HYBRID ADDITIVE-SUBTRACTIVE FEMTOSECOND 3D MICROFABRICATION SYSTEMS AND SERVICES

femtika

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ABOUT FEMTIKA

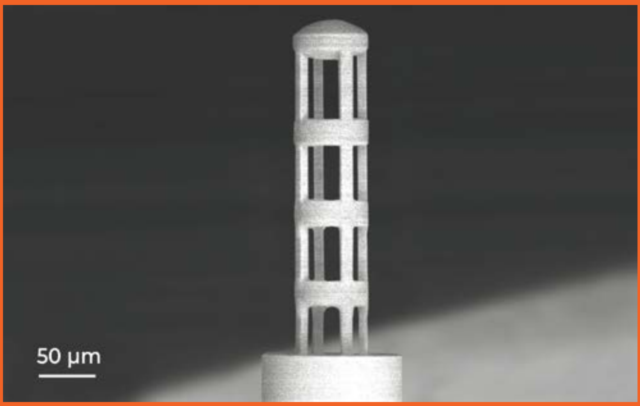
FEMTIKA is a leading provider of advanced laser technology solutions in multiphoton polymerization and selective laser etching. Our cutting-edge technology allows for precise and efficient processing in a wide range of industries, including microelectronics, medical devices, and aerospace engineering.

Founded in 2013, our team of experienced scientists and engineers have been at the forefront of laser technology research and development. Our commitment to innovation and excellence has led to the development of unique and highly effective laser solutions that deliver superior results.

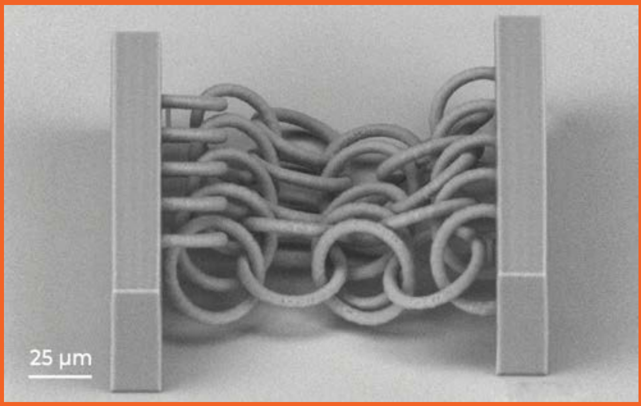
Our state-of-the-art facility is equipped with the latest equipment and technology, allowing us to provide our clients with the highest level of service and support. We also offer comprehensive training and technical support to ensure that our clients have the knowledge and tools they need to achieve their goals.

At FEMTIKA, we are dedicated to providing our clients with the best laser technology solutions available on the market. We strive to exceed our clients' expectations and help them achieve success in their industries.

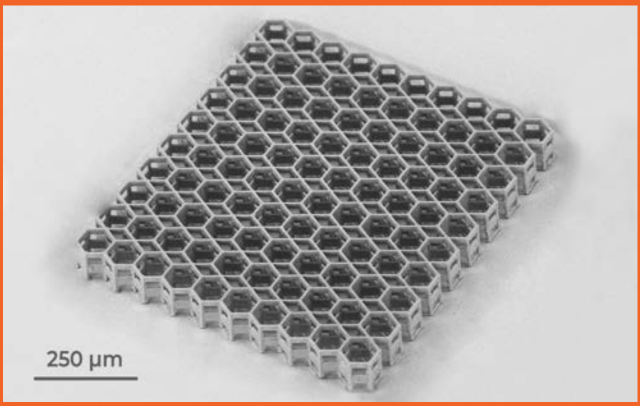
The company belongs to the European Photonics Industry Consortium (EPIC), the TOOLAS cluster, and the Lithuanian Laser Association.



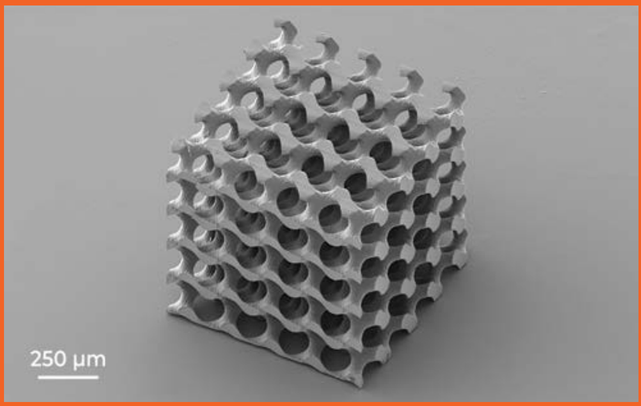
3D Structures on Fiber Tip



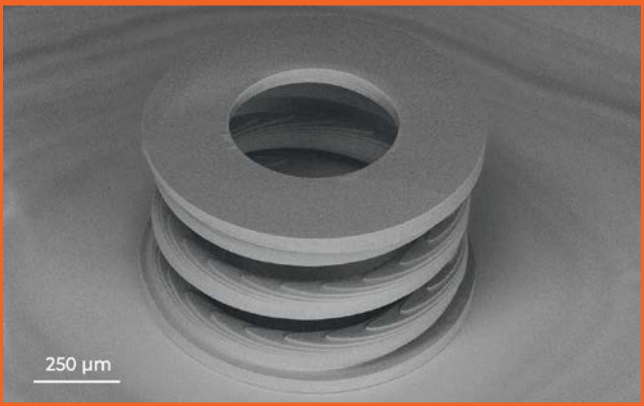
3D Chain-Mail Structure



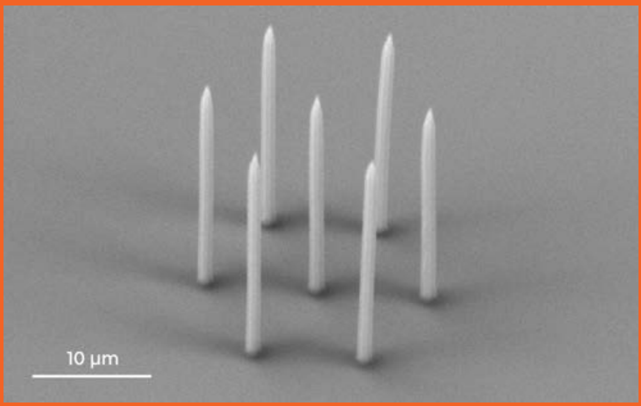
3D Scaffold



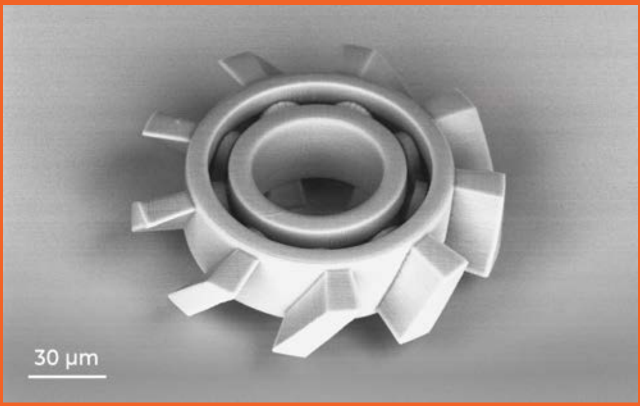
3D Gyroid Structure



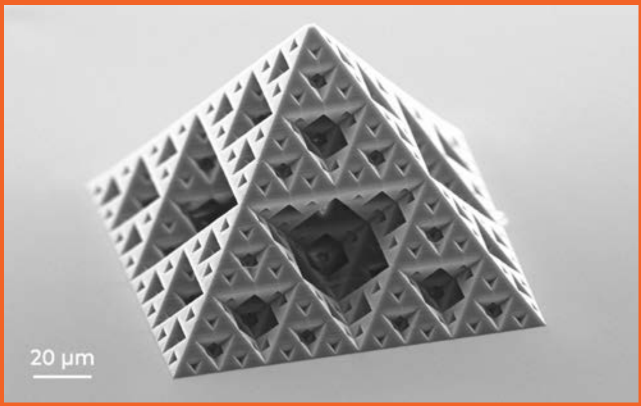
3D Meso-Spring



Microneedles



3D Scaffold



3D Gyroid Structure

MULTIPHOTON POLYMERIZATION

APPLICATIONS

- Micro-optics
- Micro-mechanics
- Scaffolds
- Sensors
- Interconnects

FEATURES

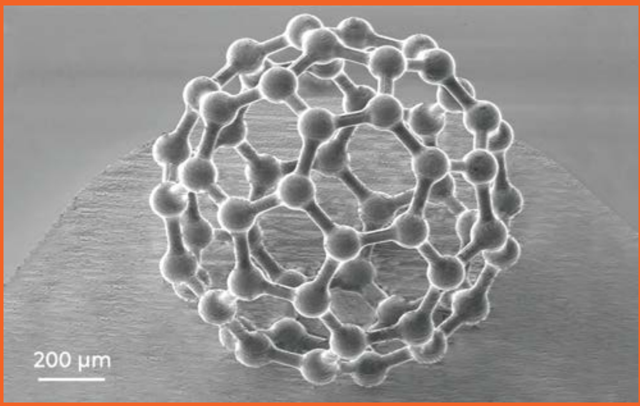
- Nanometer resolution additive manufacturing technique
- True 3D structures in micrometer scale
- Various polymers available
- Stitching error-free manufacturing

Multiphoton-polymerization (MPP) is a technology that enables the production of arbitrary shape polymeric structures within submicrometric resolution. First, a photoresist sample is prepared by drop-casting polymer material mixed with a photoinitiator on the glass slide and then pre-baking. Afterward, the 3D microstructure is fabricated using a direct laser writing technique. Consequently, the polymer hardens in places of drop where it is affected by laser radiation due to a process called photopolymerization. Finally, the microstructure is immersed in an organic solvent to develop an unpolymerized photoresist.

MPP is often used in the manufacturing of microelectronic devices, as it allows for the creation of very small and detailed structures with high levels of precision. Additionally, because the light is highly focused, it can be used to create complex 3D shapes.

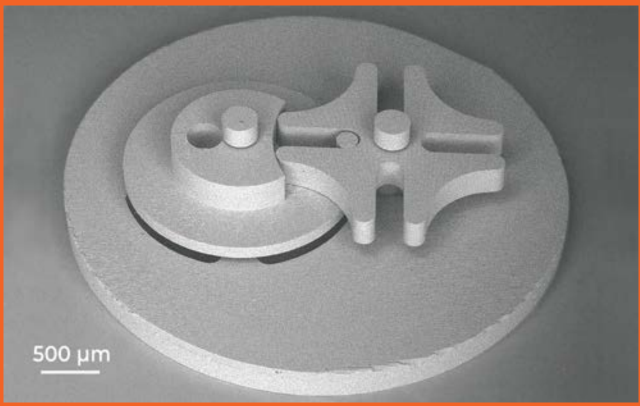
SPECIFICATIONS

Technology	Additive manufacturing
Materials	SZ2080, SU-8, Ormocers, Glassomer, hybrid organic-inorganic photopolymers, elastomers, proteins
Minimum XY feature size	150 nm
Minimum surface roughness Ra	≤ 20 nm
Maximum fabrication speed	30 mm/s

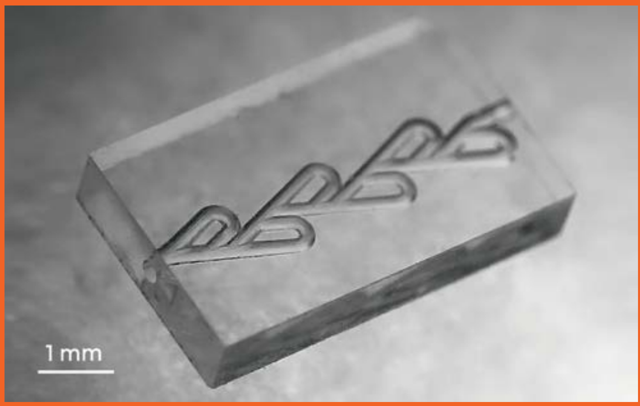


3D Glass Structures

3D Nozzle

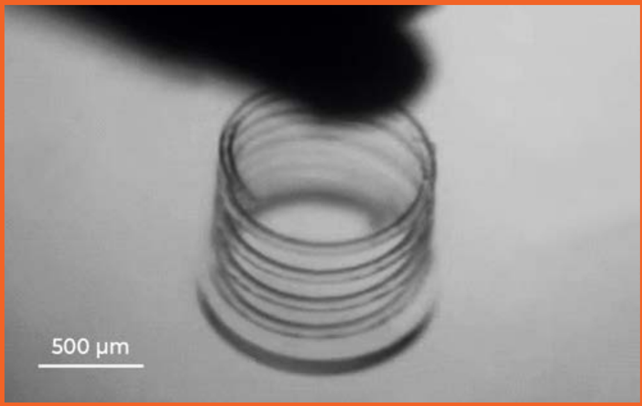


Geneva Gear



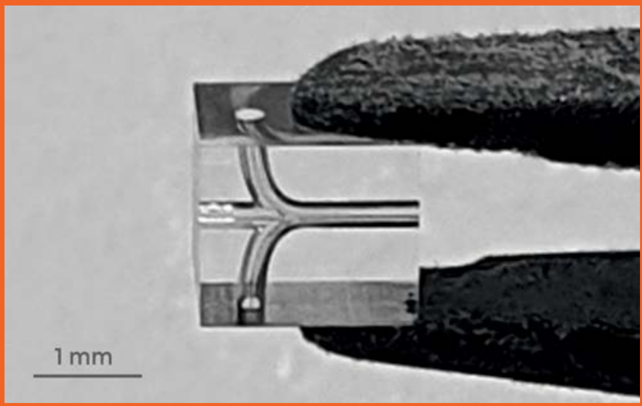
Tesla Valve

Micro Channels Formation



Threads for Screw

3D Gears Mechanisms



3D Interconnect Channels

SELECTIVE LASER ETCHING

APPLICATIONS

- Micro-mechanics
- Micro-fluidics
- LAB-ON-CHIP

FEATURES

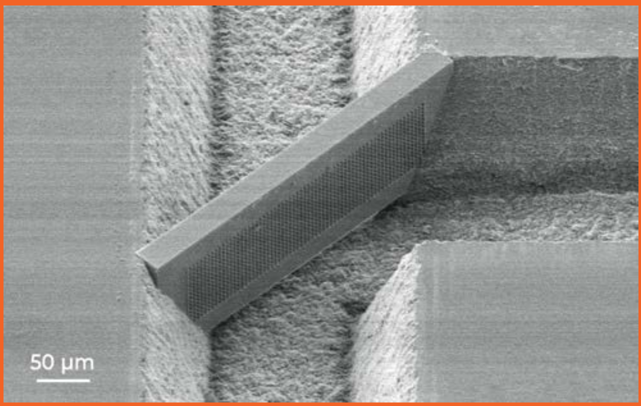
- Subtractive manufacturing technique
- Arbitrary-shaped 3D structures from glass μm to cm scale
- Various glasses applicable
- Self-alignment system for automatic laser beam alignment
- Micrometer feature resolution

Selective laser etching (SLE) is a subtractive laser technology allowing fabrication of complex-shape 3D glass parts with micrometer precision. This technology consists of two fabrications steps: femtosecond laser irradiation and subsequent chemical etching. Tightly focused femtosecond laser beam induces modifications of transparent material within the focal point of laser beam. By spatially moving the laser focus well-defined structure is written in point-by-point fashion up to substrate surface. Afterward, the sample is immersed in etchant solution, which etches out laser modified areas.

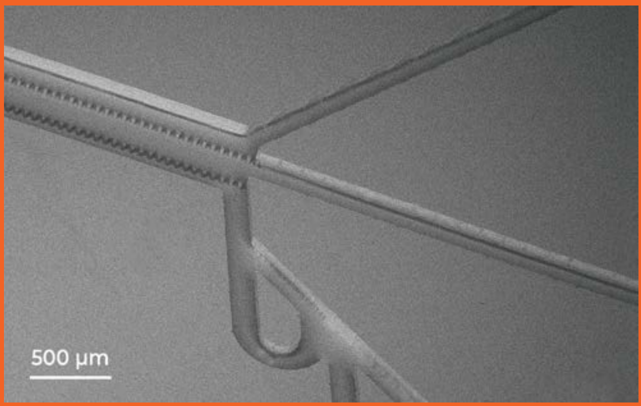
SLE is often used in the manufacturing of electronic devices and other precision components, as it allows for high levels of accuracy and detail in the etched patterns. Additionally, because the laser beam is highly focused, it can be used to etch very small and intricate designs.

SPECIFICATIONS

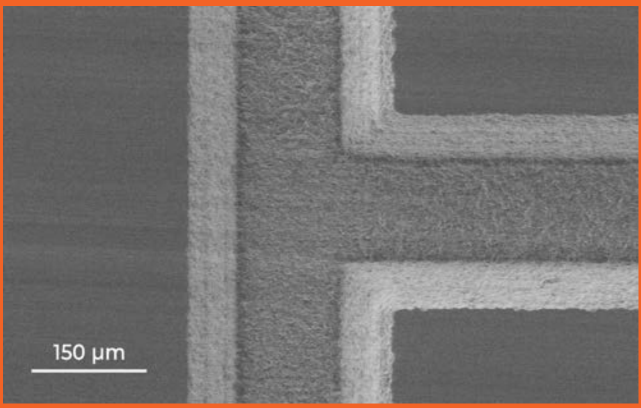
Technology	Substractive manufacturing
Materials	Fused silica, Borofloat 33
Smallest feature size	> 1 μm
Minimum surface roughness	< 200 nm
Maximum object height	1 cm
Aspect ratio	> 1 : 200
Minimum micro hole diameter	5 μm
Writing speed	50 mm/s



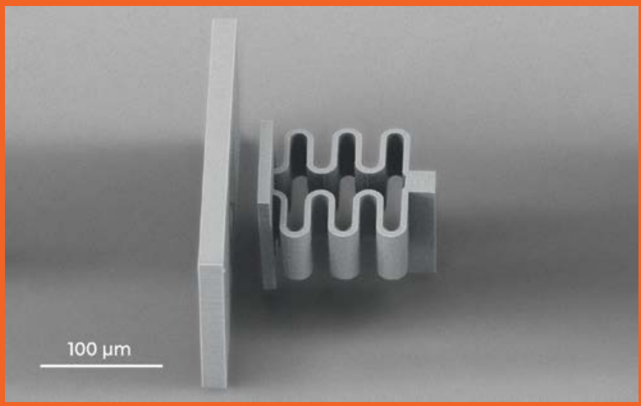
Lab-on-Chip Device



Liver-on-Chip

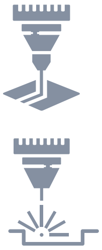


Lab-on-Chip Device



Micromechanical Sensor

HYBRID FABRICATION



APPLICATIONS

- Micromechanics
- Lab-on-Chip
- Microfluidics
- Sensors

FEATURES

- Additive and subtractive techniques combined in one Laser Nanofactory system
- Arbitrary-shaped 3D structures from micrometers to centimeters scale
- Fast switch from additive to subtractive microfabrication
- Customizable configuration – integrate additional devices

Femtosecond lasers are extremely versatile tools allowing a great variety of different microfabrication processes. Each process has its own requirements for laser, beam delivery or material parameters. Our Laser Nanofactory workstation allows **hybrid fabrication**, meaning that various processes are supported by the same equipment. The two of our most frequently used processes are multiphoton polymerization and selective glass etching, however that is far from all! By precisely tuning its parameters the same machine is capable to perform more processes including:

- Refractive index modification of transparent materials
- Micro-ablation
- Surface structuring
- Micro-welding

In addition, Laser Nanofactory is a modular system, allowing further adaptation to your application. It supports various sample holders (e.g. for microscope slides, wafers, fibers) and different fabrication heads, optimized for your desired laser applications.


LaserShield
StereoBlue
euromex

CONTRACT MANUFACTURING

Femtika's contract manufacturing process begins with a thorough assessment of the client's requirements and a comprehensive design consultation. Our team of experts provides valuable recommendations and design suggestions tailored to the client's manufacturing needs. Once the design is finalized, Femtika utilizes state-of-the-art femtosecond laser systems to create accurate and precise prototypes, which undergo outstanding testing and validation against the client's specifications. With the successful completion of prototyping, the manufacturing process transitions to large-scale production, where Femtika's advanced femtosecond laser capabilities enable efficient fabrication with high throughput and minimal production time. Throughout the process, strict quality assurance measures are implemented, including inspections and performance testing, to ensure that the manufactured products meet the desired standards. Finally, the products are securely packaged and delivered to the client's location in a timely manner. By following this comprehensive process, Femtika ensures highest quality and satisfaction for their clients in femtosecond laser technology-based contract manufacturing.

Feasibility Study

- Research of micro-structure fabrication method
- Fabrication of microstructure prototype
- Measurement and alignment with technical requirements
- Study report preparation

Development

- Development of micro-structure fabrication process
- Development of mass production fabrication design
- Development of needed machinery and automation

Laser Nanofactory Station

- Evaluation of site requirements and site preparation
- Machinery manufacturing
- Installation on site
- Training of users

Small Scale Production

- Evaluation of repeatability
- Optimization of fabrication process
- Fabrication report preparation


LASER NANO FACTORY
femtika

LASER NANOFACTORY WORKSTATION

TECHNICAL SPECIFICATIONS

Technology		Multiphoton Polymerization			Selective Laser Etching	Hybrid

LASER SOURCE

Femtosecond laser	Wavelength	780 nm	1030 ± 10 nm 515 ± 10 nm		1030 ± 10 nm	1030 ± 10 nm and 515 ± 10 nm
	Repetition rate	100 MHz	11 MHz ... 76 MHz	Single-shot – 1 MHz	Single-shot – 1 MHz	Single-shot – 1 MHz
	Pulse duration	< 100 fs	50 fs 120 fs 170 fs	290 fs – 20 ps (tunable)	250 fs (450 fs) – 10 ps (tunable)	190 fs – 10 ps (tunable)
	Max. average power	250 mW	2 W	5 W	10 W	from 5 W to 20 W*
	Long-term power stability	< 0.5% RMS over 24 h	< 0.5% RMS over 100 h			

POSITIONING

Linear stages with synchronized Galvano scanners	XYZ POSITIONING STAGES MOUNTED ON GRANITE BASE WITH BRIDGE	
	Travel (XYZ)	160 mm × 160 mm × 60 mm *
	Accuracy (XYZ)	± 300 nm
	Resolution (XYZ)	1 nm
	Maximum speed (XY)	200 mm/s
	GALVANO SCANNERS	
	Accuracy	50 μrad
	Repeatability	0.4 μrad RMS

OTHER PARAMETERS

Monitoring on time	The fabrication process is monitored by an integrated machine vision system		
Stitching	Stitchless fabrication using Infinite Field of View (IFoV)		
Focusing optics	Objectives – from 0.4 to 1.4 NA *	Objectives – from 0.25 to 0.45 NA *	Objectives – from 0.25 to 1.4 NA *
Autofocus system	Automatic glass/polymer or glass/air interface optical detection		
Self-Align-System (SAS)	Automatic laser beam path alignment system		
Substrate	Universal vacuum sample holder with computer-controlled, position synchronized illumination for transparent samples		

Technology	Multiphoton Polymerization	Selective Laser Etching	Hybrid
Beam delivery & control	Motorized attenuator, polarization rotator, beam expander. Integrated power meter enables real-time power monitoring		
Software	Convenient control of all necessary process parameters and machine settings. The software handles standard formats of 3D designs created by popular CAD programs, like STL		
Laser safety	Ergonomic housing to ensure laser safety class 1 and environment stability conditions for laser microfabrication process		

* Customizable.

PHYSICAL DIMENSIONS

Dimensions when all doors are closed (W × L × H)	1790 mm × 920 mm × 2270 mm
Dimensions when doors are opened (W × L × H)	2680 mm × 1900 mm × 2300 mm
Weight	~ 700 kg

ENVIRONMENTAL & UTILITY REQUIREMENTS

Operating temperature	20 °C ± 2 °C
Relative humidity	≤ 60%
Electrical requirements	110 V AC, 20 A – 230 V AC , 10 A
AC power (normal operation)	typical 2 kW

The conditions of the environment are preferred to be as stable as possible.

DRAWINGS

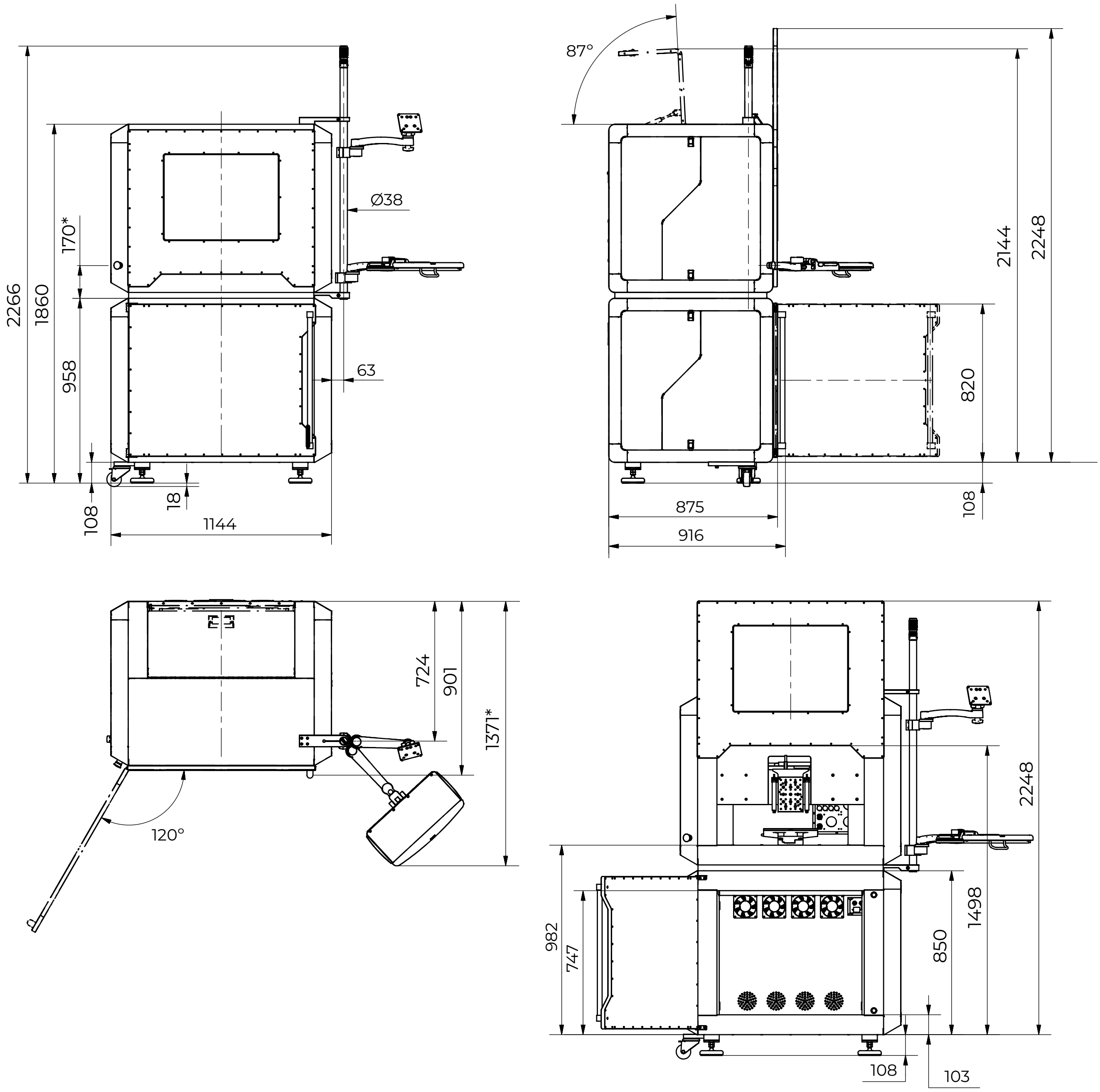


Figure 1. Laser Nanofactory dimensions in milimeters

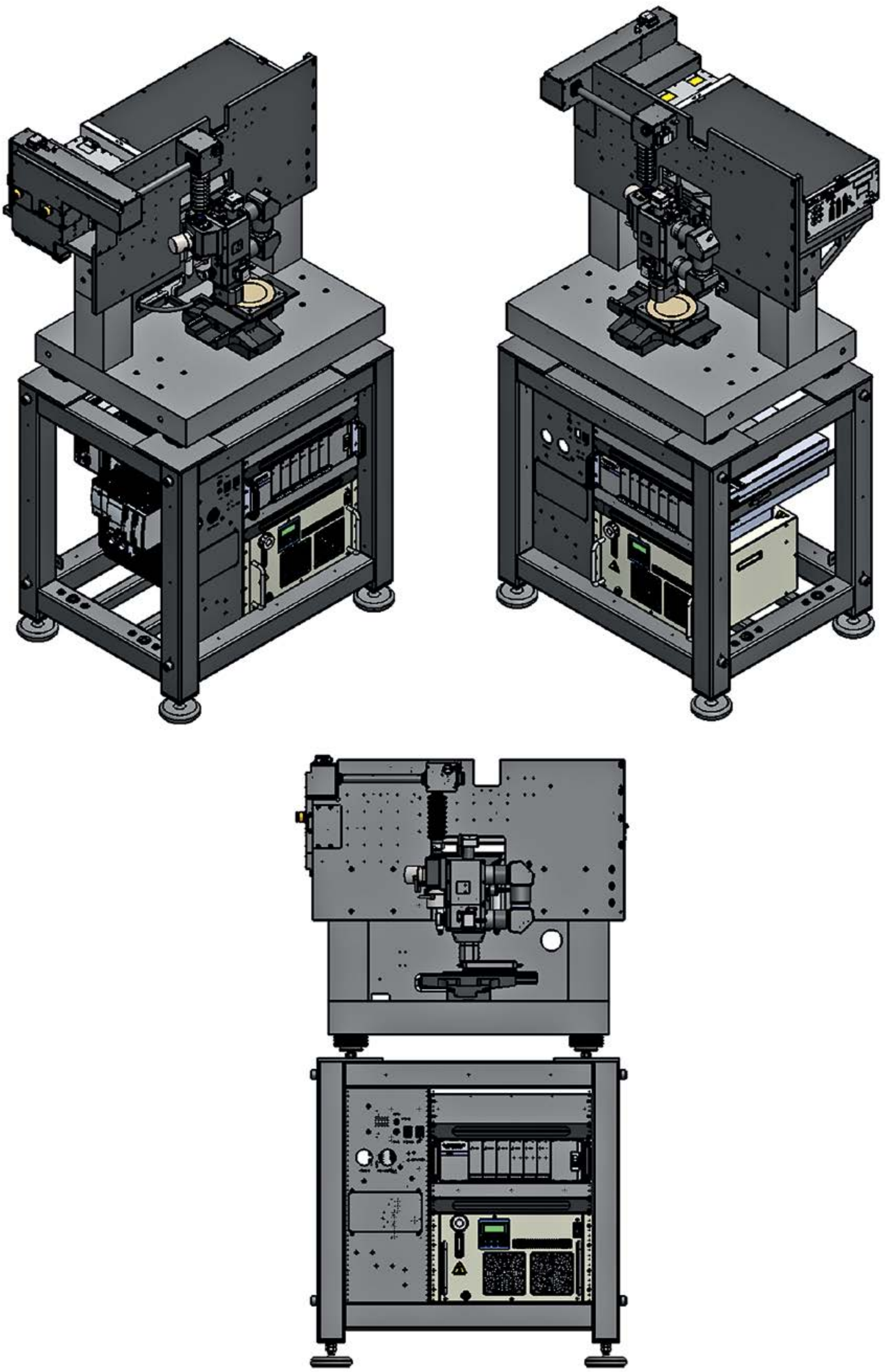
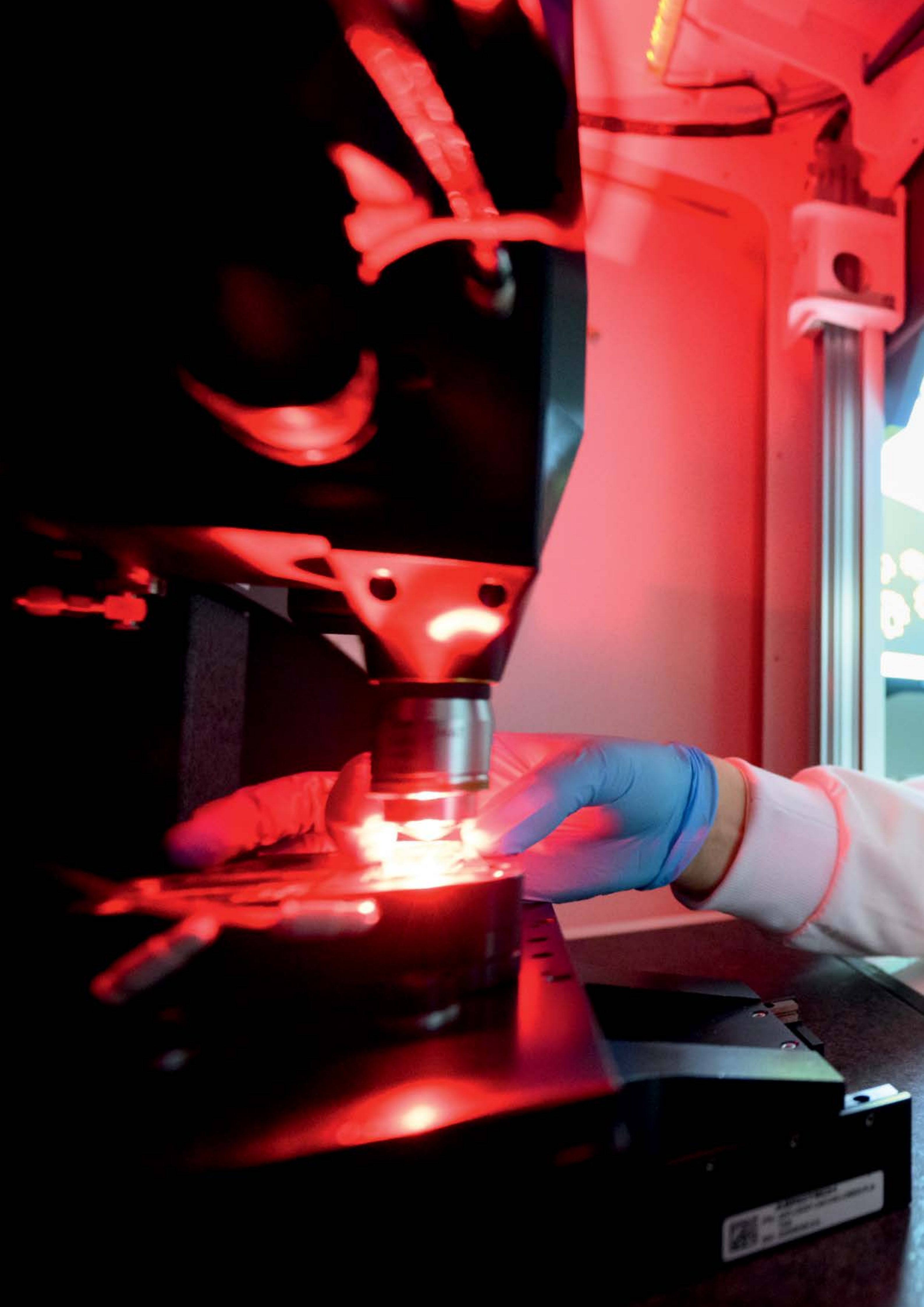
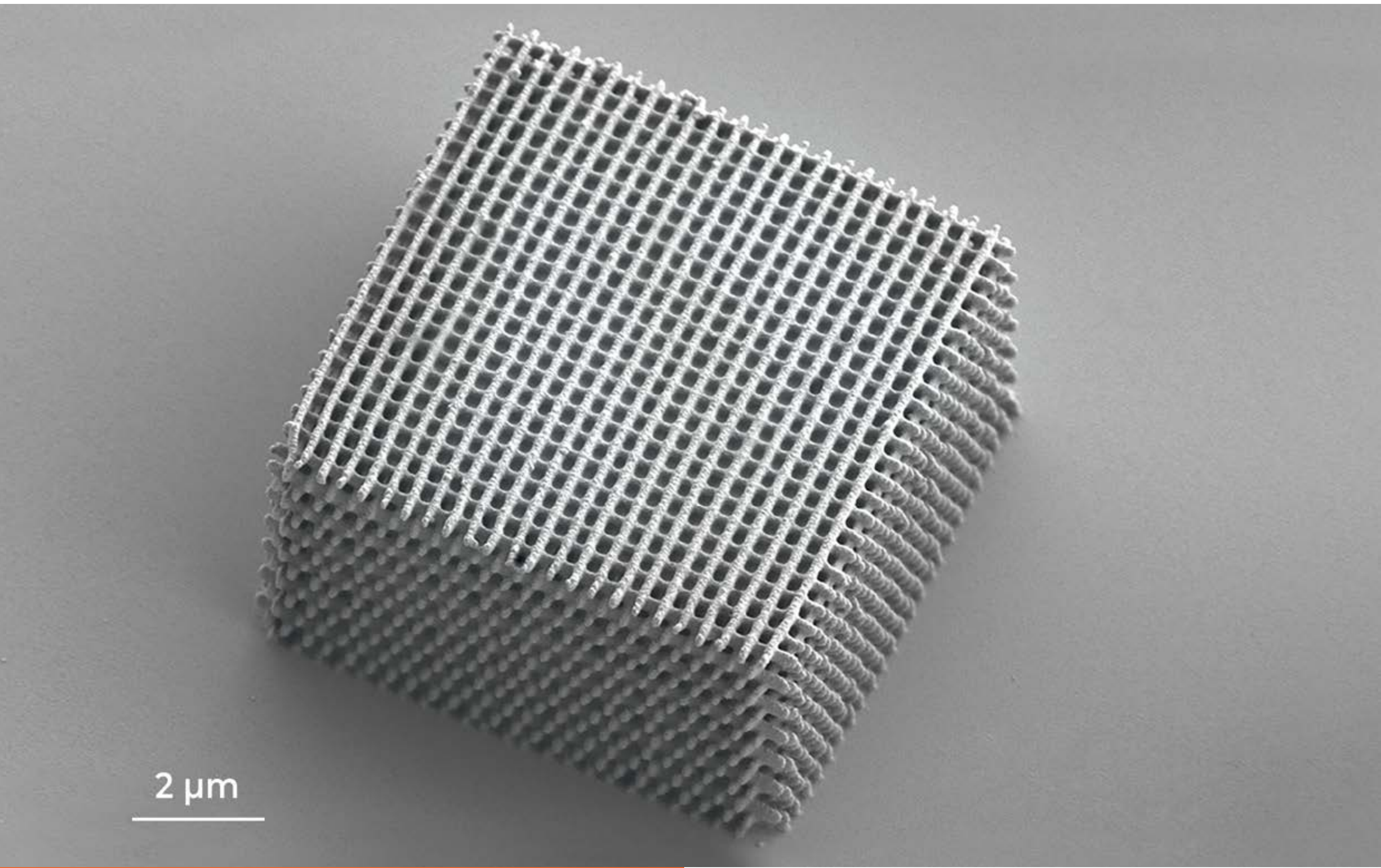


Figure 2. Laser Nanofactory drawings



TECHNOLOGIES & APPLICATIONS

MULTI-PHOTON POLYMERIZATION



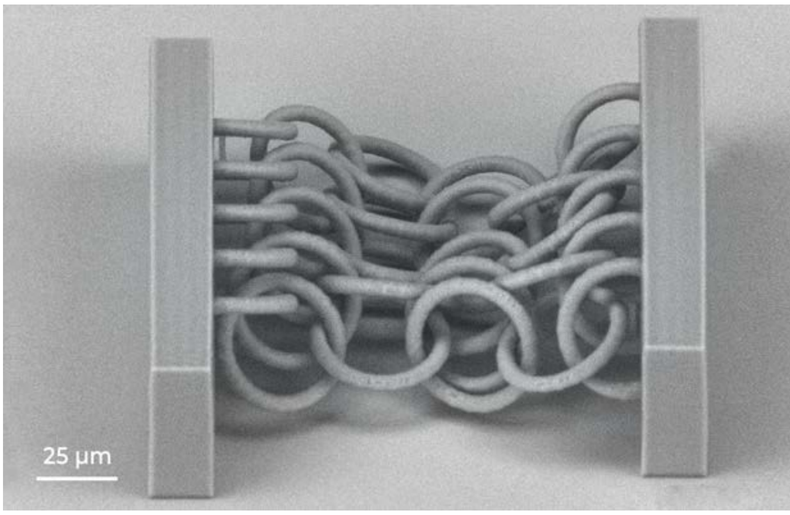
Microfabrication by multi-photon polymerization is a direct laser-write technique which allows 3D structuring of photopolymers at the micro- and nano-scale. This can be achieved through combination of various nonlinear effects, careful consideration of laser radiation parameters and precise focusing conditions. For this reason 3D laser lithography was used for creation of functional devices in fields of nanophotonics, microoptics, microfluidics, micromechanics, tissue engineering and much more. It is important to note, that there is huge variety of materials that can be processed by applying 3D laser lithography, including hybrid organic-inorganic photopolymers, biodegradable polymers, elastomers, proteins and so on.

PHOTONIC CRYSTAL

Photonic crystals is one application for multiphoton polymerization (MPP). The MPP technique enables the production of arbitrary shaped 3D structures from various polymers. The single linewidth of the woodpile photonic crystal shown in the illustration is lower than 200 nm. As the dimensions of the feature resolution could be comparable to the wavelength of visible light, alternating periodic structures such as photonic crystals can be made which can serve for modulating the light path. Various photonic devices can be made by employing MPP.

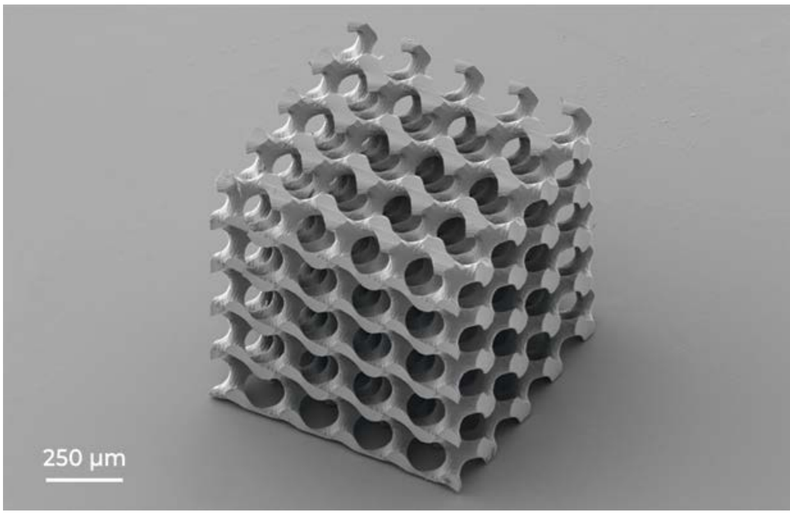
3D CHAIN-MAIL STRUCTURE

Functionally intertwined geometries such as chain mail make it possible to create flexible structures out of hard material. Standard 3D printing does not enables printing of movable structures because supports are required to maintain the shape. Meanwhile, structures can be fabricated inside a gel or liquid monomer by using the multiphoton polymerization technique which makes support-free 3D printing possible. In this way, movable assembly-free structures can be created. This property opens up the possibility of producing free micromechanical structures that could be used in various fields such as micromechanics and microrobotics.



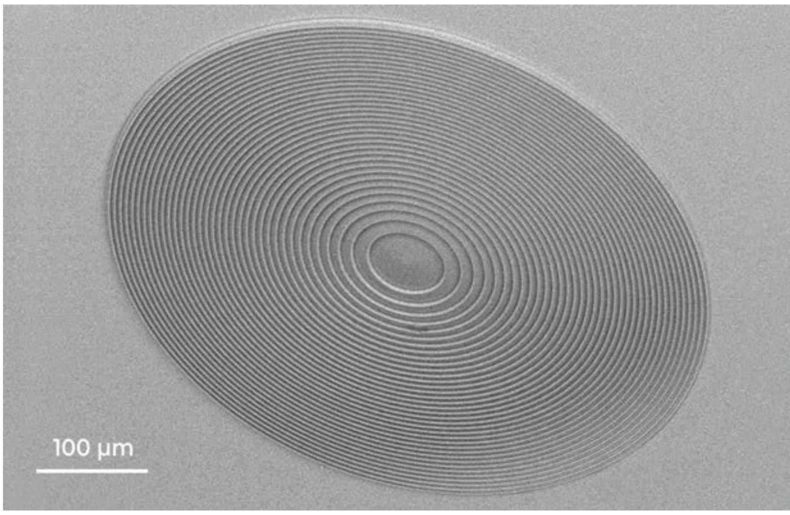
3D GYROID STRUCTURE

Multi-photon polymerization is a suitable technology for meta-material fabrication. Metamaterials are composites whose physical properties are different from those of the materials they are made from. The 3D gyroid structure is mechanically rigid, but light. The structure is fabricated by using the widened objective working (WOW) distance approach, with which the working distance of the high numerical aperture objective can be increased. The overall size of this structure – is 1 mm × 1 mm × 1 mm. The structure height is much greater than the working distance of the objective used (0.19 mm). This microfabrication technique makes it possible to fabricate mesoscale structures – structures whose total size is a few orders larger than their finest feature.

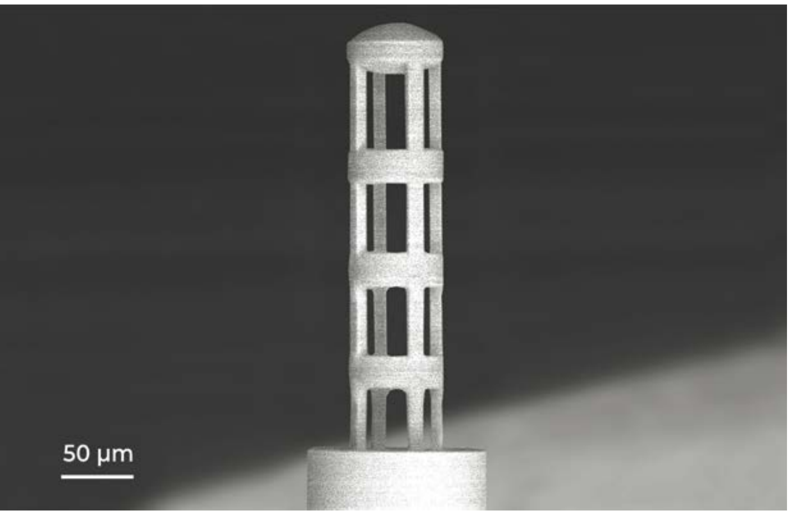


FRESNEL LENS

Microoptics is one of the applications for multi-photon polymerization (MPP) technology. Using this technology, polymeric structures with a resolution of hundreds of nm can be obtained. Due to the accuracy of the technology, micro-optical structures of complex shape such as Fresnel lenses can be fabricated. In this way, a Fresnel-like lens with a varying aspherical profile can be produced. The illustrated lens has a diameter of 500 um. Superb nearly spherical aberration-free focusing can be obtained in each Fresnel zone. Microoptics can be used in various optics and photonics applications for the purpose of miniaturization.

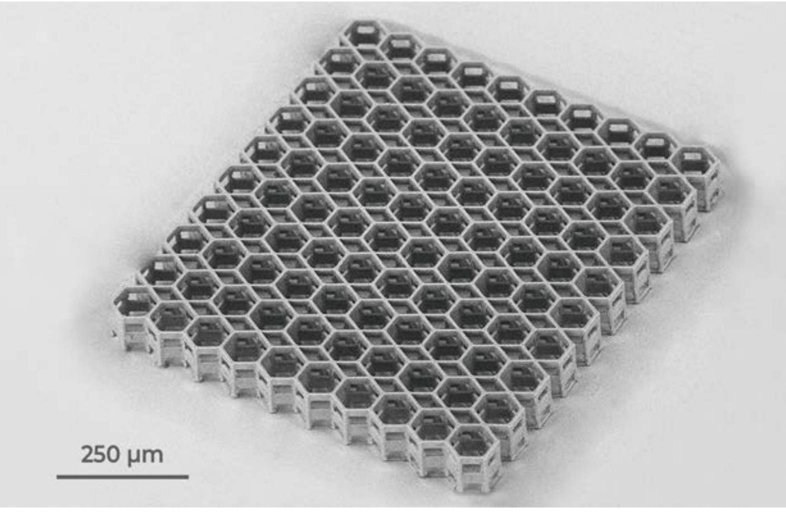


3D STRUCTURES ON FIBER TIP



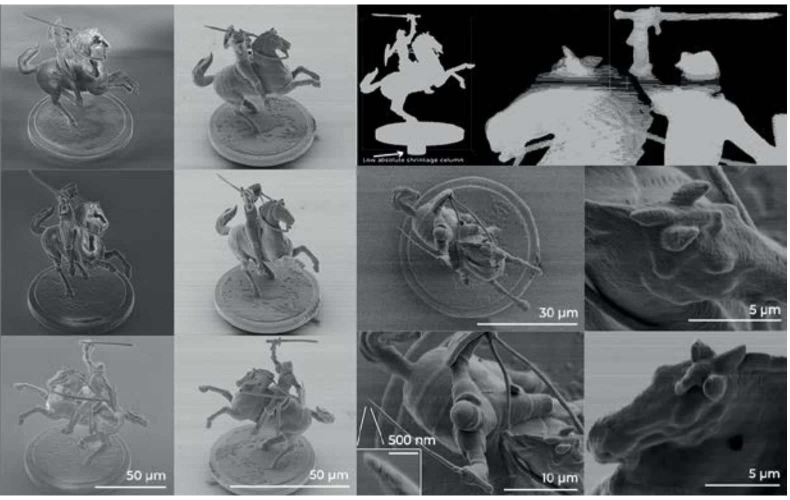
Microoptics is one of the applications for 3D laser lithography. This technology is unique in that micro-optics can be directly printed on top of functional devices, avoiding the assembly step. In this picture, the microlens with a diameter of 50 um is fabricated on top of the fiber. The 3D supports ensure a required 250 um distance between the fiber tip and the lens. Such integrated optical components enable the visualization or filtering of optical signals. Possible application areas can be found in miniaturized sensing technologies.

3D SCAFFOLD



One of the challenges in tissue engineering is the need for cell-size cages where cells can be encapsulated. A porous 3D structure of arbitrary geometry formed from biocompatible material is the perfect option for scaffold manufacturing. Scaffold-like structure can be produced within a resolution of up to 150 nm capable of entrapping submicrometer sized cells by multiphoton polymerization (MPP) technique. MPP is a flexible technology that allows for the formation of various resolutions and different shaped structures.

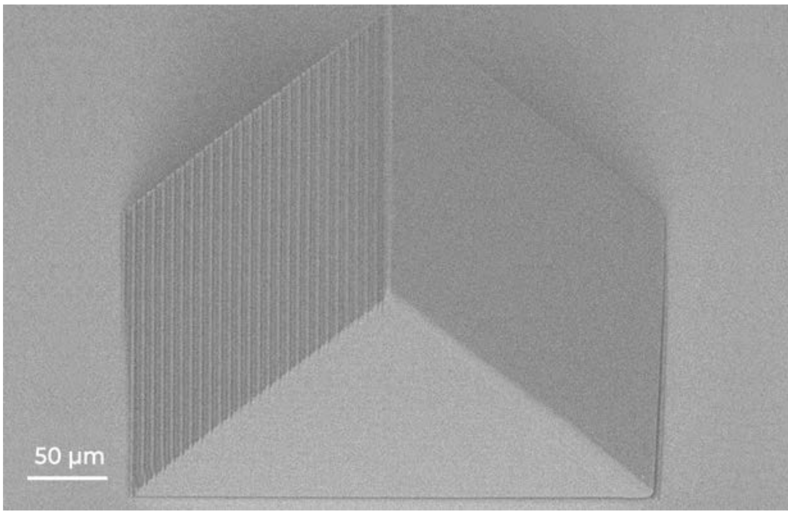
CERAMIC STRUCTURES



The multiphoton polymerization technique with hybrid polymers in combination with pyrolysis enables the removal of the organic part of the polymer and produces ceramic structures. Structure shrinkage during pyrolysis is homogeneous and is approximately 25 %. This property gives precise control of the structure geometry and obtains even higher resolution than the resolution in the polymeric parts which could be up to 100 nm. In contrast with polymers, ceramic structures show high mechanical rigidity, 1000 times more rigid than polymeric material. Ceramic structures are suitable for the fabrication of micromechanical parts.

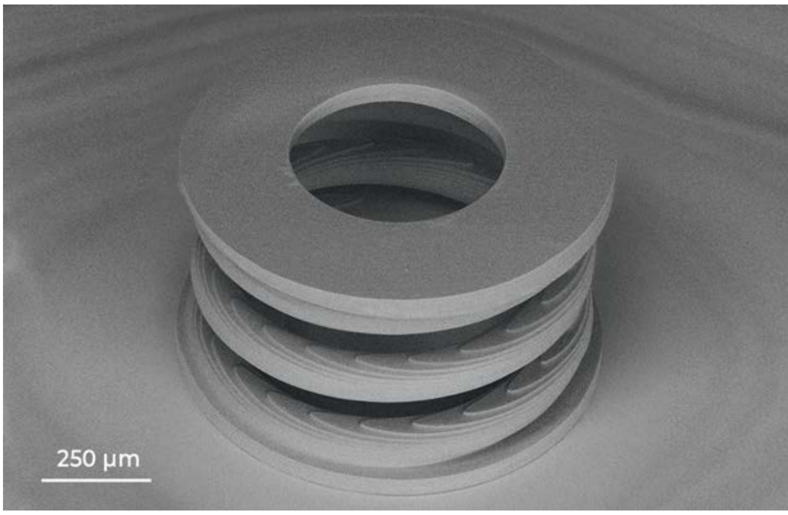
PRISM FOR ELIPSOMETRY

Microoptics is one of the applications for 3D laser lithography. This illustration shows a fabricated micro prism with a grating on one side.
Since only one optical surface is needed, dynamic slicing and hatching can be used to increase throughput. Multiphoton polymerization is a flexible technique that allows different quality and various functionality surfaces to be maintained on the same structures depending on the needs of the application. These microoptical components can be printed on functional devices such as fiber tips to filter and detect light signals.



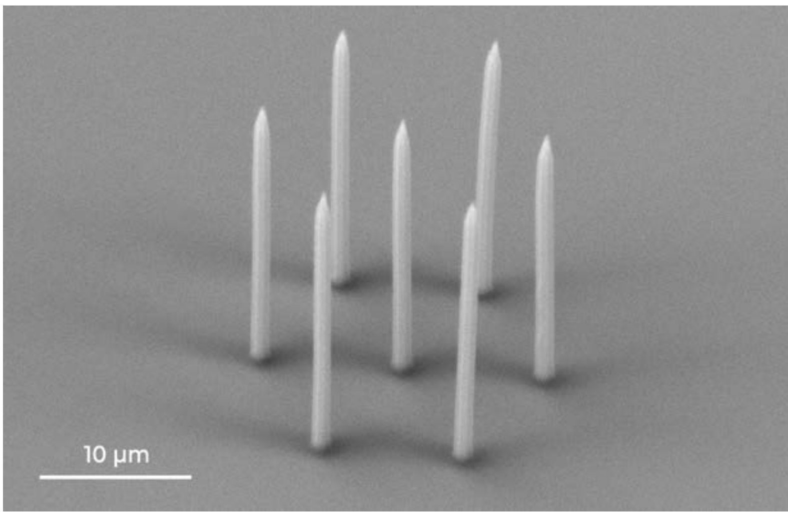
3D MESO-SPRING

3D laser lithography is a suitable technology for the production of high-precision micromechanical components, an example being the single-helix three-turn 3D meso-spring for micro-mechanical applications. The design of such a part gives it flexibility, so that these small parts could be used in microrobotics or in watches. Different polymeric materials could be chosen depending on the exact application.

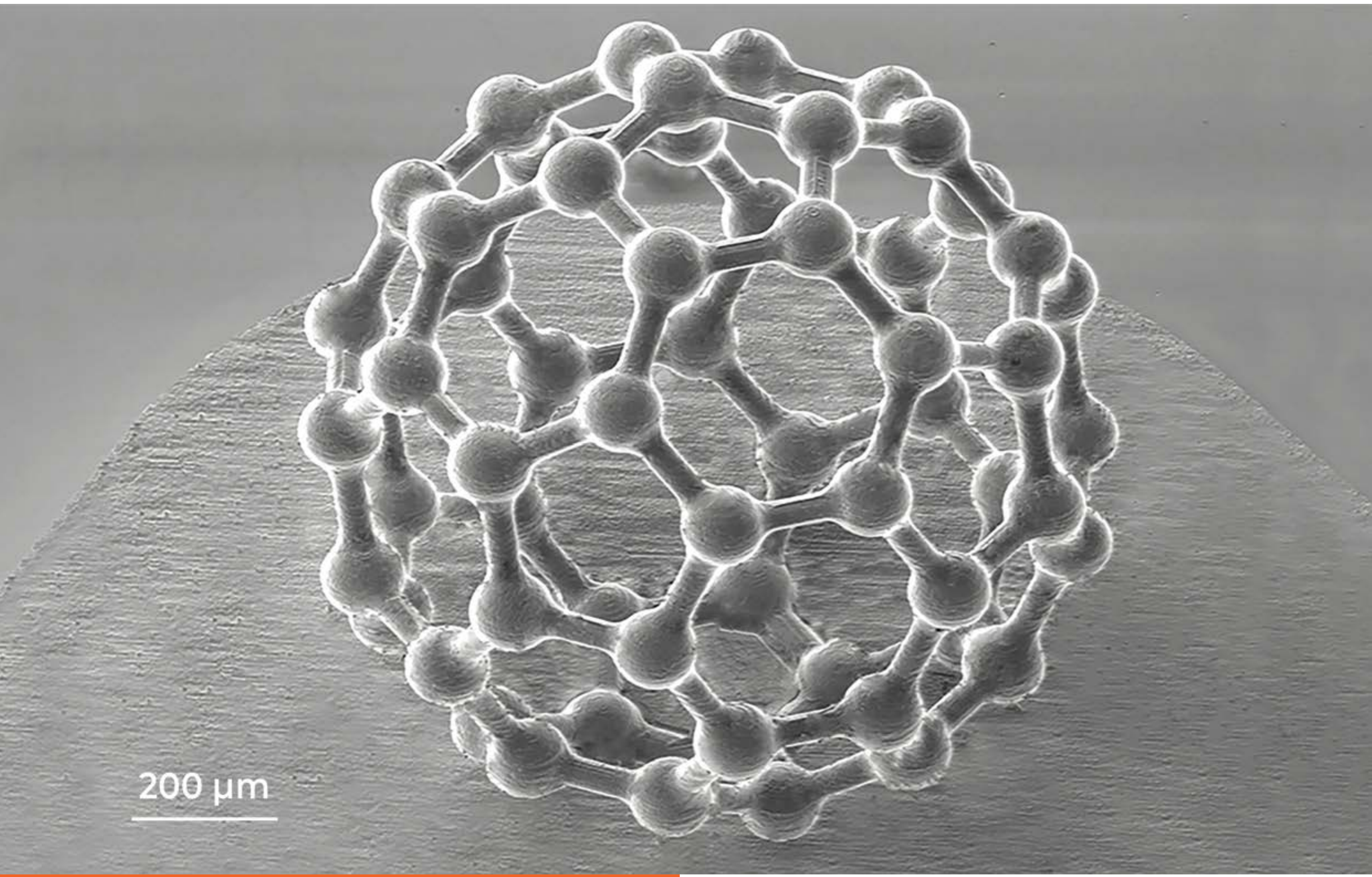


MICRONEEDLES

Microneedles, currently a hot topic in various medical device and bioengineering fields, can be used for drug delivery or diagnostics. One of the best ways to produce them is the multi-photon polymerization technique which enables the production of precise and firm microneedles. Even more complex shapes of polymeric needles can be obtained by maintaining the high sharpness of the needle tips. Various polymeric materials can be used for microneedle fabrication depending on the exact application. In most cases, the structures can easily be replicated by using various molding techniques.



SELECTIVE LASER ETCHING



Selective laser etching is a two-step process. First, the volume of fused silica is modified by ultrashort radiation, then the material is chemically etched away. In this way, mechanically stable and durable 3D structures can be created of glass or in the volume of glass.

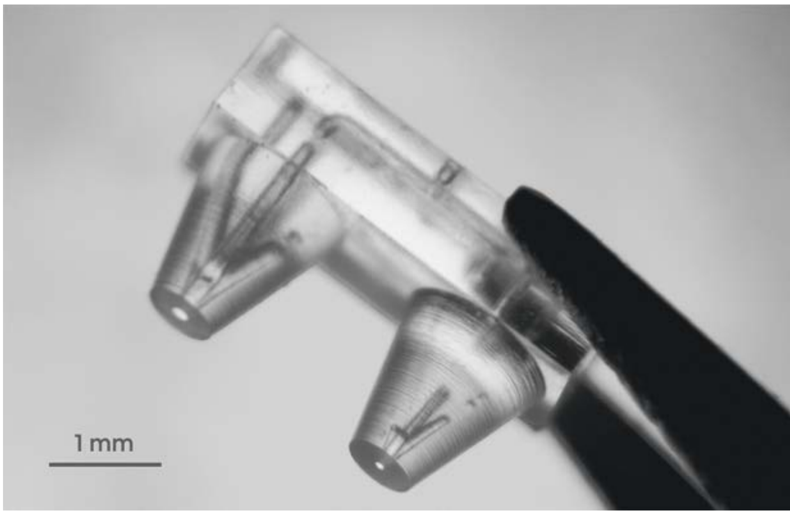
- Finest surface roughness (RMS) at the bottom of the groove ~ 200 – 300 nm
- Finest surface roughness (RMS) on the sides of the groove ~ 100 nm
- Smallest feature size ~ 1 – 2 µm

3D GLASS STRUCTURES

Selective laser etching (SLE) technology enables the fabrication of true 3D glass structures with complex architecture, for instance, fullerene molecule-like structures. By using the SLE technique, high selectivity and low surface roughness can be achieved, both of which create the possibility of complex architecture high-aspect ratio structure production. With this technology, the surface roughness of the etched surfaces is typically around 200 nm (RMS). A fullerene molecule-like structure demonstration proves that SLE is suitable for fabricating high-aspect ratio porous complex structures.

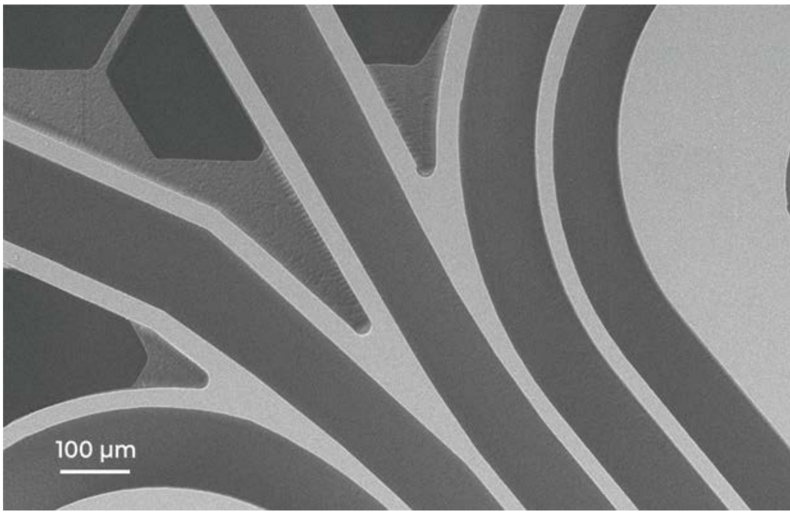
3D NOZZLE

A technique called selective laser etching (SLE) makes it possible to produce 3D structures out of glass. Micronozzles are just one possible use for this technology. The great accuracy and potential for complex geometries that an SLE-made nozzle can achieve, which cannot be done with other technologies, are what make it special. The nozzle size can reach a few centimeters while the smallest channel may have a diameter of only a few micrometers. The nozzle could be used to deliver high-pressure gases and liquids to variable diameter outputs. Fluid dispensing and various printing techniques are examples of potential nozzle usage.



MICRO CHANNELS FORMATION

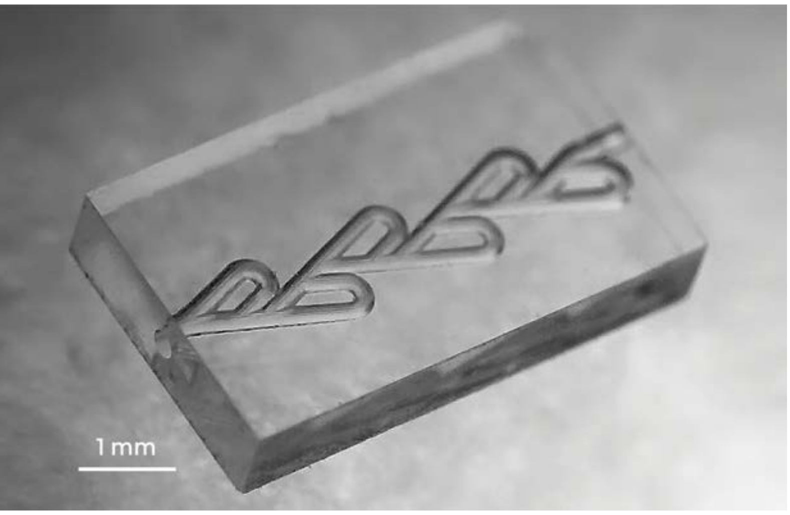
Selective laser etching (SLE) technology permits the microfabrication of complex-shaped microfluidic channels out of fused silica glass. The process consists of two technological steps. First, the desired part of the CAD design is directly written into the volume of the glass, which is subsequently etched away in the second processing step. The SLE technique makes it possible to produce taper-free micron precision channels with a low surface roughness of ~200 nm RMS. Because fused silica glass is transparent in the visible range, biocompatible and inert to most chemicals, SLE-made microfluidics perfectly suit many science applications such as biochemical research.



THREADS FOR SCREW

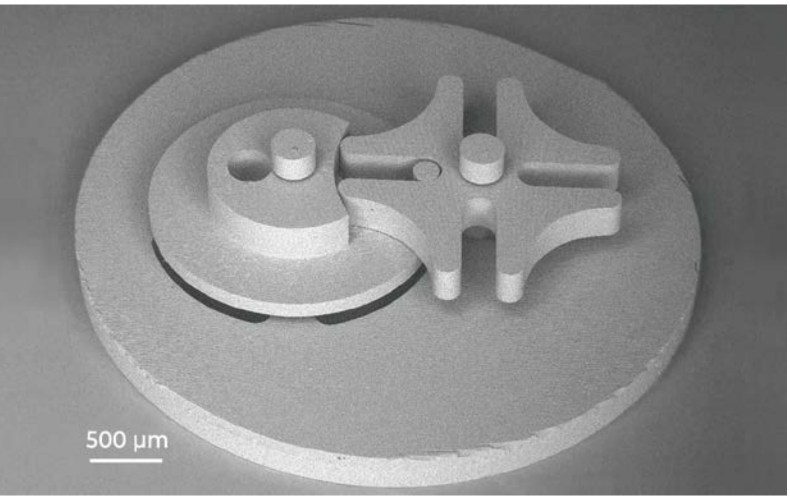
Selective laser etching (SLE) is a femtosecond laser-based technology that enables 3D printing of complex glass microparts in two technological steps: direct laser writing inside the volume of glass and subsequent etching. The SLE technology permits straightforward conversion of the desired CAD design to a 3D micropart. Even mm-size structures with a few micrometers of precision can be printed in this way. One example is threads for screws in glass. Sub-mm size thread structure is hard to fabricate in glass due to its spiral shape and the need for high precision and low surface roughness. These requirements must be met for the screw to be inserted inside the structure without damaging the thread.

TESLA VALVE



One of the most promising applications for SLE is microfluidics. SLE-made surfaces can have relatively low surface roughness (~200 nm RMS). SLE technology far exceeds ablation in terms of flexibility and enables the production of 3D free-form structures, such as channels with integrated functional elements, or 3D channel systems embedded inside the volume of glass, bringing new capabilities and flexibility to the field. These properties make it possible to avoid other supplementary processes such as sealing ablated channels or the need to use other manufacturing techniques for integrating some more trivial structures. In this way, Tesla valve microfluidic channels can be fabricated inside the volume of glass. This microchannel design allows the liquid to flow in only one direction.

GENEVA GEAR

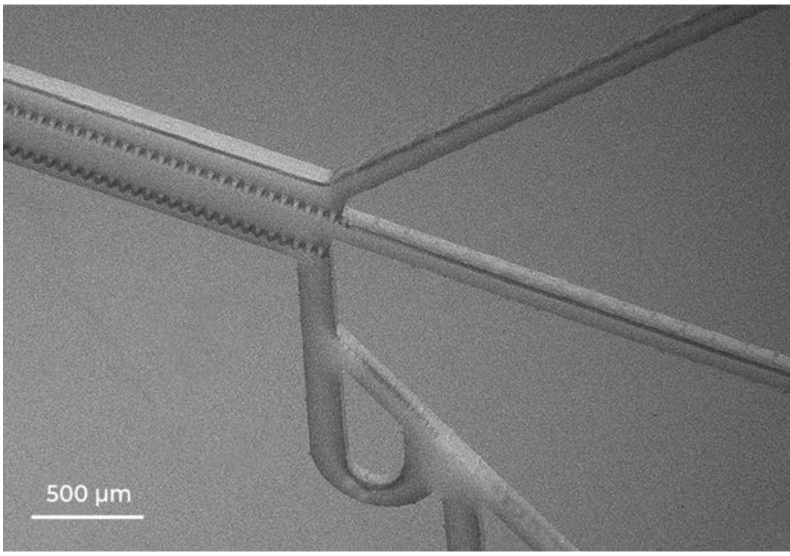


The Geneva gear is an arbitrary-shaped micromechanical component and is one of the most used devices for producing intermittent rotary motion. The Geneva mechanism contains two intermeshing elements. By rotating one gear through 360°, another gear is moved by fixed 90° increments. Using SLE technology, these mechanisms can be fabricated out of a single piece of glass without the need for an assembly step. Being assembly-free, the structure can be produced on a small scale (down to hundreds of µm) without extremely complex micromanipulation. Moreover, by attaching a small magnet to the mechanism and placing it over a rotating magnet, we show that smooth continuous movement of the structure can be implemented. This is made possible by the exceptionally fine gaps between the different moving parts of the structure (less than 10 µm) and particularly good surface roughness (~ 200 nm RMS), which allows for minimizing excessive friction.

OTHER SAMPLES

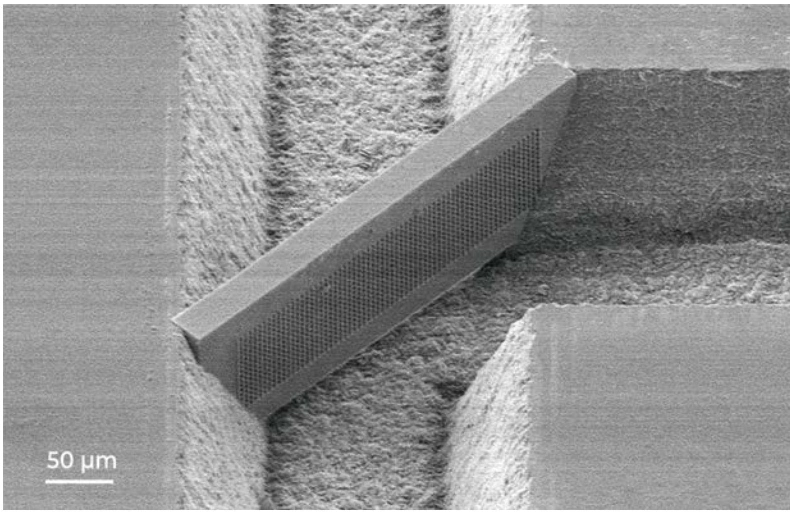
LIVER-ON-CHIP

By using a hybrid microfabrication approach, complex lab-on-chip devices can be produced. One example is the liver-on-chip as an in vitro liver model. The channel system is made by using the selective laser etching technique (SLE). Polymeric filters are integrated inside the prepared microfluidic system by using multi-photon polymerization (MPP). The channels in the glass along with polymeric micropillars form a microfluidic device where different types of inserted cells can form a complex cellular architecture and manipulate cell-to-cell interactions. These devices can be applied in biomedical research since the possibility of combining both SLE and MPP offers convenient prototyping of fully functioning devices using only one tool.

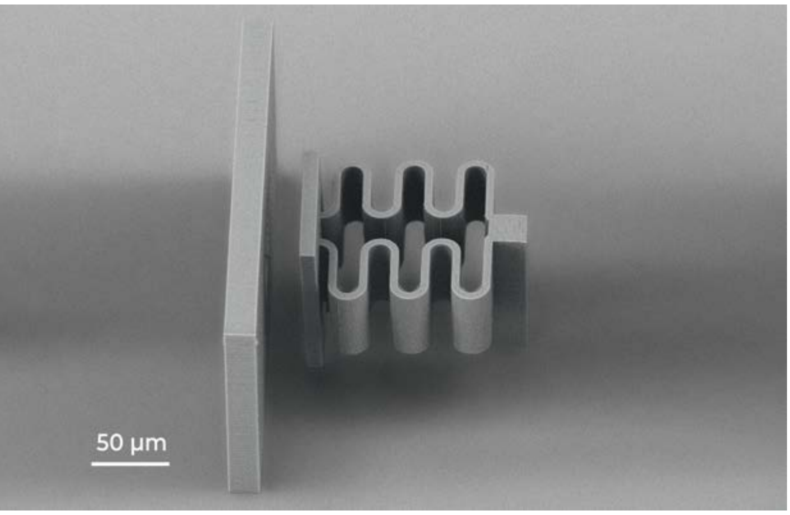


LAB-ON-CHIP DEVICE

The hybrid-fabrication approach enables rapid production of channels out of fused silica via laser ablation, while multiphoton polymerization is used to integrate fine-mesh 3D filters of arbitrary geometry inside the channel. To prove the effectiveness of this approach, a microfluidic macromolecule separator prototype is produced intended for new generation drug development and production. It is designed to separate low and high-molecular-weight substances in mixture solutions. The polymer and glass components needed for these devices are selected and incorporated freely during the manufacturing process, bringing a new level of functionality to the device, and simplifying the fabrication workflow. Due to the versatility of multiphoton polymerization, various complex geometry filters can be implemented at very high resolutions. For example, the pores of this filter are 500 nm wide.

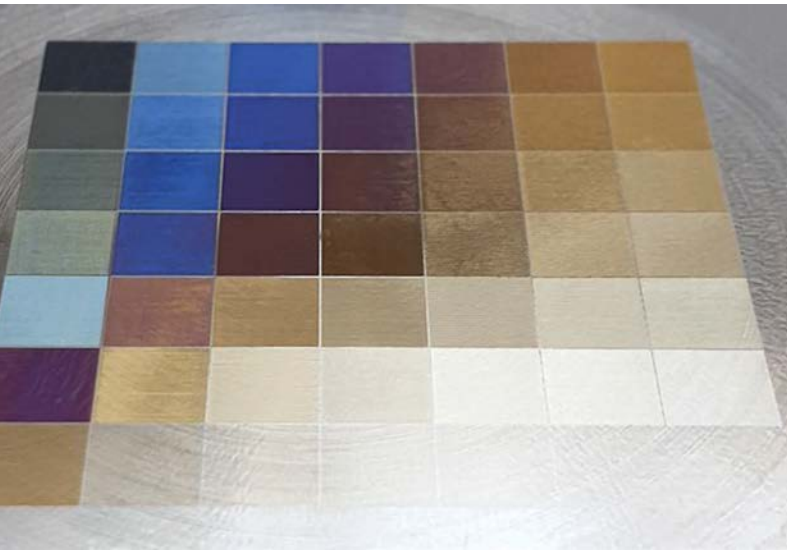


MICROMECHANICAL SENSOR



Femtosecond direct laser writing processes enable hybrid microfabrication of additive and subtractive technologies to create integrated systems. By selective laser etching (SLE), glass microstructures can be made and polymeric structures can be integrated into the glass microstructures using multiphoton polymerization (MPP).
This incorporation of techniques demonstrates the capability of combining mechanical deformable devices made of silica with an integrated polymer structure for passive chemical sensing application. As glass is an amorphous material, its material properties are identical in all directions. Also, thin glass structures are flexible, and the deformations are elastic. These glass properties can be applied for investigating the mechanical properties of polymeric structures through a coupled microchemical sensor system.

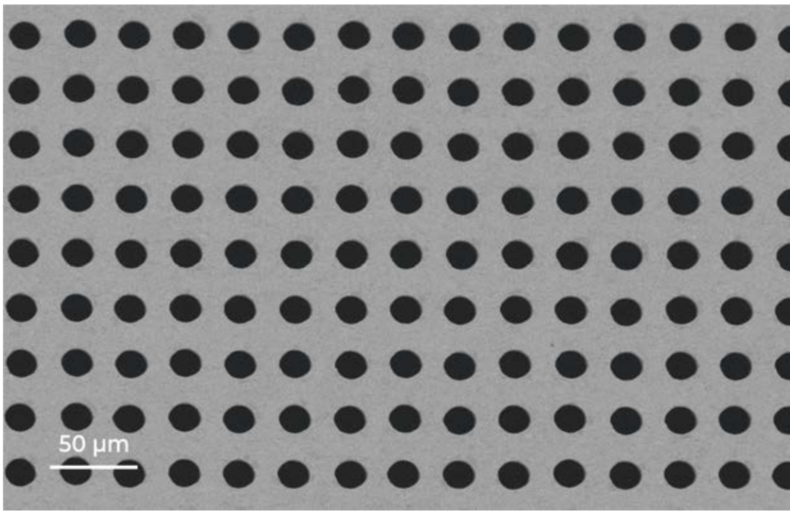
LASER SURFACE TEXTURING



The femtosecond laser produces an oxidation formation on a titanium alloy surface. Varying colors can be achieved by creating oxide layers of different thicknesses. Electrolysis is another technology for metal coloring, but due to the precision of the laser we can selectively color the titanium with high speed and accuracy.
Numerous cosmetic, industrial, and automotive applications exist for “colored titanium.” It is utilized in jewelry, watchmaking, medical device and tool marking. Moreover, titanium is not the only metal that has this property. Though not as vibrant, similar effects can be achieved on stainless steel, copper, silver, gold and some other metals.

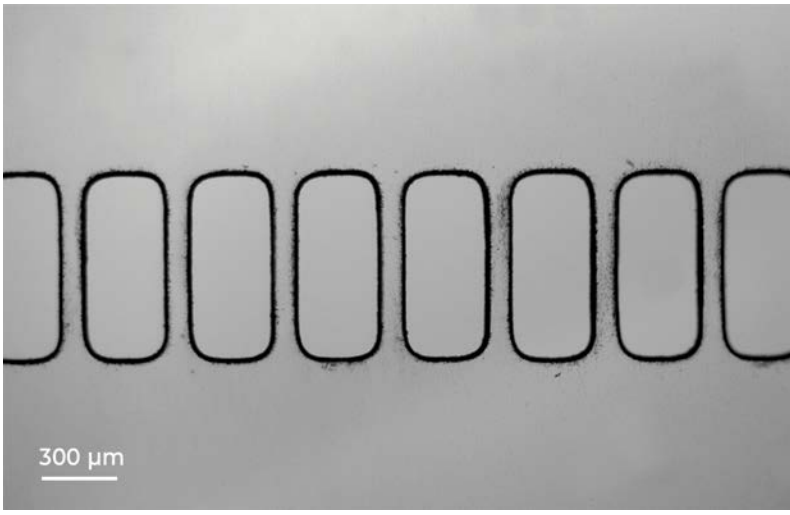
HOLES IN HARD METAL

Femtosecond laser micro-drilling stands out by its accuracy and minimum heat affected zone. The process is applicable to a wide variety of materials, including different metals, ceramics, polymers, and glass. The ablation speed and the taper of the hole depend mostly on material thickness and hole diameter. For example, ablation speed – up to one hole of 30 μm in diameter and 18 μm out diameter in 50 ms. Femtosecond laser micro-drilled holes are required for filters, nozzles and many different tools.



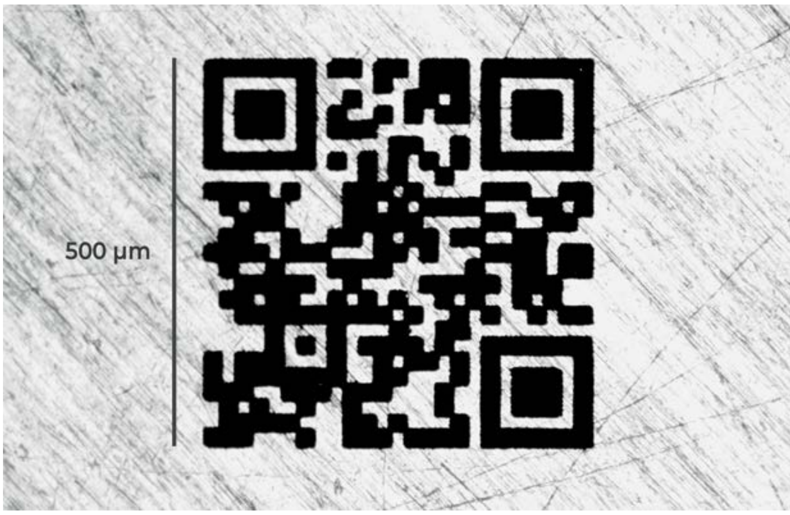
MICRO CUTTING

Femtosecond laser cutting is well known as Cold Processing since the ultrashort pulses produce a minimal heat affected zone and allow precise cuts in various materials. This process has the advantage of allowing cuts to be made without leaving debris. For example, squares with rounded corners in a polymer. The pitch between the holes is substantially smaller than the size of the hole. Spaces are thin and straight, ablation edges are clear, and there is minimal thermal influence.

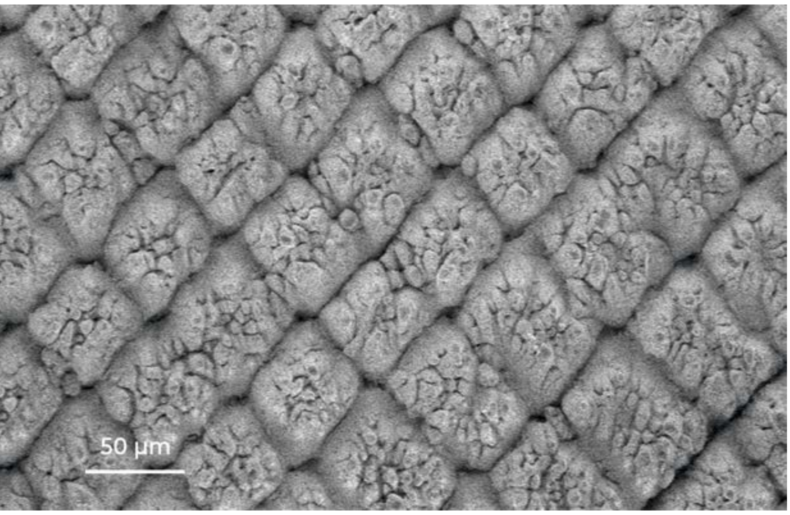


LASER MARKING

Laser QR code marking has a broad range of applications, including security and tracing. Laser processing precision makes it possible to engrave tiny QR codes on different material surfaces as well as imprinting QR codes into transparent material volume. This makes counterfeiting much more difficult. In the watch industry, for example, it is possible to mark every part of a watch, even the very smallest.

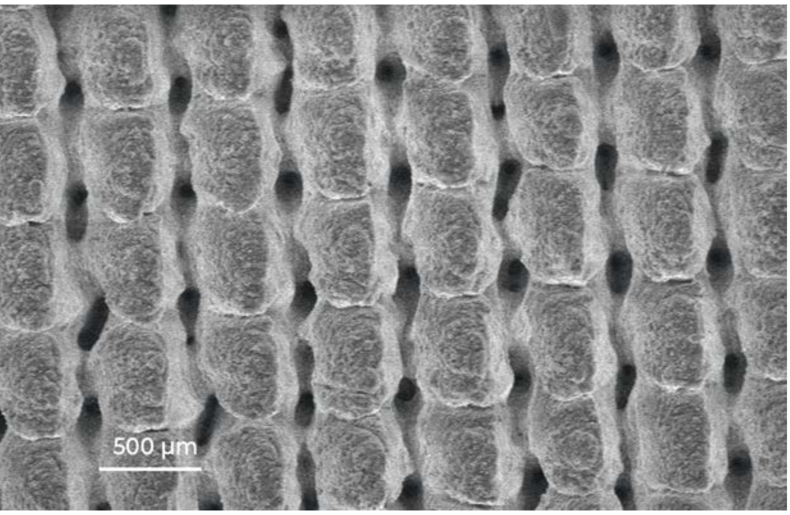


HYDROPHOBIC SURFACE



A hydrophobic surface formed on a copper alloy sample using femtosecond laser texturing. The contact angle between this surface and a water drop is 150 degrees, which means that the surface has the potential for self-cleaning, anti-icing and other properties linked to hydrophobicity. Such wettability manipulation is called the Lotus effect and is possible due to the hierarchical structures that are formed with the help of ultrashort pulses. This type of surface can be formed on metals like titanium, steel, aluminum and other materials such as different plastic and glass substances. In general, femtosecond laser texturing gives flexible surface manipulation conditions for forming targeted structures in applications ranging from medical tool surface functionalization to fluid separation and friction manipulation.

HYDROPHILIC SURFACE



Hydrophilic surface properties created through metal surface micro-texturing. A sponge like aluminum surface soaks up water and spreads it evenly across the surface. Directional metal wetting can be performed using this technique and the flow can even be directed vertically upwards (opposite to the Earth's gravity). Proper manipulation of surface wettability gives full control over the function of a part. Hydrophilic surface applications include coating adhesion and medical implant osseointegration.

INDUSTRIES

BIOTECHNOLOGIES

Biomedical 3D manufacturing is an ever growing topic. Femtosecond laser-based 3D multiphoton polymerization is a superb tool for fabrication of micro-scaffolds with complex functional architectures, wide-scaled and out of any relevant material.

OPTICS AND PHOTONICS

Producing of photonic devices based on high-resolution (up to hundreds of nm) single features for applications in visible and IR part of the spectrum. Fabrication of microoptics of any desirable shape as the optimized surface geometries allow minimising aberrations or creating exotic light distributions, like, for instance, Bessel beams or optical vortexes.

MEDICINE

Objects with controllable feature sizes that can be smaller, bigger or at the cell size can be produced. This leads to capability to produce new generation medical devices, such as cell perforators, micro-robots and similar. They combine extremely small size and unmatched functionality, paving the way for completely new outlook to medical device design and fabrication.

MICROFLUIDICS

Amplified femtosecond lasers were shown to be extremely capable in producing microfluidical components. As they can be realized for both additive and subtractive manufacturing channels, arbitrary free form integrated elements and bonding can be realized with only one laser micromachining setup. This opens an array of new possibilities which can enrich this active research area with new set of capabilities.

MICROMECHANICS

3D femtosecond micro-manufacturing provides the steppingstone for downsizing mechanical elements down to sub-micrometer scale. What is more, due to diverse light-matter interaction regimes achievable with fs pulses it is possible to produce these elements from wide range of materials, starting with polymers and ending with glasses, dielectric crystals or metals. Gears, springs, cantilevers and other classical mechanical elements can be produced in micro-scale using this method.

SURFACE STRUCTURING

Functional surfaces are incredibly important in the fields ranging from medicine to space exploration. The surfaces created with fs pulses can be easily made both repelling and adhering, playing into needs of basically any application, including tool manufacturing, aviation, maritime and medicine.

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