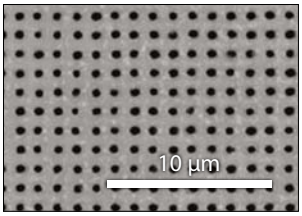
EXAMPLES OF INDUSTRIAL APPLICATIONS

STEEL FOIL M-DRILLING

- No melting
- Micron diameter

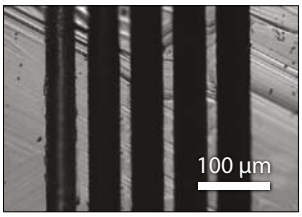


Applications:

- Filters
- Functional surfaces

DIAMOND CUTTING

- Low carbonization
- No HAZ
- Low material loss

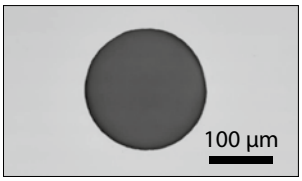


Applications:

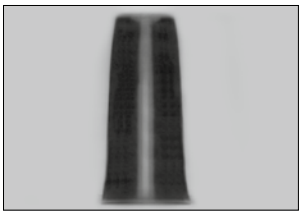
- Diamond sheet cutting
- Chip breaker formation
- Diamond texturing/patterning

GLASS HOLES

- Various hole sizes with routine tapper angle better than 5 deg
- Minimal debris around the edges of holes



Top view



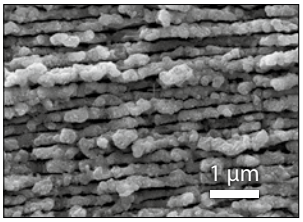
Cross-section

Application:

- Microfluidics
- VIAs

NANO RIPPLES

- Up to 200 nm ripple period fabricated using ultra-short laser pulses
- Individual nano-feature size on ripples: 10 – 50 nm
- Controlled period, duty cycle and aspect ratio of the ripples



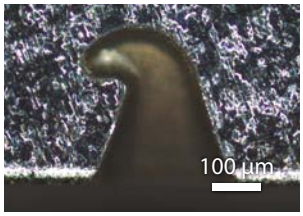
Developed in cooperation with Swinburne University, Australia

Application:

- Detection of materials with increased sensitivity using surface-enhanced Raman scattering (SERS)
- Bio-sensing, water contamination monitoring, explosive detection etc.

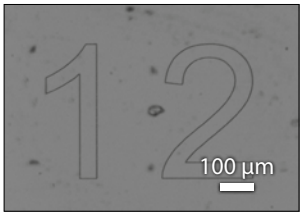
METAL MICROMACHINING

- 3D structures formed on steel surface
- High precision and surface smoothness achieved



MARKING OF CONTACT LENS

- Marking made inside the bulk of contact lens, preserving surface of lens and distortions
- Exact positioning of markings – 3D text format

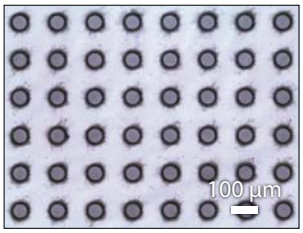


Application:

- Product counterfeit protection
- Serial number and customer identification

THIN GLASS DRILLING

- Taper angle control
- Low heat affect
- No cracking or chipping around holes

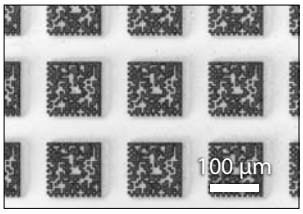


Applications:

- VIAs

DATAMATRIX

- Data inscribed on a glass surface or inside bulk
- Extremely small elements, down to 5 µm in size

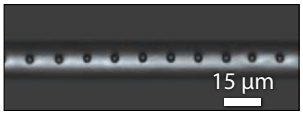


Application:

- Product marking

GLASS TUBE DRILLING

- Controlled damage and depth
- Hole diameter of few microns



Applications:

- Medical applications
- Biopsy equipment

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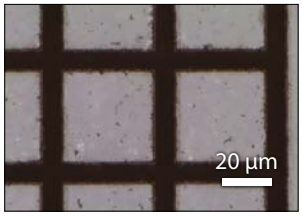
FERROELECTRIC CERAMICS ETCHING

- No or low melting and HAZ
- Easily removable debris
- Good structuring quality

Applications:

- Infrared sensors for cameras
- Memory chips

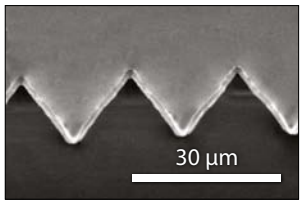


SILICON LASER ASSISTED ETCHING

- No HAZ
- No melting

Applications:

- Solar cell production
- Semiconductor industry

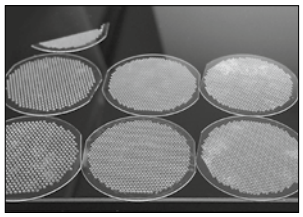


MASK FOR BEAM SPLITTER PATTERN DEPOSITION

- Borosillicate glass
- 150 um thickness
- ~900 holes per mask
- Mask diameter 25.4 mm

Appplication:

- Selective coating

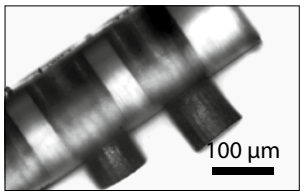


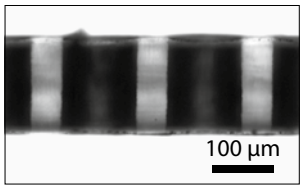
STENT CUTTING

- Holes in stent wall, cross-section view
- Polymer stent
- No heat effect, no debris
- Minimal taper effect

Application:

- Vascular surgery



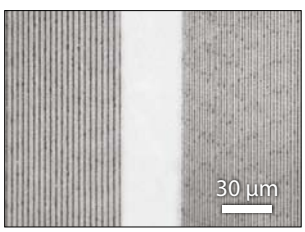


TEXTURIZED SAPPHIRE SURFACE

- Micron resolution
- Large area processing
- Single pulses used to form craters on the surface

Application:

- Better light extraction in LED
- Semiconductor structure growth



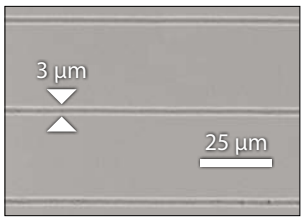
MARKING AND PATTERNING

- Smallest spots down to 3 µm in width
- Micron level positioning
- No heat effect

Metal

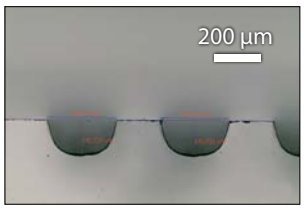
MICRO CHANNEL FORMATION

- Wide range of materials – from fused silica to polymers
- Controllable channel shape
- Low debris
- Smooth surface



Applications:

- Microfluidic sensors
- Waveguides

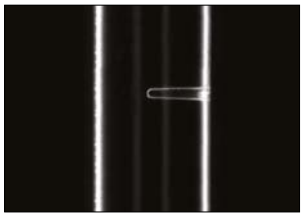


OPTICAL FIBER DRILLED TO THE CORE

- Diameter from <10 µm
- Various hole profiles possible
- Depth and angle control

Applications:

- Optical fiber sensors
- Material science

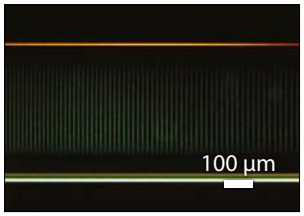


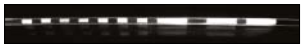
OPTICAL FIBER SCATTERING

- No impact on fiber strength
- No surface damage
- Even light dispersion

Applications:

- Medical fibers
- Oncology



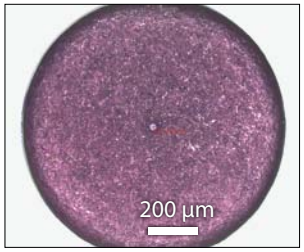


SYNTHETIC RUBY DRILLING

- No cracks after drilling
- Taper angle control

Application:

- High precision mechanical parts



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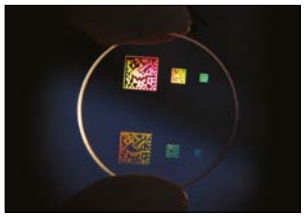
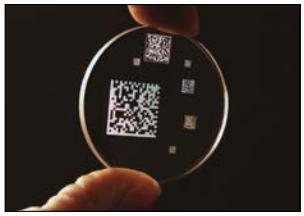
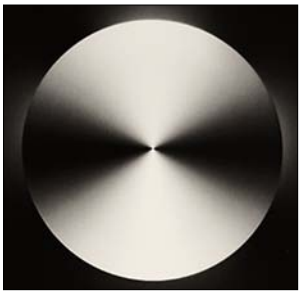
GLASS BULK PROCESSING

- Refractive index volume modification
- Bragg gratings with 99% diffraction efficiency
- Birefringent gratings/elements
- Low influence on strength of the substrate

Birefringence modification inside fused silica. Photo in crossed polarized light


Sapphire

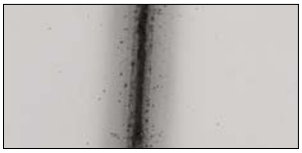

Glass

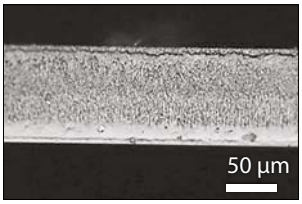

S-waveplate *

* M. Beresna, M. Gecevičius, P. G. Kazansky and T. Gertus, Radially polarized optical vortex converter created by femtosecond laser nanostructuring of glass, Appl. Phys. Lett. 98, 201101 (2011).

NON TEMPERED GLASS CUTTING

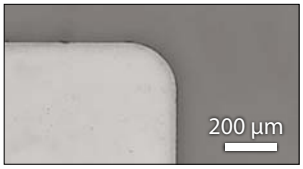
- Thickness: 0.03 – 0.3 mm
- Mechanical or heat assisted break after scribing
- Speed: up to 800 mm/s
- Any shape
- Round corners
- Surface quality: Ra ≤ 2µm





SAPPHIRE CUTTING

- Thickness: 100 – 900 µm
- Easy to break
- Circle shapes diameter: 3 – 15 mm
- Corner radius: from 0.5 mm
- Speed: up to 800 mm/s
- Cut quality: Ra ≤ 2 µm
- No surface cracks
- No or low chipping
- Non ablating process



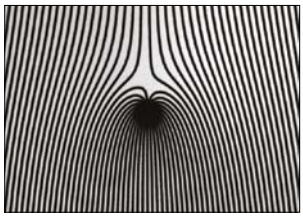
Thickness: 420 µm, clear sapphire

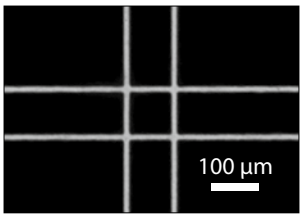
SELECTIVE METAL COATING ABLATION (REMOVAL)

- Selective ablation of metal coatings from various surfaces
- Depth and geometry of ablation may vary

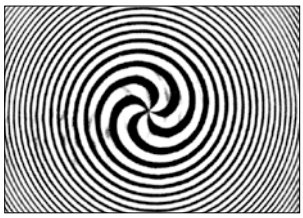
Application:

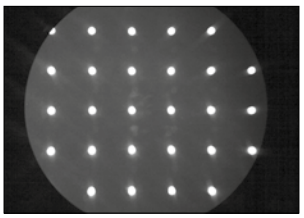
- Lithography mask production
- Beam shaping elements
- Optical apertures
- Other

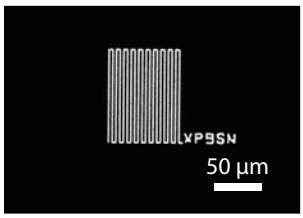

Amplitude grating formation



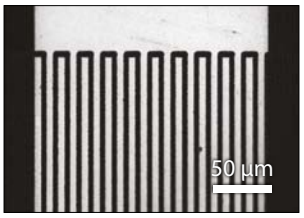
Titan coating selective ablation


Chrome ablation for beam shaping


Apperture array fabrication



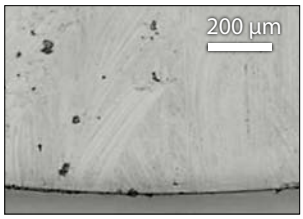
Gold layer removal without damage to MgO substrate – Au layer removal without damaging

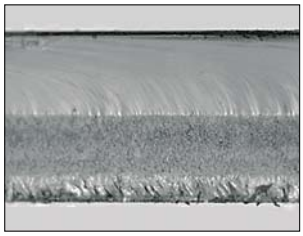


Chrome ablation from glass substrate

TEMPERED GLASS CUTTING

- Single pass process
- In bulk damage (closed cut), surface remains intact, practically no debris
- Homogeneous cut surface





Workshop of Photonics

Samples provided by
Workshop of Photonics
www.wophotonics.com

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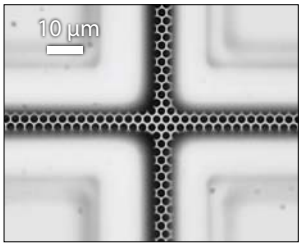
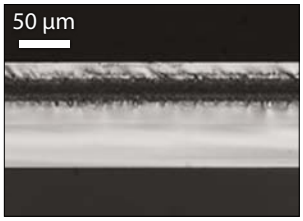
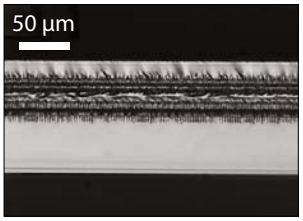
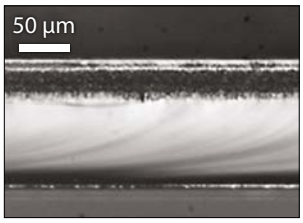
SAPPHIRE DICING FOR LED INDUSTRY

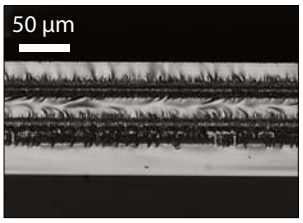
- Wafer thickness 50 to 330 µm
- Narrow street width up to ~10 µm
- Bending strength (650–900 MPa)
- High light extraction efficiency
- Controllable damage length
- Easy breaking
- Scribing with DBR coated backside of sapphire

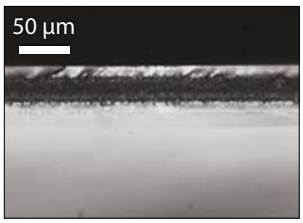


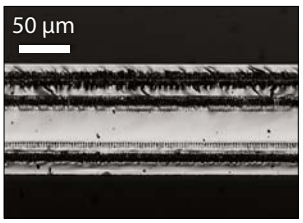










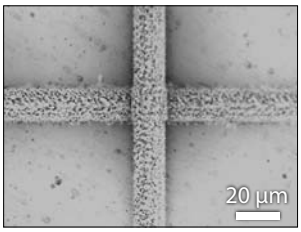


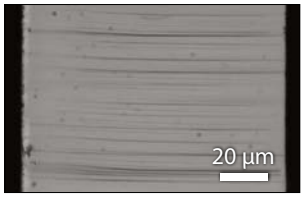
SILICON CARBIDE DICING

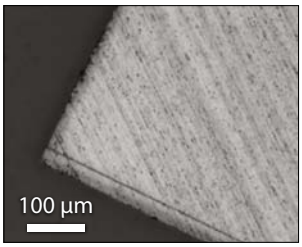
- No chipping on the edges
- Cleaved-surface roughness <1 µm
- Easy breaking

Applications:

- High power, high frequency electronics







Samples provided by
Evana Technologies
www.evanatech.com

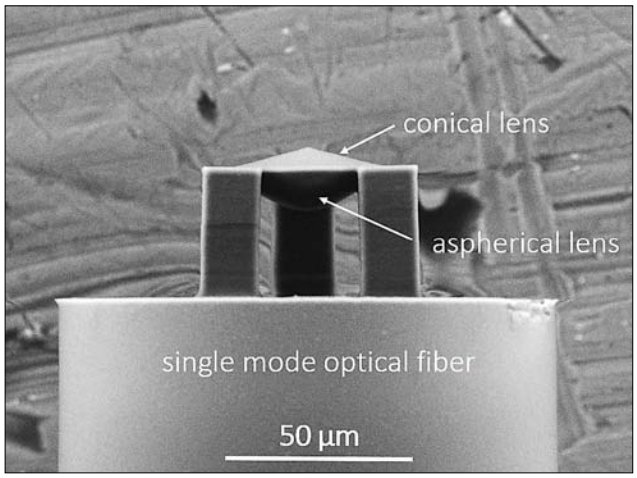
MULTI-PHOTON POLYMERIZATION

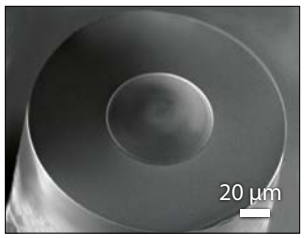
Multi-photon polymerization (MPP) is a unique method allowing the fabrication of 3D microstructures with a spatial resolution of the order of 100 nm. MPP technology is based on non-linear absorption at the focal spot of a tightly focused femtosecond laser beam, which induces well confined photopolymerization reactions. <290 fs pulses at >100 kHz repetition rates are advantageous for material modification via avalanche ionization – enabling fabrication of materials ranging from hybrid composites to pure proteins.

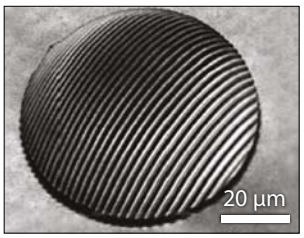
APPLICATION IN MICRO-OPTICS

Most of the photopolymers used in MPP technology are transparent in the visible range and could be directly applied in various micro-optical applications. Various mechanical as well as optical properties can be tuned.

Examples: prisms, aspherical lenses, lenses on the tip of an optical fiber, multi-lens arrays, vortex beam generators, diffractive optical elements, etc.







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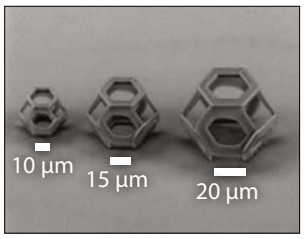
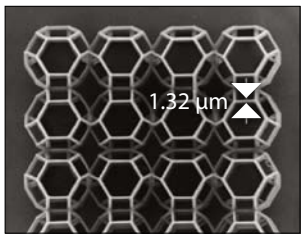
M. Oubaha et al. Novel tantalum based photocurable hybrid sol-gel material employed inthe fabrication of channel optical waveguides and three-dimensionalstructures, Appl. Surf. Sci. 257(7), 2995–2999 (2011).

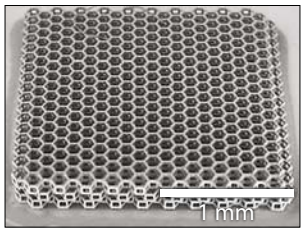
APPLICATION IN BIOTECHNOLOGY AND REGENERATIVE MEDICINE

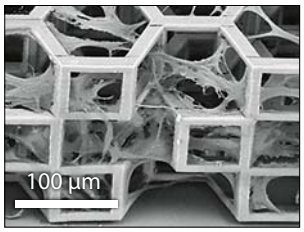
MPP technique can be realized in biocompatible and even biodegradable materials, thus it is a perfect platform for regenerative medicine research and applications.

Examples: 3D polymeric scaffolds for cell growth and tissue engineering, drug delivery devices, micro-fluidic devices, cytotoxic elements.







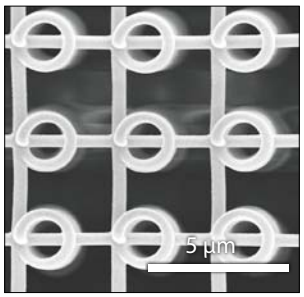


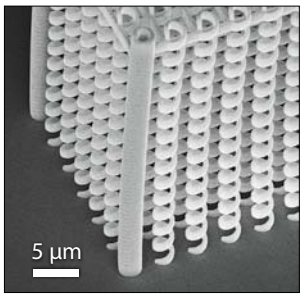
M. Malinauskas et al. 3D artificial polymeric scaffolds for stem cell growth fabricated by femtosecond laser. Lithuanian J. Phys., 50 (1), 75-82, (2010).

APPLICATION IN PHOTONICS

Highly repeatable and stable technological process enables the fabrication of various photonic crystal devices for controlling spatial and temporal properties of light at micrometer distances.

Examples: photonic crystal spatial filters, supercollimators, structural colours, etc.





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V. Purlys et al. Spatial filtering by chirped photonic crystals, Phys. Rev. A 87(3), 033805 (2013).

V. Purlys et al. Super-collimation by axisymmetric photonic crystals,Appl. Phys. Lett. 104(22), 221108 (2014).

V. Mizeikis et al. Realization of Structural Colour by Direct Laser Write Technique in Photoresist, J. Laser Micro Nanoen. 9(1), 42 (2014).

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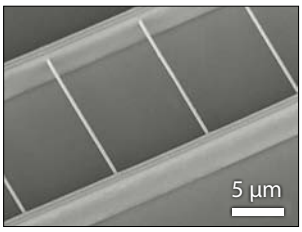
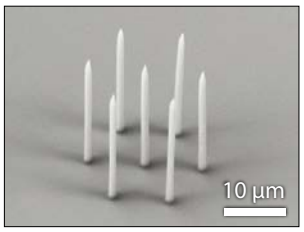
APPLICATION IN MICROMECHANICS

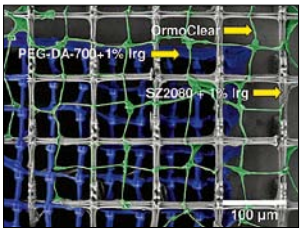
MPP technology gives the user ability to create multiscale and multimaterial 3D objects out of substances with various physical, chemical, and biological properties.

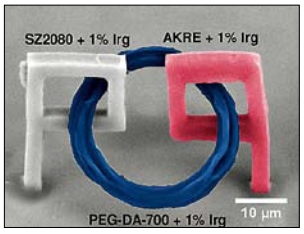
Examples: cantilevers, valves, micro-pore filters with controllable pore sizes, mechanical switches. [1)]





Examples of multicomponent structures. [2)]



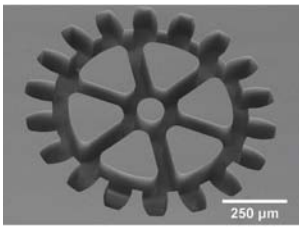


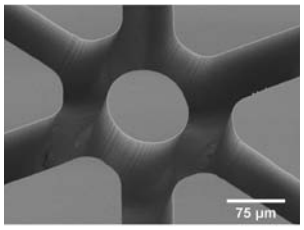
[1)] V. Purlys, Three-dimensional photonic crystals: fabrication and applications for controlof chromatic and spatial light properties, Ph.D. Thesis. Vilnius University: Lithuania (2015).

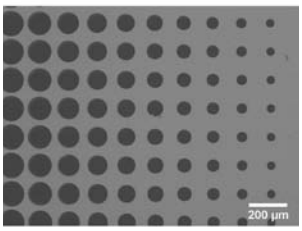
[2)] M. Malinauskas et al. Ultrafast laser processing of materials: from science to industry, Light: Sci. Appl., to be published, (2015).

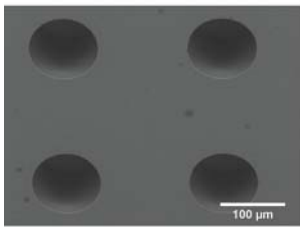
LASER ASSISTED SELECTIVE ETCHING

Can be applied in microoptics, micromechanics, medical engineering, etc.

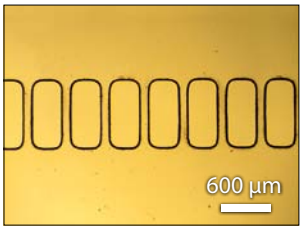


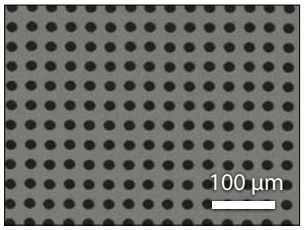






LASER ABLATION

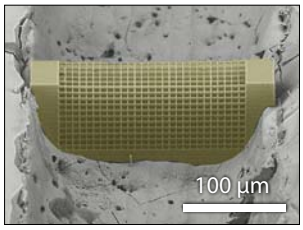


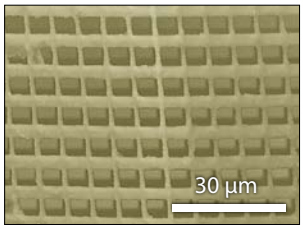


Hybrid microfabrication

ABLATION AND LITHOGRAPHY

Laser ablation allows a rapid production of glass channels while 3D laser lithography is used to integrate fine-mesh filters inside the channels. Then whole system is then sealed by laser welding.





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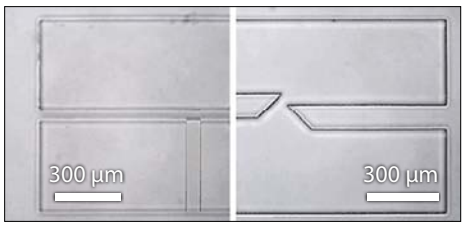
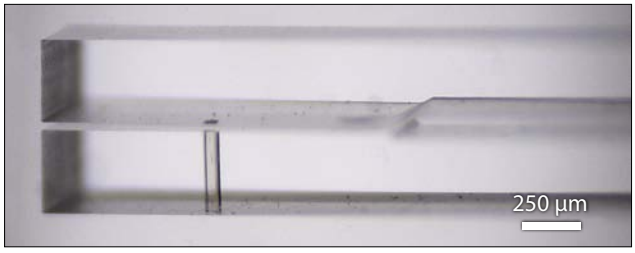
ETCHING AND POLYMERIZATION

Combining selective laser etching and photopolymerization allows manufacturing of cantilevers for sensing applications.





Tičkūnas et al., Opt. Express, 25(21), 26280-26288 (2017).

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