Lu₂O₃:Ti,Mg²⁺ material including Rietveld refinement (left). Emission spectrum including fitting (top right) and persistent luminescence spectra after 30 s delay (bottom right). Material emitting after 1 h ceasing excitation (inset).

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References

- [1] K. J. Rao, B. Vaidyanathan, M. Ganguli, P. A. Ramakrishnan *Chem. Mater.* 11 (1999) 882-895.