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LASER-INDUCED GLASS STRUCTURING FOR MICROFLUIDICS

Barhoum K., Shishkina A.S., Zakoldaev R.A (ITMO University)
Scientific advisor –Research fellow, Ph.D., Zakoldaev R.A (ITMO University)

An investigation on the construction of microchannels in bulk glass using a femtosecond laser was conducted to determine the favorable parameters of the laser for the process. After laser writing, the channels were cleaned in water under the action of ultrasound, which helped not to change the geometry of the channel and make the cleaning process non-toxic. The fabrication of microchannels in two-phase glass is also considered. The stage of ultrashort laser writing is followed by the stage of etching in potassium hydroxyl (KOH) to finalize the process and observe the effect of the etchant on the shape of the channels, while giving the glass porous properties.

Introduction. Microfluidics studies are one of the emerging fields that have attracted much attention in the last few decades due to its extensive applications in many chemical and biological devices such as particle detection microfluidics, DNA chips (microarrays), high performance liquid chromatography (HPLC) as well as optofluidic. Associating such promising technology with laser-induced micro-components inside material, which can be in numerous shapes and 3D geometries as required for the application, can offer additional benefits. Using peripheral equipment for flow control can reduce the cost of reagents and increase the precision of the process.

Many methods have been used for creating microchannels, such as photo-lithography which is the most used form of lithography and allows fabrication of channels of different cross sections. Wet and dry etching is widely used to create microchannels as well. This technique uses chemical and/or physical removal of the targeted material to fabricate patterns to control the flow of microfluidics. While these techniques possess numerous disadvantages (shrinkage and deformation of the material for lithography, and low reactivity of glass for wet and dry etching) Laser-induced fabrication of microchannels provides high preciseness and a wide variety of fabrication possible shapes and geometries, and can overcome these difficulties by using ultrashort laser pulses which allows changes to be made inside transparent material and choosing the right fabrication parameters helps get rid of possible damage to the substrate (stress, deformation, etc.). That is why laser-induced microchannel fabrication is getting more widely used and far more thoroughly investigated.

Main part. Interaction of ultrashort laser beams with transparent material leads to changes in the structure of the glass substrate, which forms regions with lower density. The created regions can be processed in an etchant to remove the material forming hollow channels inside the substrate. The choice of the etchant can have a huge impact both on the shape of the channels and the properties of the substrate. Strong acids can alter the geometry of the channel's internal walls, while using weak etchants might be time-consuming and not suitable for etching long channels (more than 1cm).

We propose laser writing inside a nanoporous silicates matrix (NPSM-17) in the form of the plane-parallel plate with the free volume of pores 50% and average size of pore 17 nm. For this, a femtosecond laser (Avesta, Antaus-20W-20u/1M) operating at 1035 nm wavelength, pulse duration 220 fs and frequency up to 1 MHz was utilized. As a result, a set of channels with cross-sections 53×16 μm were fabricated. After the cleaning steps, the fabricated structures were freed of debris, providing empty space in the channel section. Additional heat treatment made it possible to change the roughness of the channels.

Also, another method for microchannel fabrication in bulk glass (DV-1) and processing the sample in KOH to provide it with porous properties was studied. The same laser was used for this method on the second harmonic with 515 nm wavelength, and channels with cross-section (2-18.5 μm) were obtained. After heating and etching steps the debris from the channels should be removed, and the glass will be with pores.

Conclusion. A study on a new method for creating microchannels was demonstrated and a recommendation of laser parameters for the fabrication process was provided. These technologies will unlock new possibilities for fabrication of microchannels inside transparent materials, which in turn helps improve the functional device of the Lab-On-a-Chip (LOC). Improving such technologies can help realize better devices for chemical and biological analysis.