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Structural and Luminescent Properties of Samarium Doped $SrSnO_3$ Nanoparticles

Carlos G. Pérez Hernández[2], A. Flores-Pacheco[2], Roberto C. Carrillo Torres[1], Alberto Acevedo Carrera[1], Raúl Sánchez Zeferino[1] and M. Enrique Álvarez Ramos[1]

[1.] Departamento de Física, Universidad de Sonora, Hermosillo, Sonora, México.
[2.] Posgrado en Nanotecnología, Universidad de Sonora, Hermosillo, Sonora, México.

The alkaline earth stannates ($ASnO_3$) have been recently investigated for their potential applications, such as components in lithium ion batteries and high-temperature humidity sensors [1]. Rare earth element doped semiconductors materials and perovskites, such $SrSnO_3$, are of interest for visible and infrared light emitting diodes applications [2]. Among the rare earth elements, samarium (Sm^{3+}) is an element which is often employed as dopant for making orange-emitting phosphors [3]. In this work, we present the synthesis of $SrSnO_3$:Sm^{3+} nanoparticles using a co-precipitation method and investigated their structural properties and photoluminescent characteristics.

In a typical co-precipitation synthesis [4], 55 mL of a 0.02M solution of $SnCl_4•5H_2O$ and 55 mL of a 0.055M solution of $Sr(NO_3)_3•5H_2O$ were prepared in deionized water. 60 mL of hydrogen peroxide was added independently in both solutions. While keeping the $SrNO_3$ solution under constant stirring, 11 ml of ammonium hydroxide were added to this solution. After 30 min, the $SrNO_3$ solution was slowly mixed with $SnCl_4$ solution, acquiring a cloudy yellow appearance. For Sm-doped samples, $Sm(NO_3)_3•6H_2O$ was added in the following molar concentrations (1, 2 and 4 %). Finally, the samples were washed and centrifuged several times alternating between water and ethanol. Obtained precipitates were dried in an oven at 80 °C for 2 h. Samples were sintered at two different temperatures (800 and 1300 °C) during 4 h.

Figure 1a-c) shows FE-SEM images of $SrSnO_3$ spherical nanoparticles annealed at different temperatures. The average particle size is about 20, 65, and 500 nm for samples without annealing, annealed at 800, and 1300 °C, respectively. The $SrSnO_3$ sample annealed at 1300 °C present elongated shapes compared to the other two samples. Sm-doped samples did not show significant changes in the morphology, shape and size respect to the un-doped sample (Fig. 1d). The corresponding Sr, Sn and O maps present a homogenous distribution of these elements (Fig. 2). Structural properties were studied by Raman spectroscopy. Fig. 3 presents the Raman spectra of Sm (4%)-doped $SnSnO_3$ nanoparticles annealed at different temperatures. For sample without annealing, Raman peaks can be observed at 147 and 179 cm^{-1} assigned to A_g vibrational mode which is related to the Sn-O-Sn and O-Sn-O bonds, respectively. Other band located at 571 cm^{-1} is associated to surface defects in SnO_2 nanocrystals, while the peaks at 701 and 1071 cm^{-1} are related to presence of $SrCO_3$ [4]. At increased annealing temperature, intense Raman peaks at ll4 (B_{2g} mode), 223 (A_g mode) and 257 cm^{-1} (A_g mode) are observed, which have been associated with orthorhombic phase of $SrSnO_3$ [5]**.** On the other hand, the peaks related to $SrCO_3$ decrease due to the annealing temperature. The PL properties of the samples were measured at room temperature, under excitation of a He-Cd laser (λ = 325 nm). Figure 4 shows PL spectra of Sm-doped $SrSnO_3$ annealed at 1300 °C, the spectra reveal a gradual increase in the intensity of transition levels of Sm^{3+} ($^4G_{5/2}\rightarrow{}^6H_{5/2}$, 560-590 nm, $^4G_{5/2}\rightarrow{}^6H_{7/2}$, 600-630 nm) due to the rise of molar concentration [6].

This work highlights how the crystalline quality and phase stability are very important for luminescence properties enhancement in perovskites, which is often difficult to achieve. The Sm-doped $SrSnO_3$

nanoparticles studied here exhibit intense red emissions, particle size less than 100 nm (after thermal annealing > 800 nm) and an orthorhombic stable phase [7].

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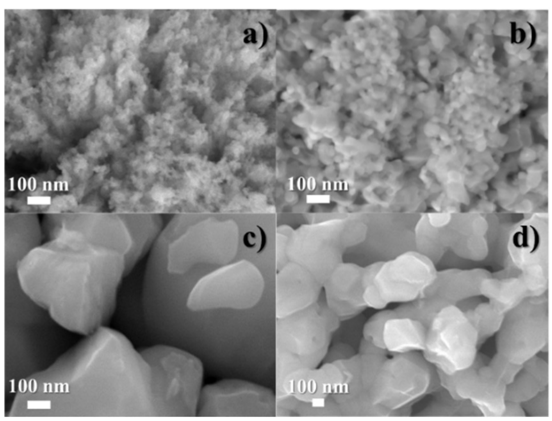

Figure 1. FESEM micrography of a) $SrSnO_3$, b) $SrSnO_3$-800, c) $SrSnO_3$-1300, and d) $SrSnO_3$-4Sm-1300.

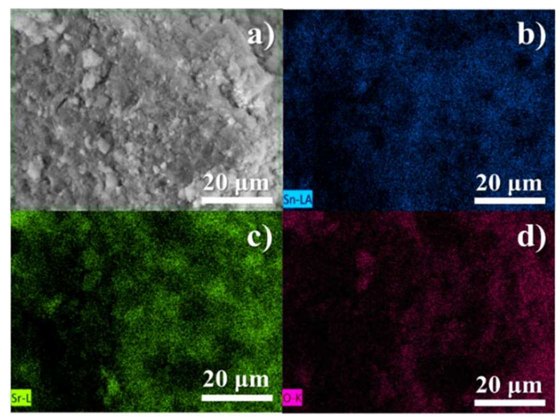

Figure 2. Elemental mapping of a) $SrSnO_3$ nanoparticles, b) Sn-LA c) Sr-L, and d) O-K.

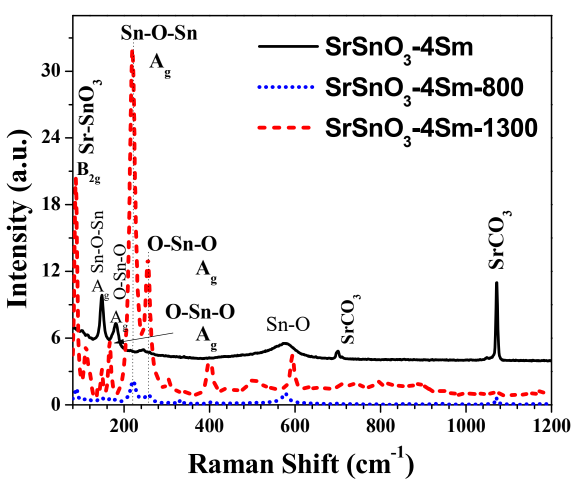

Figure 3. Raman spectra of Sm-doped $SrSnO_3$ nanoparticles annealed at different temperatures.

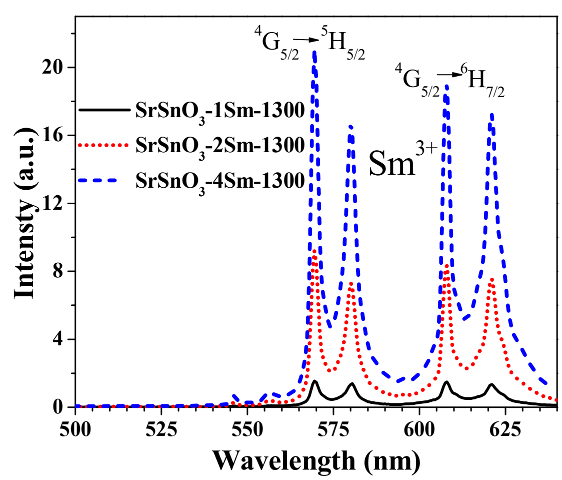

Figure 4. PL spectrum of Sm doped $SrSnO_3$ nanoparticles annealed at 1300 °C.