Optical properties of Er^{3+} ions in lead-germanate based glasses

J. Fernández[a,b,c], A. de Oleaga[a], and R. Balda[a,b,c]
[a]Dpto. Fisica Aplicada I, Escuela Superior de Ingenieros, Alda. Urquijo s/n 48013 Bilbao (Spain)
[b]Centro Mixto CSIC-UPV/EHU and [c]Donostia International Physics Center (DIPC), Basque Country (Spain)
email:wupferoj@bi.ehu.es

The development of high capacity telecommunication networks has generated a large amount of research to find new rare-earth doped glasses for optical fiber amplifiers. Glasses with phonon energies lower than that of silica offer the possibility to develop more efficient lasers and fiber optic amplifiers at wavelengths which are not accessible with silica. Among them, germanate based glasses are promising host materials for applications in optical devices because of their excellent optical properties in the mid-infrared region. They have smaller phonon energies than silicate, phosphate, and borate glasses [1,2], and this property increases the quantum efficiency of luminescence from excited states of rare-earth ions and the upconversion efficiency of infrared into visible light, which is low in conventional oxide glasses. Lead-germanate glasses combine high mechanical strength, high chemical durability, and temperature stability with good transmission in the infrared region [3] up to 4.5 µm, which make them promising materials for technological applications such as new lasing materials, upconverting phosphors, and optical waveguides [4-6].

In this work, together with the optical properties of Er^{3+} doped lead-germanate based glass of composition $60GeO_2$-25PbO-$15Nb_2O_5$ (GPN), we report a study of the infrared to visible upconversion processes.

The infrared emission at 1550 nm was obtained under 800 nm excitation. The fluorescence spectrum at 1550 nm corresponding to the $^4I_{13/2}\rightarrow{}^4I_{15/2}$ transition is shown in Figure 1. The decay curves of this fluorescence was obtained at three different temperatures 10 K, 77 K, and 295 K. The decays were found to be single exponentials at all temperatures with a lifetime value of 5.7 ms for the sample doped with 1mol% of Er^{3+} ions. This value is in agreement with the radiative lifetime within the experimental error, which indicates a high quantum efficiency of the emission from the $^4I_{13/2}$ level.

Figure 2 shows the room temperature upconverted emission spectrum of Er^{3+} doped GPN glass obtained under near infrared excitation at 800 nm. The observed emissions correspond to transitions $^2H_{11/2}\rightarrow{}^4I_{15/2}$ (525 nm), $^4S_{3/2}\rightarrow{}^4I_{15/2}$ (547 nm), $^4F_{9/2}\rightarrow{}^4I_{15/2}$ (660 nm), and $^4S_{3/2}\rightarrow{}^4I_{13/2}$ (850 nm). As can be observed the most intense emission corresponds to the green emission from $^4S_{3/2}$ level.

The dependence of the three lines intensity on the pump power is quadratic which indicates a two photon upconversion process to populate the $^4S_{3/2}$, $^2H_{11/2}$ and $^4F_{9/2}$ levels. This in turn may be associated to excited state absorption (ESA) and/or to energy transfer upconversion (ETU).

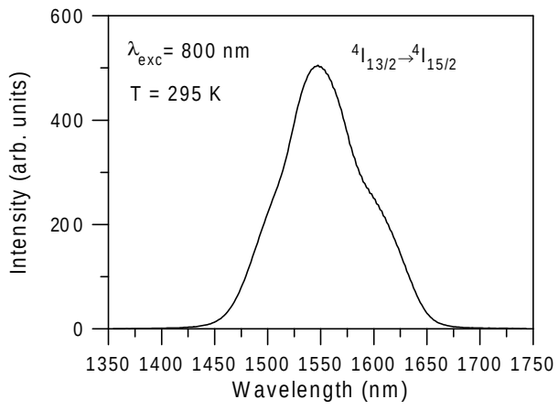

Figure 1. Emission spectrum of Er^{3+}-doped GPN glass under 800 nm excitation.

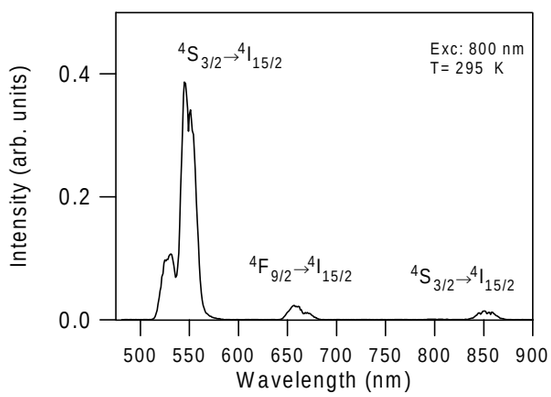

Figure 2. Upconversion spectrum of Er^{3+}-doped GPN glass obtained under 800 nm excitation.

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