

# Designing new NIR persistent luminescence materials: the case of Yb<sup>3+</sup>-doped rare earth oxysulfides

I.P. Machado<sup>1</sup>, J.M. Carvalho<sup>1,2</sup>, C.C.S. Pedrosa<sup>1</sup>, V.C. Teixeira<sup>3</sup>, H.F. Brito<sup>1</sup>,  
L.C.V. Rodrigues<sup>1,\*</sup>

<sup>1</sup>University of São Paulo, Institute of Chemistry, São Paulo-SP, Brazil. <sup>2</sup> University of Turku, Department of Chemistry, Turku FI-20014, Finland. <sup>3</sup> Brazilian Synchrotron Light Laboratory, Brazilian Center for Research in Energy and Materials, SP, Brazil.

\* Corresponding author: [lucascvr@iq.usp.br](mailto:lucascvr@iq.usp.br)

Despite the huge amount of publications about persistent luminescence, there is a lack of materials with emission in the near infrared (NIR) region. NIR persistent luminescence materials can be potentially applied as in vivo nanoprobes [1–3]. Among many activator ions for NIR persistent luminescence, the Yb<sup>3+</sup>-activated materials are good candidates due to their unique 980 nm emission [4].

According to the Vacuum Referenced Binding Energy diagram of lanthanide ions (Ln<sup>2+</sup> and Ln<sup>3+</sup>), the energy of ground levels of trivalent Eu and Yb is similar [5]. We expect that the substitution of Eu<sup>3+</sup> for Yb<sup>3+</sup> ion should not change the persistent luminescence mechanism, creating persistent luminescence material activated by the NIR emission of Yb<sup>3+</sup>. Based on the very efficient Y<sub>2</sub>O<sub>2</sub>S:Yb<sup>3+</sup>,Mg<sup>2+</sup>,Ti<sup>3+/IV</sup> red persistent luminescence materials we designed the R<sub>2</sub>O<sub>2</sub>S:Yb<sup>3+</sup>,Mg<sup>2+</sup>,Ti<sup>3+/IV</sup> phosphors (R<sup>3+</sup>: La, Gd, Y) which presented efficient NIR persistent luminescence.

After irradiation at the O<sup>2-</sup>(2p)→Yb<sup>3+</sup>(4f<sup>13</sup>) and S<sup>2-</sup>(3p)→Yb<sup>3+</sup>(4f<sup>13</sup>) charge transfer bands (310 nm), the R<sub>2</sub>O<sub>2</sub>S:Yb<sup>3+</sup>,Mg<sup>2+</sup>,Ti<sup>3+/IV</sup> materials exhibit NIR photoluminescence arising from the Yb<sup>3+</sup> <sup>2</sup>F<sub>5/2</sub>→<sup>2</sup>F<sub>7/2</sub> transitions. The NIR emission could easily be visualized from fluorescence micrographs essays. When ceasing the irradiation on the materials, both Ti<sup>3+</sup> and Yb<sup>3+</sup> persistent luminescence can be observed, ranging from the red (600) to the NIR (980 nm) region of the spectrum, respectively. The persistent luminescence mechanism of Yb<sup>3+</sup> probably involves a hole trapping process as the proposed to Eu<sup>3+</sup> materials, followed by the hole feeding to the Yb<sup>3+</sup>-e<sup>-</sup> pair. The infrared persistent luminescence involving the Yb<sup>3+</sup> <sup>2</sup>F<sub>5/2</sub>→<sup>2</sup>F<sub>7/2</sub> transition makes this new material suitable for future applications.

Keywords: Infrared, persistent luminescence, Yb<sup>3+</sup>, materials design.

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