The influence of silver nanoparticles in the $Yb^{3+} \rightarrow Er^{3+}$ energy transfer mechanism of $PbO\text{-}GeO_2$ glasses

F. A. Bomfim[1], L. R. P. Kassab[2], J. R. Martinelli[1], J. J. Neto[3], N. U. Wetter[3], and C. B. de Araújo[4]

[1]*Centro de Ciências e Tecnologia de Materiais - IPEN, São Paulo, Brazil*
[2]*Laboratório de Vidros e Datações da FATEC-SP, CEETEPS/UNESP, São Paulo, Brazil*
[3]*Centro de Lasers e Aplicações - IPEN, São Paulo, Brazil*
[4]*Departamento de Física, Universidade Federal de Pernambuco, Recife, Brazil*

The influence of silver nanoparticles (NPs) on the frequency upconversion due to the energy transfer between erbium (Er^{3+}) and ytterbium (Yb^{3+}) ions in a co-doped glass is reported for the first time. Erbium doped glasses have been studied and used in a variety of photonic applications. Nevertheless, efficient pumping of this ion is limited by the low absorption cross-section of Er^{3+} around 980 nm that can be improved by co-doping the material with Yb^{3+} ions [1]. Recently, Er^{3+} doped lead-germanate glasses containing silver NPs were studied [2]. Lead-germanate glasses are excellent materials for photonic applications due to their high mechanical resistance, high chemical durability and thermal stability, large transmission window (400 to 4500 nm), high refractive index, large nonlinear optical response, and low cutoff phonon energy (400 - 800 cm^{-1}) [3]. Besides, these glasses have proved to be good hosts for NPs nucleation [2]. To the basic glass composition $41PbO\text{-}59.0GeO_2$ (in mol%) we added 0.5 wt% of Er_2O_3, 3.0 wt% of Yb_2O_3 and 1.0 wt% of $AgNO_3$; the samples were obtained melting the starting oxide powers, quenching and annealing during different times to reduce the Ag^+ ions to Ag^0 in order to nucleate silver NPs. Measurements of transmission electron microscopy were performed and the visible upconversion spectrum was measured by optically pumping the sample with a high power CW diode laser emitting 5 W at 980 nm. Emission bands centered at 524, 547, and 659 nm were observed corresponding to $^2H_{11/2} \rightarrow {}^4I_{15/2}$, $^4S_{3/2} \rightarrow {}^4I_{15/2}$, and $^4F_{9/2} \rightarrow {}^4I_{15/2}$ transitions of Er^{3+} ions, respectively. Measurements of the upconversion intensity as a function of the laser power were performed. The influence of silver NPs in the $Yb^{3+} \rightarrow Er^{3+}$ energy transfer mechanism is discussed and is attributed to the influence of the surface plasmon resonance (associated to the NPs) that favors the emissions in the green region in comparison with the red emission. We remark that in the absence of the silver NPs green and red emissions have almost the same intensity.

Work supported by CNPq (through the Millenium Institute on Nonlinear Optics, Photonics and Bio-Photonics Project, and the Nanophotonics Network Program).

[1] J. Zhang, S. Dai, G. Wang, L. Zhang, H. Sun, L. Hu. Phys Lett. A 345, 409 (2005).
[2] D.M. da Silva, L.R. Kassab, S.R. Lüthi, C.B.de Araújo and A. S. L Gomes, Appl. Phys Lett. 90, 81913 (2007)
[3] L.R.Kassab, W.G.Hora, W.Lozano, M.A.S. de Oliveira and G. S. Maciel, J. Opt. Commun., 269, 356 (2007).

Corresponding author: Francisco Araújo Bomfim, fbomfim@ipen.br

Keywords: silver nanoparticles, heavy metal oxide glasses, frequency upconversion