Combination of additive and subtractive laser 3D microprocessing for lab-on-chip and chemical sensing applications

SUMMARY

The present technology combines additive and subtractive laser 3D microprocessing in hybrid glass/polymer microsystems, using single femtosecond laser source, thus enabling fabrication of functional structures for passive lab-on-chip and chemical sensing applications.

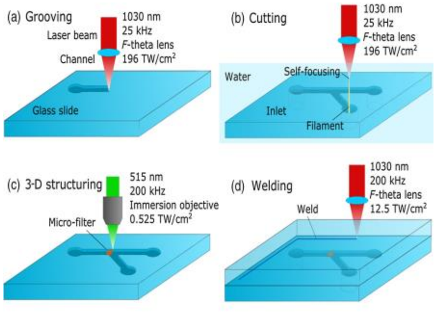
BACKGROUND

Recently, lab-on-chip devices proved to be highly functional, integrable and widely applicable. To make them more affordable to the end-users, the price of such chips must be lower. To achieve that, more simple technologies have to be used in their production, to reduce production costs. Preferably, contemporary lab-on-chip devices should also use little energy or be passive if possible.

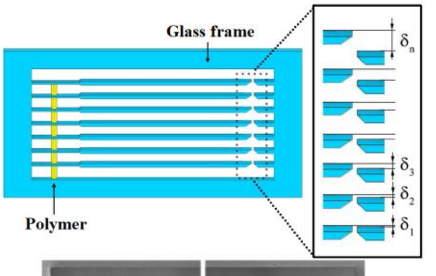
TECHNOLOGY

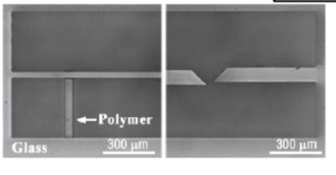
We propose a technology that combines additive and subtractive laser 3D microprocessing in hybrid glass/polymer microsystems, using single femtosecond laser source. The methods are simple and easily applicable:

1) Passive particle separator for microfluidics. First, laser ablation is used to produce microfluidic channels in the glass substrates. Then, 3D laser lithography is employed to integrate microfilters, made from hybrid organic–inorganic photopolymer SZ2080, into the channels. Finally, the chip is sealed with a glass cover by laser welding. All the steps are performed using an Yb:KGW femtosecond laser source. The integrated filters can sort microparticles (from 1 to 10 μm diameter) in water [1].



2) Passive micromechanical sensor. Laser-assisted etching is used to fabricate 3D microstructure (cantilevers) in glass. Then, via the two photon polymerization technique, a polymeric beam, made from hybrid organic–inorganic photopolymer SZ2080, is integrated between the cantilever and the fixed glass base. Polymeric beam swells or shrinks when immersed in different liquids, causing the cantilever to bend upwards or downwards. Thus cantilever acts as an amplification system and tester for investigating the elastic properties of the polymeric beam or can be used as a sensor for specific liquids [2].





TECHNOLOGY READINESS LEVEL

TRL 3 – experimental proof-of-concept demonstrated.

INTELLECTUAL PROPERTY

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PUBLICATIONS

[1] L. Jonušauskas, S. Rekštytė, R. Buividas, S. Butkus, R. Gadonas, et al. Hybrid subtractive-additive-welding microfabrication for lab-on-chip applications via single amplified femtosecond laser source. Opt. Eng. 56(9) 094108 (2017). https://doi.org/10.1117/1.OE.56.9.094108

[2] T. Tičkūnas, M. Perrenoud, S. Butkus, R. Gadonas, S. Rekštytė, et al. Combination of additive and subtractive laser 3D microprocessing in hybrid glass/polymer microsystems for chemical sensing applications. Opt. Express 25, 26280-26288 (2017). https://doi.org/10.1364/OE.25.026280

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BENEFITS

- Simple, versatile and easily applicable method of manufacturing.
- Additive and subtractive processing is done by the same single laser source, so separate fabrication steps can be integrated into one manufacturing system.
- Made from easily accessible materials – glass and photopolymer SZ2080.
- Filter meshes can be customized according to the needs.
- Particle separator and micromechanical sensor are passive, i.e. do not need external source of energy to operate.

APPLICATION

The present technology can be used in various applications:

- Lab-on-chip devices;
- Microfluidic devices for cell sorting, counting, liquid mixing and filtering;
- Biomedicine;
- Micro-optics;
- Investigation of properties of new polymeric materials and micro-elements;
- Investigation of chemical properties of liquids.

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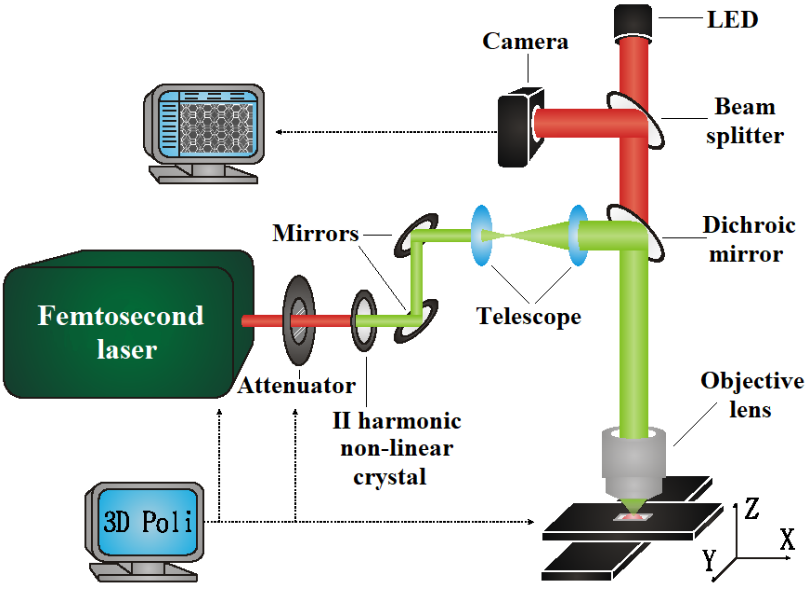
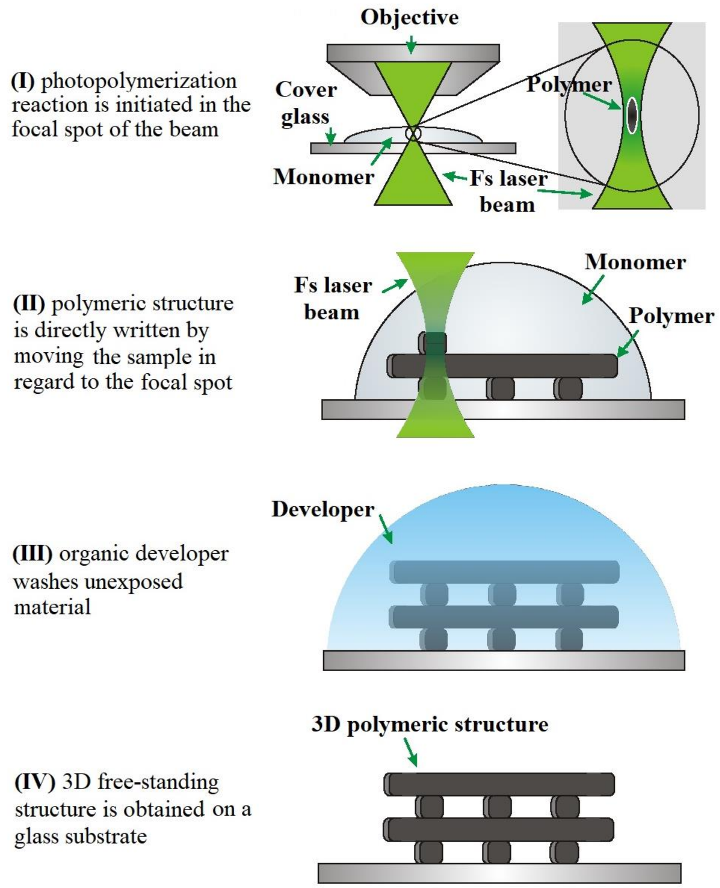
Technical information: Direct Laser Writing 3D Meso-Scale Lithography

DLW 3D MESO-SCALE LITHOGRAPHY SETUP



DLW 3D MESO-SCALE LITHOGRAPHY PROCESS



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Direct Laser Writing (DLW, a.k.a. Two-Photon Polymerization, Multiphoton Processing) 3D lithography is a technique of precise additive manufacturing, accomplished by illuminating positive-tone or negative-tone photoresists via femtosecond pulsed light. This technique allows producing features on a scale of nanometres in a photosensitive material, without the need to use complex electron beam or UV optical systems or photomasks (see DLW 3D fabrication setup).

This technique relies on a multi-photon absorption process in a material. Typically its two-photon absorption when a simultaneous absorption of two-photons of the twice longer wavelength within the ultra-confined volume within a material restricted by the focus of a laser beam. It occurs once high intensities of light are reached (typically order of TW/cm2). At the focal point of the laser beam a photochemical reaction, such as photopolymerization (photo-induced crosslinking), occurs (see I). In liquid resins, this process leads to liquid-to-solid transition (see II). By manipulating the position of the focal point in respect to volume of the modified material, e.g. by moving the stage (substrate) and/or scanning the beam, 3D structures are materialized.

After the laser 3D structuring, the unexposed resin is dissolved in a developer (see III) and the fabricated structure is revealed (see IV).

More details are available elsewhere: M. Malinauskas et al., Nanophotonics lithography: a versatile tool for manufacturing functional three-dimensional micro-/nano-objects, Lith. J. Phys. 52(4), 312 (2012)