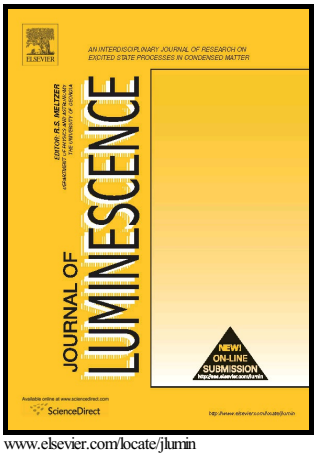

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Luminescence and upconversion processes in Er^{3+}-doped tellurite glasses

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Abstract

This work presents a spectroscopic investigation of tellurite glasses with the composition $65TeO_2$-$15Li_2O$-20ZnO doped with different concentrations of Er_2O_3. Optical absorption and emission spectroscopy were performed at room temperature to determine emission properties of Er^{3+} in the visible and near-infrared regions. The samples presented intense green emission due to the $^2H_{11/2} \rightarrow {}^4I_{15/2}$ and $^4S_{3/2} \rightarrow {}^4I_{15/2}$ transitions. Emission intensities at 992 and 1550 nm exhibit a relative increase with increasing doping concentration. Luminescence decay curves for the $^4S_{3/2} \rightarrow {}^4I_{15/2}$ transition follows a non-exponential behavior, while the $^4I_{11/2} \rightarrow {}^4I_{15/2}$ and $^4I_{13/2} \rightarrow {}^4I_{15/2}$ transitions presented simple exponential behavior with high lifetime values. Under 975 nm excitation, upconversion luminescences in the green and red regions are observed, with a relative increase for red emission as function of doping concentration. The possible mechanisms considering multi-phonon relaxation, energy transfer and cross-relaxation processes were discussed for green and red emissions under excitations at 488 and 975nm. The square dependence of green emission on the excitation power indicates two photons contribution to the upconversion emission. The full width at half-maximum values of emission at 1550 nm increased with increasing Er^{3+} concentration, showing the potential of the studied material as infrared amplifier.

Keywords: Tellurite glasses, Erbium-doped, Luminescence, Upconversion

1. Introduction

Rare-earth doped materials are widely used in photonics with vast applicability in optical amplifiers and solid state lasers, which require high emission quantum yields [1–5]. To produce functional devices, the development of these materials must have improved quantum yield at selected wavelengths. The property that directly affects the quantum yield is the energy loss due to nonradiative interactions [6]. TeO_2-based glasses, for instance, are attractive for such applications due the low vibrational frequencies (800 cm^{-1}), in addition to the high refractive index (2.1–2.3), good thermal and chemical stability, wide spectral transparency range (0.3–5 μm), and low melting point ($\sim$ 700 °C) [7–9].

Differently from other network formers such as SiO_2, B_2O_3 and P_2O_5 [10], TeO_2-based glasses require the addition of alkali oxides (Li_2O, Na_2O, K_2O) in their composition to facilitate vitrification [11]. The addition of Li_2O into TeO_2 glass leads to a decrease in the glass transition, which increases the thermal stability and changes the optical properties of the system [7, 12]. One way to track-back these optical properties is to add transition metal oxides such as ZnO, Nb_2O_5 and Ag_2O [13–15] in the glass composition. Oxides can change their role as network modifier/former depending upon their concentration. As network modifier, ZnO oxide decreases the network connectivity, which can be a drawback for optical applications [13]. Otherwise, as network former, ZnO can promote the formation of $Zn_2Te_3O_8$ units increasing the network connectivity leading to systems with promising properties to act as hosts for optically active ions [14, 16].

In this sense, Er^{3+}- doped zinc-tellurite glasses are interesting materials to achieve favorable emissions at blue, green, and red colors and at 1.5 μm [17–20]. Emissions in visible range can be achieved by upconversion processes using near-infrared (NIR) radiation [21] as excitation due to intermediate levels with long lifetimes ($^4I_{11/2}$ and $^4I_{13/2}$). Besides, these emissions drew a lot of attention due to their applications in modern lighting devices and optical displays [22–25].

Since the current demand for transmission capacity of wavelength division multiplexed telecommunication systems from *C* band (1530-1565 nm) to *L* band (1570-1610 nm) [19] has increased, the bandwidth of silica-based erbium-doped fiber amplifier (EDFA) (35 nm) has become insufficient [19]. If compared with silica glasses, Er^{3+}-doped tellurite glass presents broader emission (76 nm) and a larger stimulated emission cross-section [4, 26], which are desirable properties for EDFA applications [27, 28]. As the emission at 1.5 μm is strongly influenced by the host composition, it is important to investigate other Er^{3+}-doped glass hosts to produce broader bandwidth.

In this work, we have prepared TeO_2-Li_2O-ZnO glasses with

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