Fabrication of photonic devices in heavy metal oxide glass by femtosecond laser direct writing

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Femtosecond laser can induce a permanent refractive index change inside various transparent materials via multiphoton absorption. This technique also opens up new possibilities for fabricating photonic devices in highly nonlinear glasses such as heavy metal oxide glass (HMO) which will be key to the development of all-optical switches and, in combination with thermal poling, to frequency converters and electro-optic modulators. Since self-focusing occurs in HMO glasses before reaching the optical breakdown threshold owing to the large n2, waveguide writing by femtosecond laser is challenging and so far waveguides at 633 nm have been achieved in HMO glass only outside of the region of filamentary propagation. In this paper, for the first time to our best knowledge, we report on the fabrication of high quality, low loss, channel waveguides and passive waveguide components at 1.5µm in bulk 12.5Bi2O3•43.75ZnO•43.75B2O3 glass without introducing self-focusing.

Linear polarized laser beam from a regeneratively amplified mode-locked Ti: Sapphire laser (150 fs pulse duration, 250 kHz repetition rate) operating at a wavelength of 800 nm was focused via 50x (NA=0.55) microscope objective into the sample. The waveguides were fabricated by translating the sample perpendicular to the beam propagation direction with writing speed of 200 µm/s and pulse energies varied from 0.16 - 0.24 µJ. By using the slit beam shaping method, the asymmetry in the transverse geometry of the waveguide can be effectively controlled by varying the slit size (shown in Fig.1). Figure 2 shows the near-field mode profile of the waveguide at 1.5µm. The profile is nearly circular with mode-field diameter of 11 µm. Waveguide propagation losses at 1550 nm were measured using Fabry-Perot method. Using this method, the lowest propagation loss of the waveguide was 0.2 dB/cm obtained with 0.2 mode-field diameter of 11 µm. Waveguide writing by femtosecond laser pulses above the critical self-focusing threshold, “Appl. Phys. Lett. 86, 121109 (2005).”

Fig. 1. Lateral image of the waveguides in various depth fabricated by different slit dimensions.

Fig. 2. Near field mode profile of the waveguide.

Fig. 3. Fabry-perot measurement for a waveguide at 1550 nm.

Fig. 4. (a) Schematic diagram of a directional coupler. Near field lateral patterns of the coupler output at 1.5 µm for (b) d = 23 µm and (c) d = 13 µm.

References