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STUDY OF OPTICAL AND STRUCTURAL PROPERTIES OF Ho^{3+}/Yb^{3+} CO-DOPED SOL-GEL SILICA GLASSES

Recently, there has been a great interest focused on luminescent materials doped with rare earth (RE) ions because of their potential applications in solid state lighting, lasers, optical sensors, telecommunications, photovoltaics, color displays [1, p. 8]. Among the rare earth ions, ions like Yb^{3+} and Ho^{3+} are especially attractive because of the wide range of emission in UV–Visible, NIR and Mid-IR [2, p. 215]. The choice of suitable host glass matrix for the RE ion dopants is a key factor [3, p. 1515].

In this work, we investigated the influence of Ho^{3+} ions on the optical and structural features of Ho^{3+}/Yb^{3+} co-doped silica glasses synthesized using a modified sol-gel method [4]. Highly dispersed silica, modified by nanoparticles of RE oxides, of a defined size and concentration, was used as an activator-filler of the sol-gel synthesis. The method enabled to obtain transparent and homogeneous materials with having yellow-colored hue that we marked as HoYbSi1, HoYbSi2 and HoYbSi3 with molar ratio of Ho_2O_3:Yb_2O_3 like 0.1:0.8, 0.2:0.8, and 0.4:0.8, respectively. The undoped silica glass was obtained for comparison. Prepared samples were polished to get smooth and uniform surface for optical measurements (disks diameter ~ 15 mm and height ~1 mm).

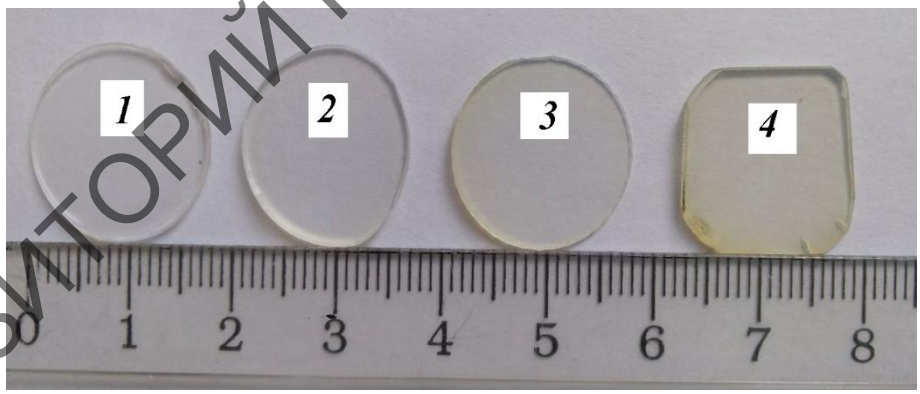

Figure 1 – The photographs of undoped (*1*) and co-doped sol-gel silica glasses with Ho^{3+}/Yb^{3+} (*2–4*)

All glasses were amorphous in the nature, as confirmed by X-ray diffraction patterns. FTIR spectra for undoped and co-doped sol-gel silica glasses are shown in Figure 2. A broad band with a maximum at 3660 cm^{-1} for QV sample (Quartz optical glass, Gus'-Khrustal'nyy, Russia) refers to the stretching vibrations of structural O-H bonds present in the silicon-oxygen framework. The integral absorption of OH groups in undoped (Figure 2, *curve 1*) sol-gel silica glass is 3.5 times greater than in QV (Figure 2, *curve QV*). The concentration is proportional to the absorption, and C_{OH} in the QV fused glass is ~ 0.1 wt. % [4]. C_{OH} in co-doped glasses varied between 0.6 – 0.9 wt. %.

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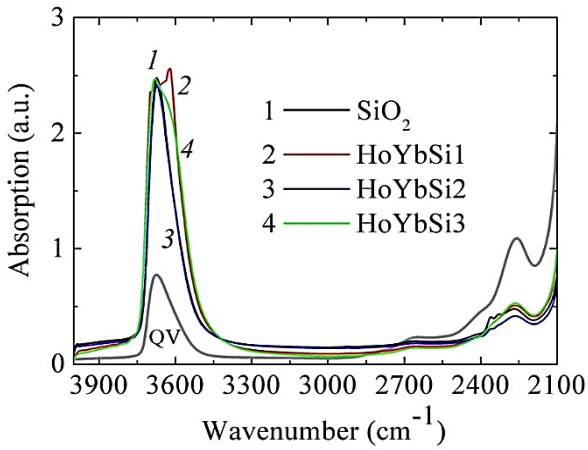

Figure 2 – FTIR spectra for QV fused silica (QV), undoped (*1*) and co-doped sol-gel silica glasses with Ho^{3+}/Yb^{3} (*2–4*)

Figure 3 presents the typical absorption spectra of undoped and Ho^{3+}/Yb^{3+} co-doped sol-gel silica glasses. The absorption spectrum of undoped glass does not contain any peak in the range of 350 – 1000 nm. In the absorption spectrum of Ho^{3+}/Yb^{3+} silica glasses, one absorption peak of ytterbium in the range of 875–1000 nm is visible, split into two maxima at 930 and 975 nm. This peak is assigned to the $^{2}F_{7/2}\rightarrow{}^{2}F_{5/2}$ transition of Yb^{3+} ion; the splitting into two maxima is caused by the Stark effect. Several less pronounced absorption peaks of holmium can also be found in the spectrum; they are assigned to transitions of Ho^{3+} ions, namely $^{5}I_{8}\rightarrow{}^{5}H_{6}$ (362 nm), $^{5}I_{8} \rightarrow {}^{5}G_{6}+{}^{3}K_{8}+{}^{5}F_{2}$ (overlapping peaks at 418, 452 and 485 nm), $^{5}I_{8} \rightarrow{}^{5}F_{4}$ (537 nm) and $^{5}I_{8} \rightarrow{}^{5}F_{5}$ (642 nm).

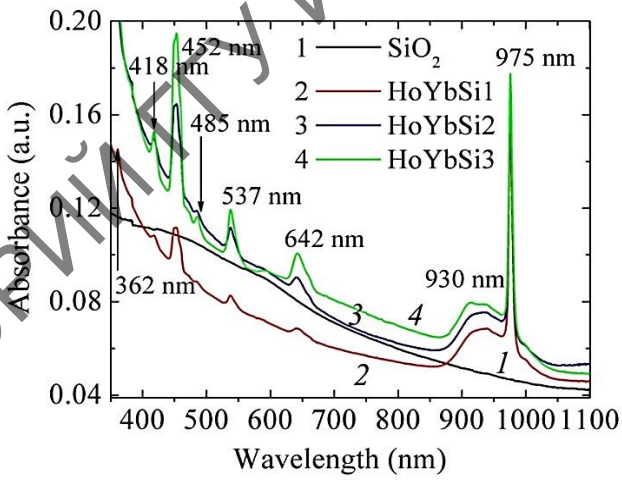

Figure 3 – Absorption spectra of undoped (*1*) and Ho^{3+}/Yb^{3+} co-doped silica glasses (*2–4*)

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