Absorption and photoluminescence of Ga-La-S:O and Ga-Ge-As-S glasses doped with rare-earth ions

M.S. Iovu*, A.M.Andriesh, N.N.Syrbu, A.B.Seddon[a], D.Furniss[a], G.J. Adriaenssens[b], Yu.S.Tver'yanovich[c]

Center of Optoelectronics, IAP, ASM, Str. Academiei 1, MD-2028 Chisinau, R. Moldova
[a]Novel Photonic Glasses Group, University of Nottingham, Nottingham N67 2RD, UK
[b]Laboratorium voor Halfgeleiderfysica, University of Leuven, B-3001 Leuven, Belgium
[c]Russian Center of Laser Physics, St. Petersburg State University, St. Petersburg, Russia

ABSTRACT

The visible luminescence from Pr^{3+}, Dy^{3+}, Nd^{3+}, Sm^{3+} and co-doped with Ho^{3+} and Dy^{3+} ions embedded in $Ga_{0.017}Ge_{0.25}As_{0.083}S_{0.65}$ glass hosts at room temperature and at T=10 K is reported, when pumping with an Ar^+-ion laser at λ=488 nm. Fluorescence emissions at 1.3 μm was observed for Dy^{3+} and both at 1.3 and at 1.5 μm for Pr^{3+} doped glasses with wavelength pumping at 950 nm. The emission bands correlate with the absorption bands characteristic for the electronic transitions of the rare-earth ions. Energy transfer from Ho^{3+}:$^5F_3$ level to Dy^{3+}:$^4F_{9/2}$ level increase the visible emission efficiency at 650 nm in the co-doped glasses. The emission spectra correlate with the absorption spectra of the investigated glasses. The investigated $Ga_{0.017}Ge_{0.25}As_{0.083}S_{0.65}$ glasses doped with Pr^{3+} are promising materials for optical fibers amplifiers operating at 1300 and 1500 nm telecommunication windows. The effect of oxygen on the absorption and luminescence spectra of Pr^{3+}-doped Ga-La-S-O (GLS) glasses with a constant cationic ratio Ga/La=0.7/0.3 and varying both oxygen (0.65 and 2.95 wt %) and praseodymium (0.1 and 1.0 wt %) content also are presented.

1. INTRODUCTION

Rare-earth doped Ga_2S_3-La_2S_3 [1-6] and Ga_2S_3-GeS_2 [7-11] chalcogenide glasses have been recognized as one of the most promising candidates for fiber optics communication devices operating at 1300 and 1500 nm telecommunication windows. The Ga_2S_3-La_2S_3 and Ga_2S_3-GeS_2 glasses are characterized by high rare-earth solubility, good mechanical and chemical durabilities, high glass transition temperature T_g (425÷560 °C), high refractive index (≥2.4), and a broad transmission window [3,4,12,13]. Due to the very low phonon energy of the Ga- and Ge-based chalcogenide glasses an increase in the radiative efficiencies of the rare earth transitions is obtained. The increase of oxygen content above the threshold amount of 0.21 wt % of oxide improved the thermal stability and optical characteristics of GLS glass 3,4]. A preliminary EXAFS results showed that the oxygen bonds to all three elements and adds strong ionic component to all of bonds. Incorporation of oxygen results in a decrease of the Urbach edge and in increase of the optical gap, thus improving the optical properties of the glass. It was shown that the presence of oxygen induces blue shift of the fundamental absorption edge and results in lowering of the low-energy components of the Pr^{3+} absorption bands. The effect of oxygen on the luminescence spectra is determined by the shift of the absorption edge in the short-wavelength spectra region with increasing of the oxygen contents, which became visible with oxide content growing [6].

The chalcogenide glasses doped with rare-earth ions exhibit fluorescence at the fixed wavelengths, due to the radiative transitions from the upper electron levels of the excited rare-earth ions [14]:

- Nd^{3+} → (0.786, 0.919, 1.08, 1.37 μm);
- Er^{3+} → (0.822, 0.869, 0.987, 1.54, 2.7, 3.5, 4.5 μm);
- Ho^{3+} → (0.76, 0.91, 1.2, 2.9, 3.9 μm);
- Pr^{3+} → (1.3, 1.6, 2.9, 3.4, 4.5, 4.8, 4.9, 7.2 μm);

* Correspondence: iovu@as.md, Center of Optoelectronics of the Institute of Applied Physics, Academy of Sciences of Moldova, Str. Academiei 1, MD-2028 Chisinau, Republic of Moldova.

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