

CdSiO₃:R³⁺ Persistent Luminescence Materials

Hermi F. Brito¹, Jorma Hölsä^{1,3}, Mika Lastusaari^{2,3}, Maria C.F.C. Felinto⁴, José M. Carvalho¹,
Lucas C.V. Rodrigues^{1,2}

¹Instituto de Química, Universidade de São Paulo, São Paulo-SP, Brazil

²Department of Chemistry, University of Turku, FI-20014 Turku, Finland

³Turku University Centre for Materials and Surfaces (MatSurf), Turku, Finland

⁴Centro de Química e Meio Ambiente, Instituto de Pesquisas Energéticas e Nucleares,
São Paulo-SP, Brazil

*lucascvr@iq.usp.br

Summary

The persistent luminescence CdSiO₃:R³⁺ materials were prepared with a solid state reaction at 950 °C. The positions of the ground state of R^{2+/3+} were determined based on spectroscopic studies. The materials presented different persistent luminescence colors depending on the R³⁺ dopant. Eventually, the persistent luminescence mechanisms for these systems were constructed.

Keywords

Persistent luminescence, mechanism, cadmium metasilicate, trivalent rare earths

Introduction

Persistent luminescence materials have lately received special attention due to their versatile applications in emergency signalization, micro defect sensing, and optoelectronics for image storage; as detectors of high energy radiation and pressure/temperature sensors. A detailed study of the mechanisms for the persistent luminescence phenomenon is required to develop new efficient photonic materials. In the last two decades, the mechanisms for the Eu²⁺ persistent luminescence phenomenon have attracted the main attention [1,2]. Only scarce studies have been reported on the mechanisms of the persistent luminescence of phosphors *e.g.* containing dopants as Ti³⁺, Mn²⁺, Ce³⁺, Eu³⁺ or Tb³⁺ [3-5]. The study of the optical properties of these luminescent materials containing different dopants is expected to contribute significantly to the understanding of the persistent luminescence mechanisms. In this work, the persistent luminescence of the CdSiO₃:R³⁺ materials is studied.

Materials, Results and Discussion

The CdSiO₃:R³⁺ materials were prepared in air with a solid state reaction at 950 °C with the R³⁺ concentrations of 0.1 and 1 mole-% of the Cd amount. The X-ray powder diffraction confirmed the presence of the metasilicate phase without orthosilicate impurities.

Based on the 4f→4f, 4f→5d and ligand-to-metal charge-transfer transitions [6], the positions of the ground states of the R²⁺ and R³⁺ ions were determined in the CdSiO₃ host band structure (Fig. 1). The ground level of Eu²⁺ is very close to the conduction band (CB) and, at room temperature, the electron from Eu²⁺ is promoted with thermal energy to CB and leaves Eu³⁺ as the only stable species. Due to the position of the ground and excited levels, the R³⁺ doped

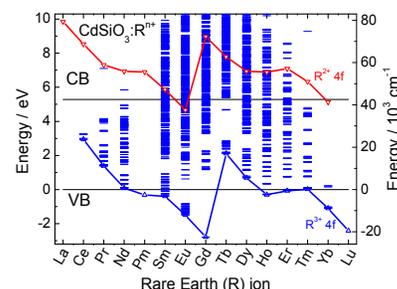
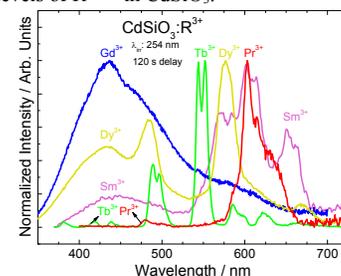


Fig. 1. Location of the 4fⁿ ground and excited levels of R^{2+/3+} in CdSiO₃.



materials can present the 4f-4f persistent luminescence (Tb³⁺, Pr³⁺), defect persistent luminescence (*e.g.* Gd³⁺) or a combination of both (Dy³⁺, Sm³⁺) (Fig. 2, left). One of the advantages of the CdSiO₃:R³⁺ materials is that different emission colors can be obtained with varying the dopant: red (Pr³⁺), green (Tb³⁺), blue (Gd³⁺) or close to white (Dy³⁺) as shown by the CIE diagram (Fig. 2, right).

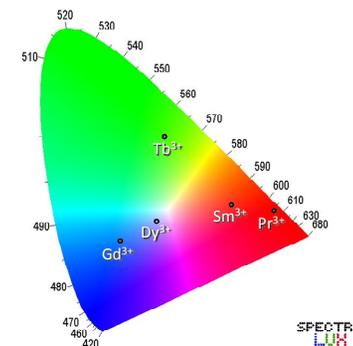


Fig. 2. Persistent luminescence spectra (left) and the CIE colour coordinates of selected R³⁺ doped CdSiO₃ as calculated by the SpectraLux program [7].

Conclusions

Based on the energy level positions, trap depths determined by thermoluminescence and with synchrotron radiation measurements (VUV-UV-vis and XAS spectroscopies), mechanisms of the persistent luminescence from CdSiO₃:R³⁺ was developed. A better understanding of the mechanism may possibly be achieved by simultaneous theoretical DFT studies.

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