A spectroscopic analysis of Near-Infrared emission and energy transfer processes from Pr^{3+} doped and Pr^{3+}:Yb^{3+} co-doped SiO_2-Nb_2O_5 xerogels

Wesley C. Muscelli[1*], Felipe T. Aquino[1], Rogéria R. Gonçalves[1]

[1]*Departamento de Química –FFCLRP –USP, Ribeirão Preto, Brazil*

*wesleyqa@gmail.com

The electric power production based on the photovoltaic (PV) energy conversion have been developed toward new technologies and materials enabling the higher conversion efficiencies with low production costs. Considering the single junction solar cells composed by semiconductors materials, intrinsic efficiencies losses should be taken into account. The spectral mismatch losses (so called transmission and thermalization losses) comprises photons with energy lower than the band gap non-absorbed and relaxation losses due to the excess energy of absorbed high energy photons. The theoretical maximum energy conversion efficiency of single junction solar cell is limited to 30%, which it is known as Shockley-Queisser limit.[1] In this sense, rare earth doped materials, which exhibit upconversion and downconversion energy process, can be incorporated into the commercial silicon solar cells in order to maximize the conversion efficiency of the sunlight spectrum into electrical energy. In this paper, we report on the spectroscopic properties of Pr^{3+} doped SiO_2-Nb_2O_5 and Pr^{3+}:Yb^{3+} co-doped SiO_2-Nb_2O_5 nanocomposites prepared by sol-gel process for infrared emission and frequency conversion. Specifically, we analyzed the influence of active ions on the infrared emission profiles of yPr^{3+}doped SiO_2-Nb_2O_5 (y = 0.3, 0.5 and 1.0 mol %) nanocomposites as well as the Yb^{3+} ion content on infrared emission profiles and energy transfer process of 0.5%Pr^{3+}: xYb^{3+} (x = 0, 0.25, 0.5, 1.0 e 2.0 mol%) co-doped SiO_2-Nb_2O_5 nanocomposites. To investigate the photoluminescence profiles, the emission spectra were recorded for all the samples exciting at 350 nm, 448 nm and 586 nm, whose wavelengths correspond to the host absorption, $^3P_0$ and $^1D_2$ excited energy levels of Pr^{3+} ions, respectively. Depending upon the excitation wavelength and rare earth concentration, different emission profiles were obtained. For instance, the emission spectra obtained for the co-doped samples showed an emission band due to $^2F_{5/2}\rightarrow{}^2F_{7/2,}$ inherent to the Yb^{3+} ions and two other emission bands at 1050 nm and 1500 nm, which can be ascribed as $^1D_2\rightarrow{}^3F_{3,4}$ and $^1D_2\rightarrow{}^1G_4$ of the Pr^{3+} ions, respectively. Decay curves were recorded for Pr^{3+}-doped and Pr^{3+}:Yb^{3+} co-doped SiO_2-Nb_2O_5 xerogels under dye laser excitation at 457 nm and monitoring the Pr^{3+}: $^3P_0\rightarrow{}^3H_6$ transition at 611 nm. All the decay curves could not be fitted with a single exponential, which is an evidence of different ion distributions along of the amorphous host matriz.[2] Furthermore, the lifetime values were also estimated for all the xerogels. It has been noticed that the higher concentration of dopants, the lower the lifetime values estimated for the Pr^{3+}doped SiO_2-Nb_2O_5 and Pr^{3+}:Yb^{3+} co-doped SiO_2-Nb_2O_5 xerogels. In the case of co-doped samples, the energy transfer efficiencies (ETE) have been estimated and a maximum value of 75% was obtained for 0.5% Pr^{3+}:1.0%Yb^{3+} SiO_2-Nb_2O_5 xerogel.

1. Ende, B. M.; Aarts, L.; Meijerink, A. *Phys. Chem. Phys*. **2009**, *11*, 11081.
2. Dieudonné, B.; Boulard, B.; Goget, G. A.; Chiasera, A.; Gao, Y.; Kodjikian, S.; Ferrari, M. *J. Non-Crist. Solids*. **2013**, *377*, 105.

The authors would like to thank FAPESP, CAPES, and CNPq for financial support.