Luminescence thermometry using Yb^{3+}/Er^{3+} codoped fluorophosphate glass and glass-ceramics

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In recent decades, glasses with Rare-Earth ions (RE^{3+}) have garnered interest in luminescent thermometry for their unique optical properties, including narrow emission bands, compatibility with various matrices like fluorophosphate, and resistance to degradation. This study focused on the synthesized fluorophosphate glasses with high (5–6 mol%) and low (1–1.5 mol%) concentrations of ytterbium (Yb^{3+}) and erbium (Er^{3+}) to evaluate their upconversion emission behavior at different temperatures.[1]

The synthesized samples exhibited low characteristic temperatures (Tg ~ 350 °C, Tx ~ 450 °C) and high thermal stability (above 100 °C). They showed an electronic absorption edge at very low wavelengths (~ 250 nm) compared to non-doped samples and prominent absorption bands of the Yb^{3+}/Er^{3+} pair in the visible range, particularly the 980 nm band of Yb^{3+} and Er^{3+}. This band acts as a sensitizer, absorbing energy and transferring it to Er^{3+}, the activator, resulting in green (525 and 546 nm) and red (659 nm) emissions via upconversion.

Different ratios of red to green integrated emissions were calculated in all samples suggesting changes in the preferred mechanism of luminescence. Energy Transfer (ET) and Ground State Absorption (GSA) followed by Excited State Absorption (ESA) occur in samples with a higher Yb^{3+}/Er^{3+} ratio, favoring green emissions, while cross-relaxation (CR) favors red emissions in samples with a lower ratio.

The $^2H_{11/2}$ (525 nm) and $^4S_{3/2}$ (546 nm) levels are thermally coupled, with electronic populations varying with temperature according to a Boltzmann distribution.[2] The thermometry model based on the integrated intensity ratio demonstrated the system functioning as a first-order thermometer, with relative sensitivity (0.30% K^{-1}) comparable to literature and absolute sensitivity (0.012 K^{-1}) higher than previously known.

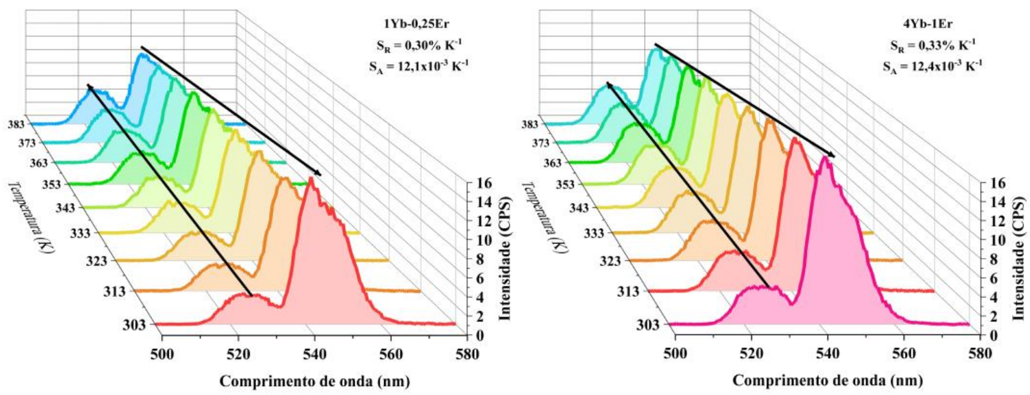

Figure 1. Temperature-dependent emission spectra for samples (a) 1Yb-0.25Er and (b) 4Yb-1Er.

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References:

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[2] D. Manzani, et al. Sci. Rep., vol. 7, p. 41596 (2017).