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# MICROCHANNEL FABRICATION IN POROUS GLASS USING FEMTOSECOND LASER DIRECT WRITING WITH SUBSEQUENT CHEMICAL ETCHING

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**Introduction.** Microfluidic system fabrication methods have attracted an excessive amount of research in the last few decades due to its various applications in the chemical and biological spheres, some of which are particle detection microfluidics [1], microfluidic mixers [2]. Laser-induced micromachining has been proven to be a promising tool to realize complicated volume 3D microsystems for microfluidic implementation. Freeform fabrication of microfluidic systems made it possible to introduce compact portable multifunctional devices that can be applied in various spheres.

Methods for microfluidic systems' fabrication have been lengthily studied and developed over the last few decades. Photolithography is one of the most widely used techniques for microfluidic structures fabrication, as it offers a high precision and allows the fabrication of complex topographies that are hard to realize using other techniques. However, it is limited to surface structuring and lacks the capability to produce freeform elements in volume. Other techniques include wet and dry etching which depends on the physical or chemical removal of the material. However, it retains some disadvantages such as deformation or shrinkage of the material in the processed area. Laser direct writing technique made it possible to overcome these hardships and offered a one-step method for volume microfluidic systems fabrication in transparent materials using ultrashort pulses. After processing the material with the direct laser writing step, a following step of chemical etching (mostly in HF or KOH acids) is needed to clean the structure of debris and finalize the elements. As laser micromachining shows a huge potential for the advancement of microfluidic systems fabrication, excessive research is dedicated to the development of new fabrication methods.

**Main part.** With laser direct writing at moderately high pulse energies, nanogratings start to appear in the processed area, which allows for chemical solutions to be applied to etch out the processed material with high selectivity and produce hollow channels buried inside transparent materials [3]. However, the choice of the substrate and the etchant is of high importance as it directly impacts the outcome of the fabrication process in terms of size, shape and even the properties of the material. Using acids like HF proved to be limited as for the length of the fabricated channel, as it is hard to get the etchant to diffuse deep into the substrate, producing conical-shaped channels. Using weaker etchants, although time-consuming, is suitable for longer channel fabrication.

In our work, we propose a new method for microchannel fabrication in nanoporous silicate matrix (NPSM-7), using two-phase glass as substrate. The resulting sample will be (NPSM-7) with the free volume of pores 25% and average size of pore 7 nm. For this, a femtosecond laser system (Avesta, Antaus-20W-20u/1M) operating at 515 nm wavelength, pulse duration 224 fs and frequency up to 1 MHz was utilized. As a result, a set of channels with cross-section (3-20 μm) were obtained.

Two types of modifications were obtained depending on the laser power: (i) smooth densified material in the laser processing area at low laser power (90-400 mW), and (ii) and alternating densified-decompressed layers forming core-cladding-like elements for the higher power (400-820 mW). Chemical etching was performed in HCl solution to clean the channels of debris and get the final element in a nanoporous matrix. After the cleaning steps, the fabricated structures were freed of debris and a size increase of around 20% was observed, providing empty space in the channel section.

**Conclusion.** A study on a new method for creating microchannels was demonstrated and a set of writing parameters and their results were shown respectively. This technique can facilitate the procedure for microchannel fabrication, which in turn helps improve the potential quality of the device of the lab-on-a-chip (LOC). Improving such technologies can help realize better utilities for chemical and biological analysis.

References:

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