**УДК 535.3, 666.247, 544.536.1**

# FEMTOSECOND LASER DIRECT WRITING ACTIVE WAVEGUIDE IN BISMUTH-IMPREGNATED POROUS GLASS

**Zhong Lijing (**ITMO University**), Zakoldaev R.A. (**ITMO University**), Sergeev M.M. (**ITMO University**), Ostanin A.A. (**ITMO University**).**
**Scientific director - Dr. Sci., Professor Veiko V.P.**
(ITMO University)

There are presented the results of the fabrication of active waveguides in PG, pre-impregnated with bismuth, and show effect of locally manipulating the state of bismuth.

**Introduction.** Porous glass (PG) has demonstrated its unique charm as a “tolerant” host material for immobilization of a variety of dopants (Er, Yb, Bi, etc.) with high concentration due to its unique properties of high surface area and physical separation of nanopores that can avoid the clustering of luminescence ions. However, the prospect of PG as a substrate for active photonic elements, especially active waveguides, has never been examined, which hinder the lab-on-a-chip application. More recently, we exploited femtosecond laser-induced densification of PG as a method for space-selective control of matrix density. The modified regions characterized by a core-cladding type with refractive index contrast in the range of $10^{-4}$ - $10^{-2}$. This time, we consider the fabrication of active waveguides in pre-impregnated PG with bismuth and show effect of locally manipulating the state of bismuth.

**Main part.** In our research, bismuth-impregnated PG was prepared by soaking the PG in Bi-containing solution ($Bi(NO)_3$) and then dry it in furnace (to dry 48 hours and at 150°C). After that, laser micromachining (Antaus fiber laser operated at 1030 nm wavelength with pulse duration of 220 fs, and repetition rate of 1 MHz, maximum pulse energy $E_p$ = 2 μJ) was employed to locally manipulate glass matrix density, state and distribution of dopants inside this glass composite.

**Conclusion.** As a result, uniform elongate modified regions have been written below glass surface (~250 μm). It was supposed its utilization as a waveguide, so near-field distribution was captured from output of the waveguide. Beside light guiding properties, luminescence properties were measured to show the transformation of dopants state within fabricated waveguide. Thus, a blue luminescence in the range of $\lambda_{exc}$ = 340-370 nm (illumination with $\lambda_{em}$ = 425-500 nm) caused by the presence of $Bi^{3+}$ ions was observed at both glass composite and the waveguide. That confirmed the presence of $Bi^{3+}$ inside the waveguide. Furthermore, an enhancement of yellow luminescence with the maximum in the range of $\lambda_{em}$ = 500-580 nm ($\lambda_{exc}$ = 400-440 nm) caused by the presence of $Bi^{2+}$ ions was revealed inside waveguide compared with initial Bi-containing PG. As a result, this indicates the simultaneous change of glass matrix density and valence state of dopants caused by laser irradiation.

Zhong Lijing Подпись

Zakoldaev R.A. Подпись

Sergeev M.M. Подпись

| | |
|---|---|
| Ostanin A.A. | Подпись |
| Veiko V.P. (Scientific director) | Подпись |