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PhD Thesis " Development of active optical fiber emitting radiation in the visible range"

Summary

As part of this work optical fibers made from tellurite glass co-doped with rare earth ions emitting radiation in the visible range as a result of upconversion were fabricated. As part of the research a stable glass with the molar ratio $50TeO_2 – 25GeO_2 – 20PbO – 3BaO – 2Nb_2O_5$, doped with Yb^{3+}/Ho^{3+}, Yb^{3+}/Tm^{3+}, Yb^{3+}/Er^{3+}, Yb^{3+}/Tb^{3+} ions was fabricated. Low phonon energy of $790cm^{-1}$ implies low probability of unfavorable multiphonon transfers and enables to obtain emission of radiation in the visible range resulting from energy transfer between the lanthanide ions and the mechanism of upconversion. By exciting of the glass, with the wavelength within the band of 976 nm, spectrum emission in the visible range was measured for every selected combinations of active dopants. Obtained results were the basis of the development of optical fibers emitting radiation in the visible range as a result of the mechanism of upconversion. As a result of luminescence measurements it was found that the shape of emission spectrum of fabricated optical fibers is significantly different from luminescence spectrum of the telluric bulk glass used for the core. In the fabricated tellurite optical fiber co-doped with 0,5 %mol Yb_2O_3/0,1 %mol Ho_2O_3 the emission intensity within the band of 545 nm ($^5S_2(^5F_4) \rightarrow {}^5I_8$) in the fabricated optical fiber is several times smaller than the emission intensity within the band of 657 nm ($^5F_5 \rightarrow {}^5I_8$). In addition, the maximum of the emission corresponding to the $^5F_5 \rightarrow {}^5I_8$ transition is shifted by 3 nm towards longer wavelengths. In the optical fiber co-doped with 0,5 %mol Yb_2O_3/0,05 %mol Tm_2O_3 bands characteristic for the enhanced spontaneous emission of 477nm ($^1G_4 \rightarrow {}^3H_6(Tm^{3+})$) and 651 nm ($^1G_4 \rightarrow {}^3F_4(Tm^{3+})$) resulting from three-phonon absorption was measured. However, compared to the bulk glass sample the intensity ratio of upconversion emission within the bands of 478nm/651 nm is different. In the optical fiber of 20 cm length it is 3,5 whereas in the volume sample this parameter is 10.

The shape of the upconversion emission spectra of the optical fiber co-doped with 0,5 %mol Yb_2O_3/0,1 %mol Er_2O_3 similarly to the other cases is different from the luminescence spectrum of the tellurite glass used for the core. The intensity ratio of the emission with the wavelength of 550 nm ($^4S_{3/2} \rightarrow {}^4I_{15/2}(Er^{3+})$) and 529 nm ($^2H_{11/2} \rightarrow {}^4I_{15/2}(Er^{3+})$) is greater than in the bulk glass sample. The advantageous ratio of the area to volume of the

fabricated optical fiber implies lower participation of the thermalization process in population the $^2H_{11/2}$ level thereby resulting in the increase in the emission intensity within the band of 550 nm ($^4S_{3/2} \rightarrow {}^4I_{15/2}$) against the emission band of 529 nm ($^2H_{11/2} \rightarrow {}^4I_{15/2}(Er^{3+})$). The observed emission bands shift of 4 nm towards longer wavelengths and decrease in the intensity of upconversion emission within the bands of 550 nm, 656 nm as a function of the length of the optical fiber are connected, as in case of optical fibers mentioned before, with reabsorption of the ASE signal resulting from the $^5I_{15/2} \rightarrow {}^2H_{11/2,}$ $^5I_{15/2} \rightarrow {}^4F_{9/2}$ transitions respectively in the erbium structure. In conclusion, fabricated optical fibers co-doped with Yb^{3+}/Ho^{3+}, Yb^{3+}/Tm^{3+} and Yb^{3+}/Er^{3+} ions enable to obtain emission spectra characteristic for amplified spontaneous emission resulting from the upconversion mechanism.