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Editorial: Femtosecond Laser Inscribed Passive and Active Guiding Structures in Transparent Materials

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Editorial on the Research Topic

Femtosecond Laser Inscribed Passive and Active Guiding Structures in Transparent Materials

As a powerful 3D processing technique, femtosecond laser micromachining has been applied to produce flexible optical and photonics structures in transparent materials in a cost-effective way. Active and passive photonic applications, including waveguide lasers, nonlinear harmonic generation, laser beam shaping, sensors and microfluidics devices in transparent materials, based on the achieved waveguides have been realized. Femtosecond laser micromachining exhibits good compatibility with a broad range of transparent materials, including crystals, polymers, and glasses. The current demand for photonic devices with excellent performances prompts further advancements of fs-laser micromachining as a methodology enabling surface and bulk modifications in the transparent materials.

This Research Topic on "Femtosecond Laser Inscribed Passive and Active Guiding Structures in Transparent Materials" covers some of the latest research advancements in femtosecond laser micromachined beam splitters, planar, ridge and cladding waveguides in crystals, glasses and ceramics. In the seven original research articles, the theoretical simulation and experimental studies of femtosecond laser inscribed guiding structures are introduced in details.

Zhou et al. realized guided-wave up-conversion luminescence in femtosecond laser writing cladding waveguides in Er^{3+}/Yb^{3+} co-doped phosphate glass. Under optical pumping at 980 nm, the guided-wave up-conversion luminescence in the visible has been realized. The experimental and calculated results of propagating modal profiles and losses have proved favorable performances suitable to Gaussian mode field and multi-mode applications. Cheng et al. achieved optical ridge waveguides in barium fluoride (BaF_2) crystal by 15 MeV C^{5+} ions irradiation combined with femtosecond laser ablation. The near-field modal profile and propagation loss of the waveguide at mid-infrared wavelengths are investigated by using an end-face coupling system. Castillo et al. reported thermally resilient planar waveguides by direct fs-laser inscription in transparent nc-yttria stabilized zirconia (nc-YSZ) polycrystalline ceramic. Their results suggest a promising use of nc-YSZ in harsh and high temperature demanding photonic environments. Bao et al. fabricated buried channel waveguides with different widths in $Yb:YVO_4$ crystal by the double line technique. Modal profiles of the waveguides were captured using an end-face coupling setup at the wavelength of 633 nm under TE and TM polarizations. Zhang et al. demonstrated the fabrication of ridge waveguides in zinc sulfide (ZnS) crystal by femtosecond laser ablation combined with Kr^{8+} ion irradiation. The waveguide propagation loss at TE mode at 4 μm wavelength is reduced to as low as 0. 6 dB/cm after thermal annealing treatment. Wu et al. obtained beam splitters in pure YAG crystals by

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femtosecond laser direct writing. A positive refractive index is induced through the nonlinear focusing above the focus position, resulting in an unusual guiding cross-sectional configuration. This novel structure might offer a new approach in the quest towards integrated photonics. Sun et al. studied cladding waveguides fabricated by femtosecond laser inscription with different parameters in Pr-doped $Lu_3Al_5O_{12}$ (LuAG) single crystal. Guided fluorescence emissions in visible range covering green, yellow-green, orange and red were obtained with a maximum slope efficiency of 4×10^{-4}.

These seven selected articles only represent part of the advanced research developments and applications in the field of femtosecond laser micromachining optical devices in transparent materials. From the current development, femtosecond laser micromachining can achieve optical devices from size of millimeters to the size of nanometers in many kinds of optical materials. We sincerely hope femtosecond laser micromachining can make significant progress in the field of optics and photonics in the future.

AUTHOR CONTRIBUTIONS

HL put forward the writing outline of the editorial, collected and sorted out the cited literature, and draft the paper. HL, YJ, and CR revised the paper and approved the final version.

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