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COMPARISON OF FUSE EFFECT GENERATION SCHEMES FOR VARIOUS DIELECTRICS AND STUDY OF THE THRESHOLD CHARACTERISTICS OF THE PROCESS

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Introduction. The fiber fuse phenomenon, a detrimental process in optical fibers, arises when intense light induces a plasma zone, leading to fiber degradation as this zone advances. This effect, visible as a glow, can cause fiber failure, especially in high-power optical settings. The damage is characterized by periodic, bullet-like cavities or irregular filaments in the fiber core, significantly impairing its function[1]. Despite its destructive nature, a deeper understanding of the fiber fuse phenomenon offers potential for controlled applications beyond optical fibers, extending to bulk materials. Harnessing this effect allows for precise structuring of glass, crucial for various technological applications. By manipulating the fiber fuse effect and applying subsequent chemical etching to laser-modified areas, three-dimensional channels can be crafted. These channels are foundational for devices like microfluidic channels and glass interposers, with modified layers and channels utilized in optical waveguides, diffraction gratings, and optical memories due to their altered refractive index[2,3]. The goal of this work is to not only understand and mitigate the risks associated with this phenomenon but also to explore its potential for innovative structuring of glass materials in advanced technological domains.

The main part. Three schemes for initiating the fiber fuse effect in bulk transparent materials were explored in this experiment. The first method involved Continuous Wave Laser Backside Irradiation (CW-LBI), where an absorbent material was affixed to one side of a glass sheet, and the opposite side was irradiated with a continuous wave (CW) laser beam. The second method combined a picosecond pulsed laser at a wavelength of 532 nm with the CW fiber laser at 1064 nm used in the first approach. The third method also employed the combined laser setup but omitted the absorber on the backside of the sample. the initiation conditions for the fiber fuse effect were systematically investigated, focusing on varying power densities of the CW laser and different pulse energies of the picosecond pulsed laser. Stainless steel and titanium metallic foils were employed as absorbers to gauge their effectiveness in facilitating the initiation of the effect within the bulk material. Two types of glass samples, K9 and pure quartz, were selected to understand how these variables influence the fiber fuse phenomenon. The obtained defects were observed for the different used variables.

Conclusions. The initiation conditions for the fiber fuse effect were meticulously studied and compared across three different schemes, and the threshold power densities required for initiating the effect were determined. Various materials, including both the glass samples and the absorbers, were tested to assess their impact on the initiation and progression of the fiber fuse effect. The defects resulting from the fiber fuse effect were characterized, and the structure of the damage induced by the fiber fuse effect was described in detail.

References:

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