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High symmetry and unusually long lifetimes in RE^{3+}-doped $Y_2Sn_2O_7$ materials

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Pyrochlore compounds with the general formula $A_2B_2O_7$ have been explored as promising host materials for rare earth (RE^{3+}) ions. These materials crystallize in a pyrochlore structure, where trivalent cations (A^{3+}) and tetravalent cations (B^{4+}) alternate in a Face Centered Cubic (FCC) lattice with vacant anion sites ensuring charge neutrality. Both A^{3+} and B^{4+} ions exhibit D_{3d} symmetry [1]. RE^{3+} can be easily incorporated into this lattice due to their similar ionic radii with A^{3+} cations, assuming the same symmetry. In this sense, a detailed investigation of RE^{3+}-doped $Y_2Sn_2O_7$ (RE^{3+} = Eu^{3+}, Er^{3+} and Yb^{3+}) powder prepared by the coprecipitation method followed by annealing at higher temperatures (700 to 1300 °C) is presented. This work explores the stabilization of the crystalline phase of $Y_2Sn_2O_7$ with changes in annealing temperature, monitoring structural changes through X-ray diffraction and Raman spectroscopy. Additionally, static and dynamic measurements of RE^{3+} luminescence are investigated, elucidating not only the crystalline structure but also the distribution of active ions. X-ray diffraction of the RE^{3+}-doped $Y_2Sn_2O_7$ shows the crystallization of pyrochlore phase, with space group $Fd\bar{3}m$, and cassiterite SnO_2 as a secondary phase. The stabilization of the crystalline phase of interest was confirmed via Rietveld refinement and Raman spectroscopy, indicating higher crystallinity at higher temperatures. The Eu^{3+} emission spectra were obtained under excitation at different wavelength, at the charge transfer (CT) band (~260nm), and at the electronic transitions $^7F_0 \rightarrow {}^5L_6$, (394nm) $^7F_0 \rightarrow {}^5D_2$ (464nm) and $^7F_0 \rightarrow {}^5D_1$ (525nm), where the $^5D_0 \rightarrow {}^7F_J$ (J = 0, 1, 2, 3 and 4) transitions could be observed. These spectra showed the presence of Eu^{3+} ions in a high-symmetry site, confirming their incorporation into the lattice [2]. For these samples, the measured lifetimes values exceeded 5 ms depending on the wavelength. For the samples codoped with Er^{3+} Yb^{3+} ions, the emission spectra were obtained under excitation at 980 nm attributed at the electronic transitions $^4I_{11/2} \rightarrow {}^4I_{15/2}$ of Er^{3+} ions or $^2F_{5/2} \rightarrow {}^2F_{7/2}$ of Yb^{3+}. The lifetime values from the excited state $^4I_{13/2}$ (Er^{3+}) for the samples annealed at 1300°C were higher than 20 ms. Intense upconversion luminescence was observed under 980 nm, affording a yellowish-green emission that can be seen by the naked eyes. The long lifetimes values observed in these samples suggest that these materials are suitable for in time-resolved analysis, including bioimaging techniques [3].

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