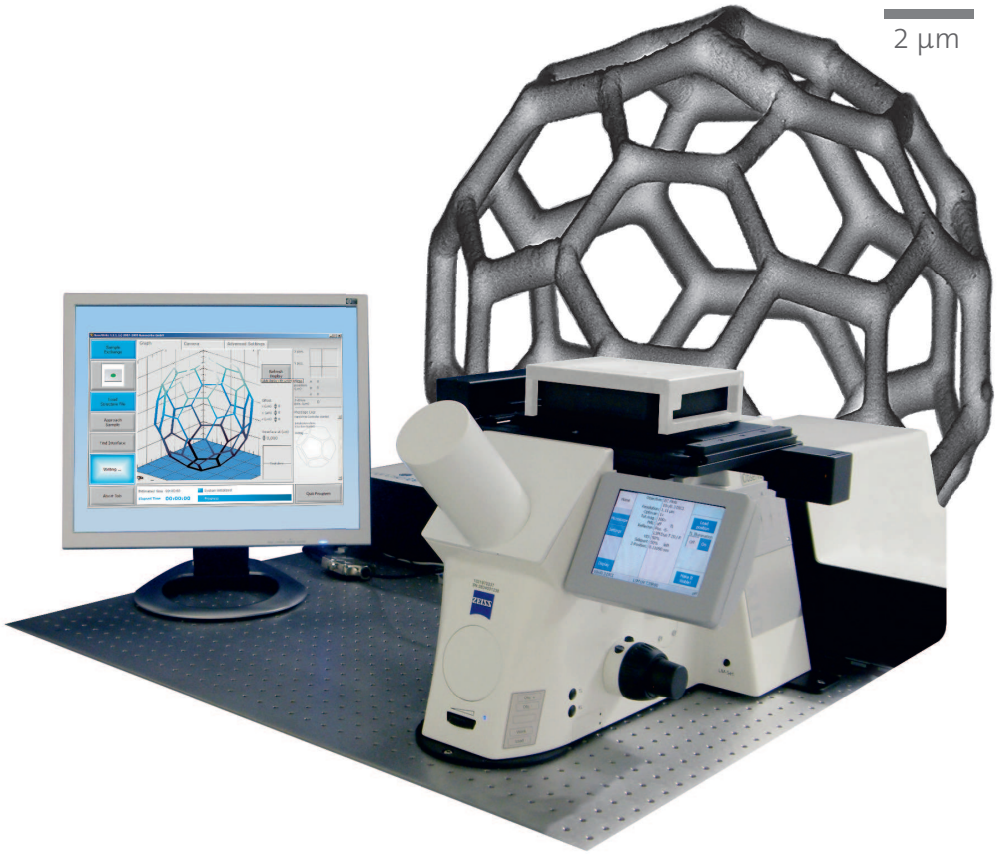
nanoscribe

True 3D Laser Lithography



Company Background

Nanoscribe is a spin-off company of the Karlsruhe Institute of Technology (KIT), the merger of the University of Karlsruhe and the Forschungszentrum Karlsruhe GmbH (National Laboratory of the Helmholtz Association).
The company was founded in 2007 by leading scientists in the field of photonic crystals and metamaterials. A close interdisciplinary collaboration with scientists both in Karlsruhe and internationally provides the basis for forefront technical developments specially designed for the needs of researchers. In 2008, following a close collaboration, Carl Zeiss invested into this innovative technology, now holding about 40% of the company's shares.

Company Philosophy

Nanoscribe is set on transferring cutting-edge technology to versatile and user-friendly systems for three-dimensional (3D) nano- and microfabrication. We pay particular attention to the needs of our customers: Nanoscribe cultivates intense connections with customers, partners and component suppliers to develop the best solution for your application.
We assure highest quality and fast cycles of innovation, expanding our market leadership and technological leadership in 3D laser lithography.
Customer satisfaction and a fast service policy are of our highest priority. We always support our customers promptly all over the world. In case of technical problems, our service team is always available on your disposal.

Contact

Please feel invited to contact us:

» **Information & press:** info@nanoscribe.de
» **Inquiry & quotation:** sales@nanoscribe.de
» **Customer service:** service@nanoscribe.de

True 3D Laser Lithography Systems

Nanoscribe develops and manufactures with its product "Photonic Professional" compact and easy to operate laser lithography systems, allowing for true 3D micro- and nanostructures in various commercially available photoresists. Applications are, e.g., in photonics, micro-optics, micro-fluidics and life sciences.

Our unique technology is specially designed for ...

» ... true 3D micro- and nanostructuring
» ... ultra-precise fabrication with feature sizes ranging down to 100 nm
» ... compact, comfortable and easy to use laser lithography systems

Advanced Photoresists

Nanoscribe produces and develops novel photoresists for 2D and 3D lithographic applications. Complete photoresist systems comprising samples and appropriate developers or etchants are provided.

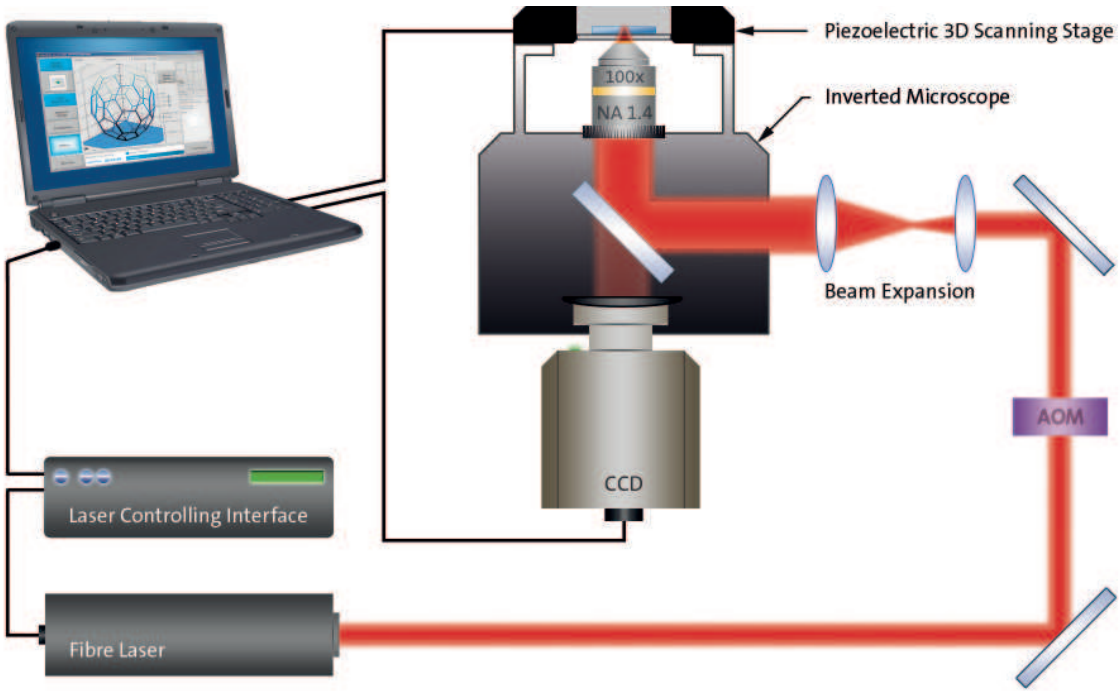
Expertise in Casting and Coating

Nano- and microstructured devices often solely reveal their full functionality when not only their shape is given but also the material requirement is fulfilled. In the last decade, a broad variety of casting techniques has been developed in order to transfer complex photoresist structures into materials such as metals, semiconductors or oxides. Nanoscribe has in-depth knowledge in casting and coating processes and offers expert advice on process know-how and the implementation of customized installations.

Online Support

To provide quick support for customers, Nanoscribe offers two online services:

» knowledgebase at www.nanoscribe.net for stimulating discussions among customers and interested people to share their experiences.
» remote support allows Nanoscribe to control customers' local PC directly from the production facility on demand.



Basic Principles of Direct Laser Writing

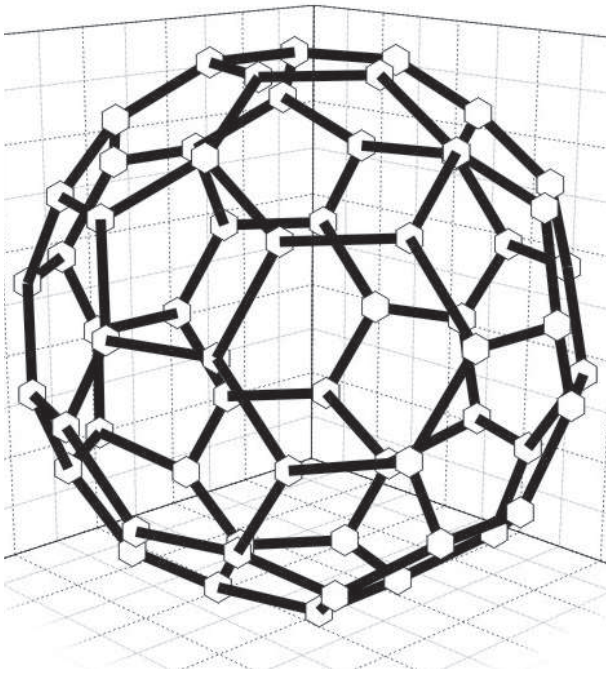
The technique of direct laser writing allows for the fabrication of almost arbitrary 3D nanostructures in suitable photoresists. It is based on multi-photon polymerization, a non-linear optical effect. The center wavelength of the laser is chosen so that the photoresist is transparent since the one-photon energy lies well below the absorption edge of the material. By tightly focusing the light of an ultra-short pulsed laser, the intensity within the very focus is sufficiently high to expose the photoresist by multi-photon absorption. This process causes a chemical and/or physical change of the photoresist within a small volume pixel ("voxel") that can be scaled by the laser power.

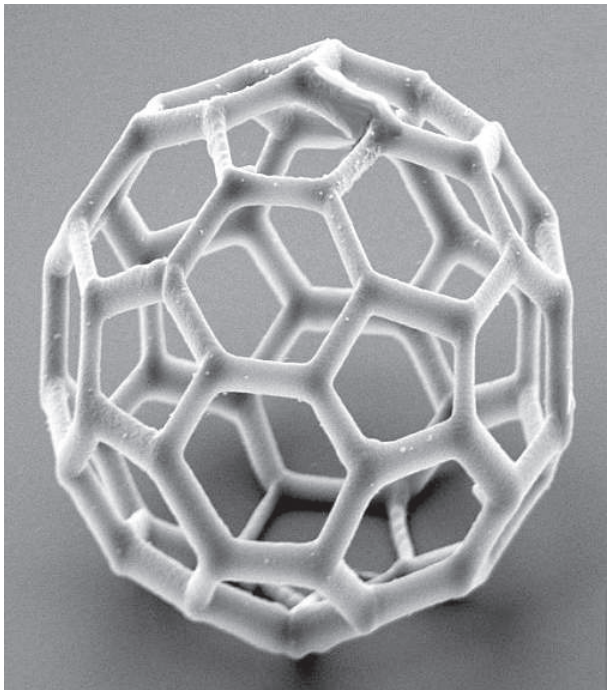
This voxel typically is of ellipsoidal shape and is the basic building block for the fabrication of 3D structures. By moving the sample relative to the fixed focal position, arbitrary paths can be written into the material. You can consider this like using a nanometer-sized pen that draws in three dimensions.

The movement of the sample and the adjustment of the laser intensity are synchronized by a computer. Later on, the material change due to exposure to the laser light and potentially a subsequent thermal treatment leads to a chemical selectivity between unexposed and exposed volumes inside a developer bath. Depending on the photoresist, either exposed (positive-tone resist) or unexposed regions (negative-tone resist) are removed.

The advantages of multi-photon polymerization are evident:

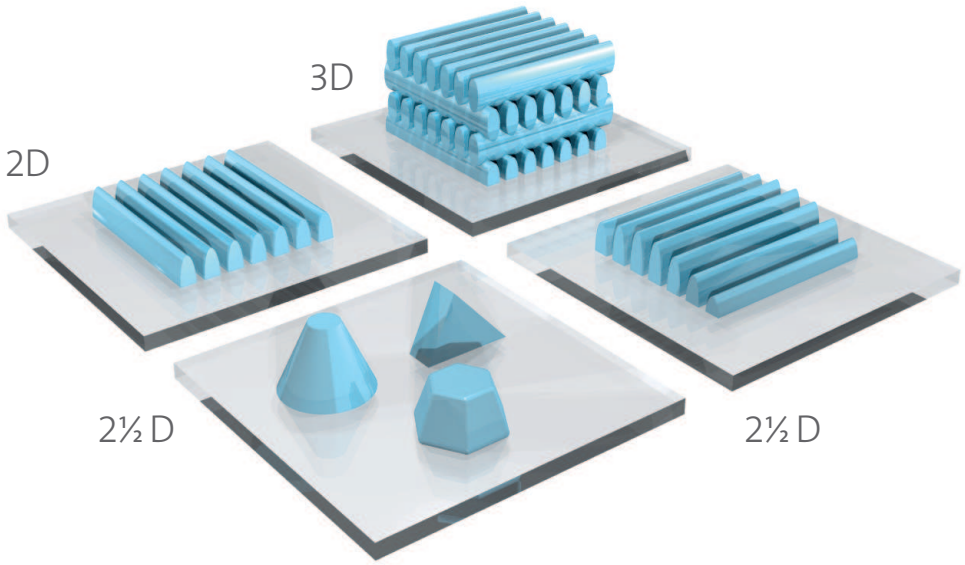
- Ability to structure truly three-dimensional, no matter how complex your structure may be.
- Superior resolution due to the non-linear response of the photoresists.
- Flexibility: The ability to structure truly 3D implies also the special, simplified cases of planar structuring (2D) or complex surface topologies that are suited for mass fabrication via pattern transfer techniques (2½ D).





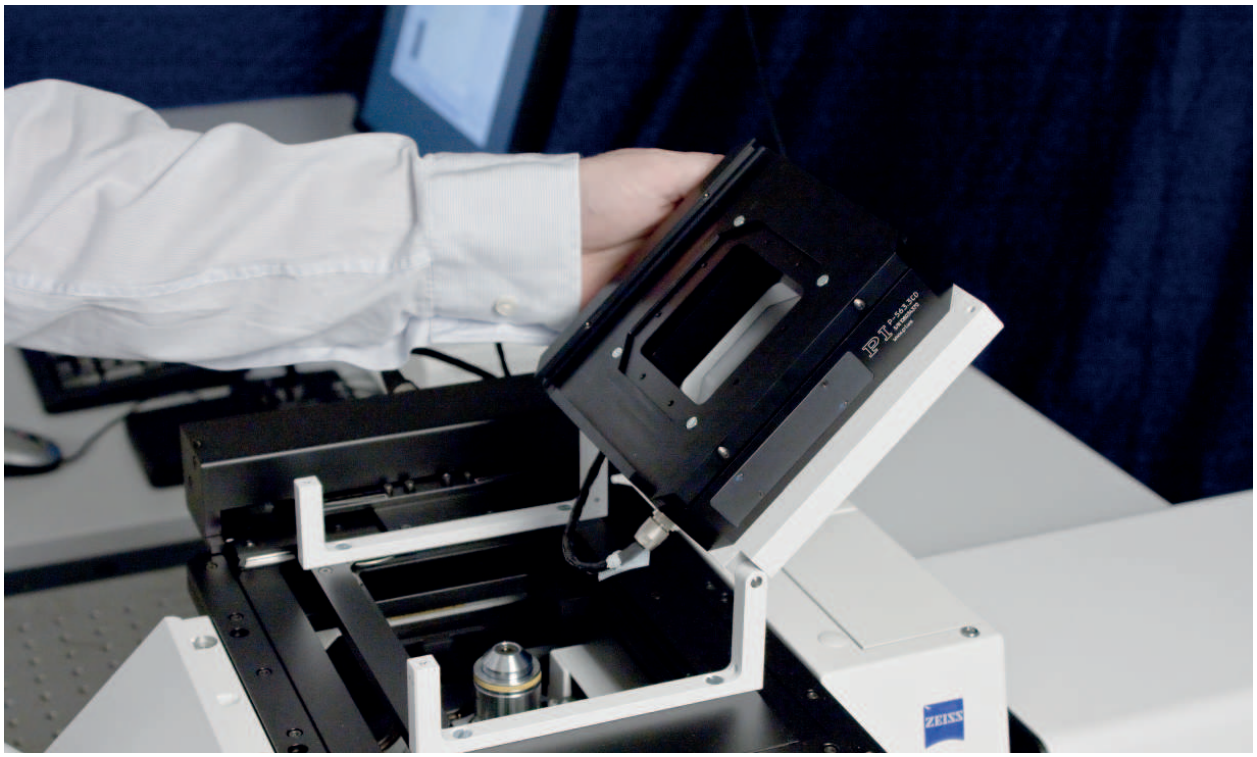
Sample Fabrication Procedure

The course of sample fabrication is simple: Blanks are usually produced by spin coating of a photoresist onto a glass substrate and subsequent mounting in matched substrate holders which are again inserted into the lithography system. The desired structures are typically programmed in a specialized general writing language (GWL) that is well adapted for 3D structures. Alternatively, the structure data is imported from common CAD data format (DXF) or a stereo lithography file (STL). The system visualizes the loaded structure data, automatically approaches the designated sample and adjusts the focus to the interface. By command the lithography system exposes the sample. The system is capable of automatically processing multiple samples in succession. Finally, the samples are developed and post-processed.



Photonic Professional

True 3D Laser Lithography System


ZEISS

Features

The Nanoscribe 3D laser lithography system "Photonic Professional" is designed for true 3D micro- and nanostructuring of photosensitive media, e.g., organic photoresists (like SU-8, IP-L, IP-G), hybrid materials (ormocere) or the amorphous semiconductor As_2S_3—materials which are capable of two-photon polymerization. Negative-tone, as well as positive-tone photoresists can be patterned. The exposed features of a negative-tone (positive-tone) photoresist become insoluble (soluble) to the photoresist developer. Having a certain application in mind, the right choice of the photoresist is of vital importance. Basic properties like, e.g., thermal and chemical resistance, etch rates, mechanical elasticity, biocompatibility, and, importantly, resolution and optical transparency must be taken into account.

Autofocus

A unique feature of Nanoscribe's laser lithography systems is an autofocus. Due to patented technology, the interface between substrate and photoresist is determined exactly and autonomously. This establishes the basis for reliable anchoring of your structures to the substrate—may these structures be 2D or 3D.

The lithography systems automatically approach the focusing objectives to the blanks and adjust the focus to a designated elevation in reference to the interface. Based on this unique technology, the lithography systems also offer a fully automated substrate tilt measurement and correction feature.

A motorized scanning stage combined with the autofocus system and tilt correction allows for the automated fabrication of large-area structures on numerous samples in a row.

NanoWrite

One of the key features of Nanoscribe's laser lithography systems is the user-friendly software. A functional and intuitive user interface considerably simplifies the realization of your structure design. The software provides easy access to all adjustable features of the lithography system and enables an automated tilt correction.
NanoWrite is able to load GWL files (script language developed by Nanoscribe to define the writing of 3D structures, specialized on the writing tasks in two and three dimensions) and to import CAD data from common DXF files as well as stereo lithography files (STL). The user interface provides a visualization of the structure data as well as a live camera view of the sample.

Substrate Holders

Nanoscribe offers several specially designed substrate holders. The most established version is a holder for 10 round cover slips with 30 mm diameter. Individual designs for particular substrates can easily be implemented for dimensions of up to 125 x 125 x 3 mm^3.

Objectives

The microscope possesses an automated objective revolver that is controlled by the software. A variety of oil immersion and air objectives are available. Depending on feature sizes, processing speed, and substrate properties, your lithography system is tooled up with dedicated objectives.

Options

Besides the aforementioned standard components and features of Nanoscribe's Photonic Professional system, we offer the following additional options which can be adapted to your specific needs.

Coupling of External Lasers

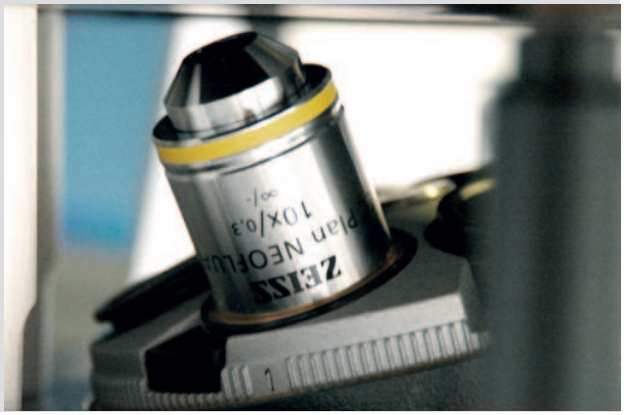
If you already have a suitable femtosecond-laser, Nanoscribe's lithography system can be adapted to be operated with this external light source. Please contact us regarding the eligibility of your laser.

Positioning Systems

In addition to the piezo-electrical scanning stage and the manual stage, further positioning solutions are available. A motorized scanning stage with a writing field of up to 100 mm by 100 mm is fully controllable via the software and allows for laterally stitching together neighboring writing volumes of the piezo to large sample areas as well as direct writing by moving the motorized scanning stage which is especially favorable for large-scale microstructuring. Additionally, consecutive and automated processing of multiple samples is possible.

Vibration Isolating Tables

We strongly recommend operating the system on a vibration isolated table. Suitable optical tables can be obtained from us on request.



Areas of Application

The advantages of multi-photon polymerization recommend our systems not only the ideal candidate for highly specialized tasks, but also an excellent generalist for manifold demands and activities, e.g., in instrument pools of nanofabrication centers. This versatility is also reflected in the field of applications.

Most prominently one can find our systems actively in operation in following research areas:

» **Photonics**
photonic crystals, metamaterials, diffractive optics, distributed feedback lasers, photonic ring resonators

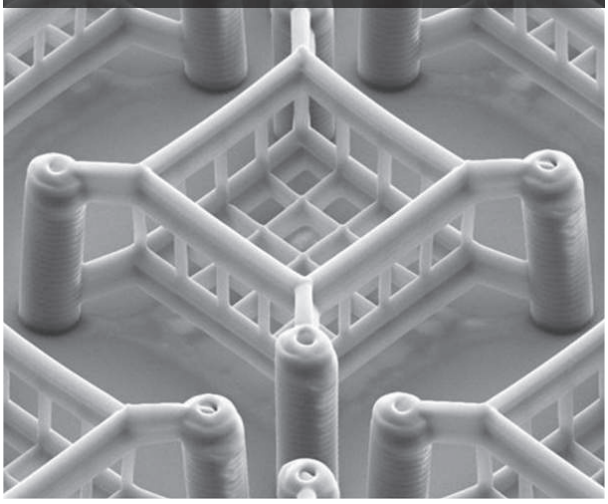
» **Micro Optics**
micro optical devices, integrated optics

» **Micro Fluidics**
lab-on-a-chip systems, development of substances, analysis

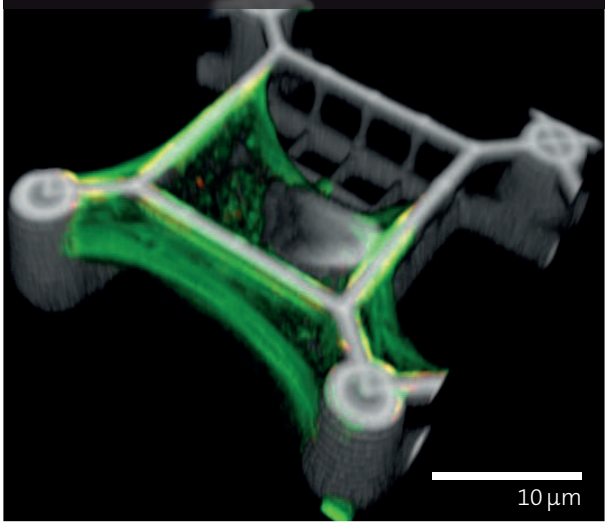
» **Life Sciences**
cell migration / stem cell differentiation / cell growth studies, tissue engineering

» **Nano- and Microtechnology**
mask manufacturing, examination of Gecko and Lotus effect

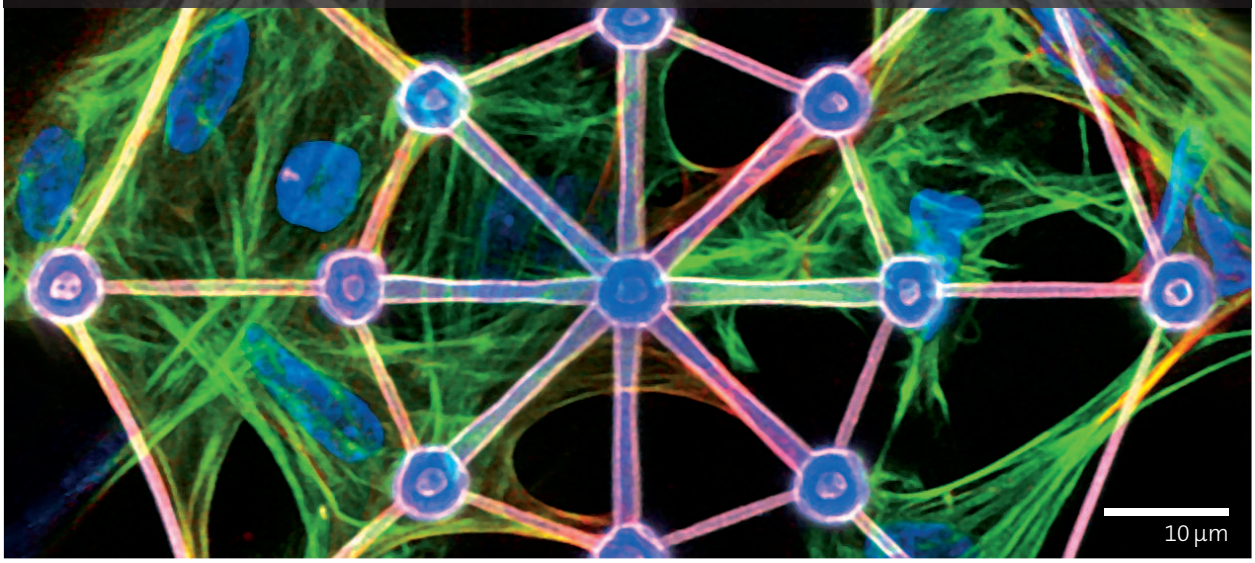
Courtesy of T. Striebel and M. Bastmeyer, KIT (Germany)



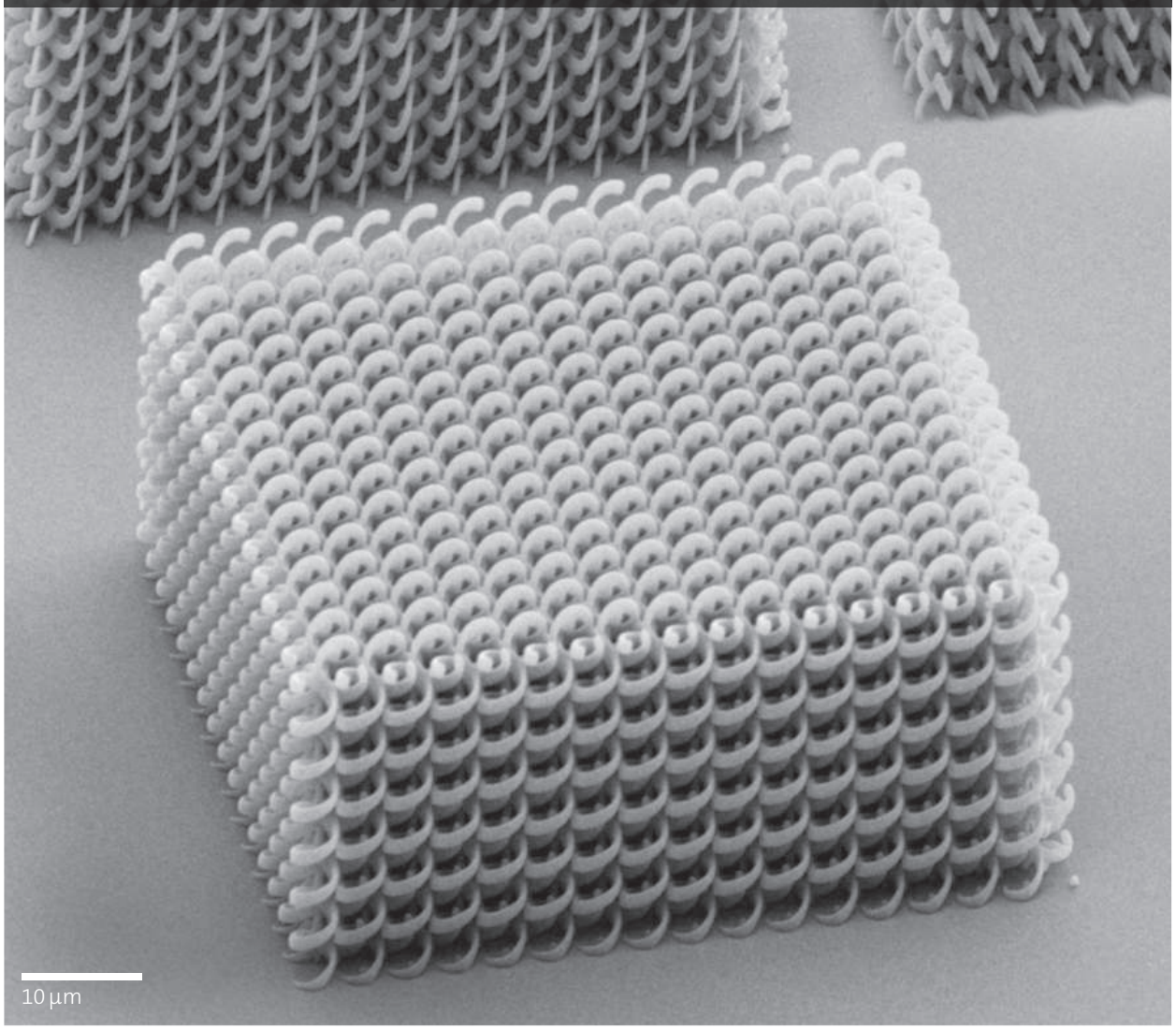
Courtesy of F. Klein and M. Bastmeyer, KIT (Germany)

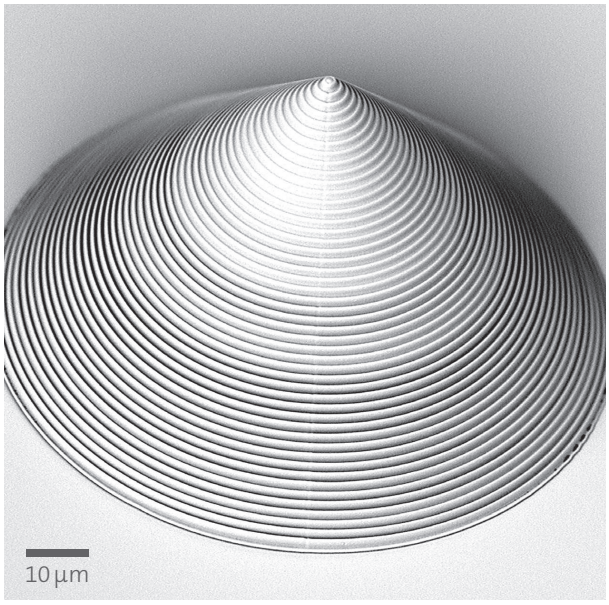


Courtesy of F. Klein, T. Striebel, and M. Bastmeyer, KIT (Germany)

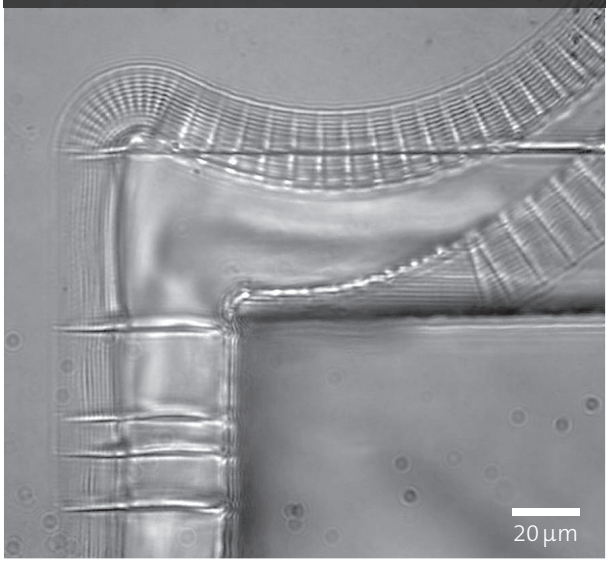


See also: M. Thiel *et al.*, Adv. Mater. **21,** 4680 (2009)





Courtesy of T. Rösgen, EHT Zurich (Switzerland)



Applicable Photoresists

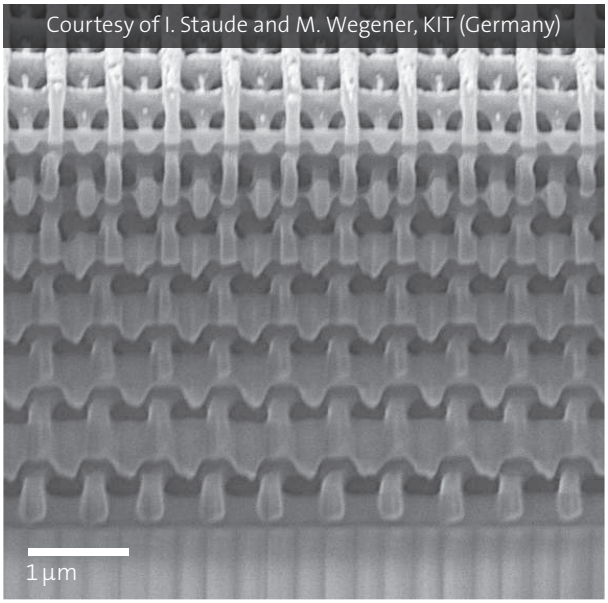
Nanoscribe continuously evaluates and develops photoresists for 2D and 3D applications. Listed in the following is a series of standard resists either commercially available from Nanoscribe or other suppliers. Please consult us to identify the photoresist best fitting your requirements.

1. IP-L and IP-G

Nanoscribe's family of IPx photoresists is specifically designed for the demands of true 3D laser lithography by two-photon polymerization: Extraordinary resolution in three dimensions combined with high mechanical stability. Both formulations available (IP-L, IP-G) are acrylic-based negative-tone resists—ideal candidates, e.g., in the field of photonics.

Basic Features:

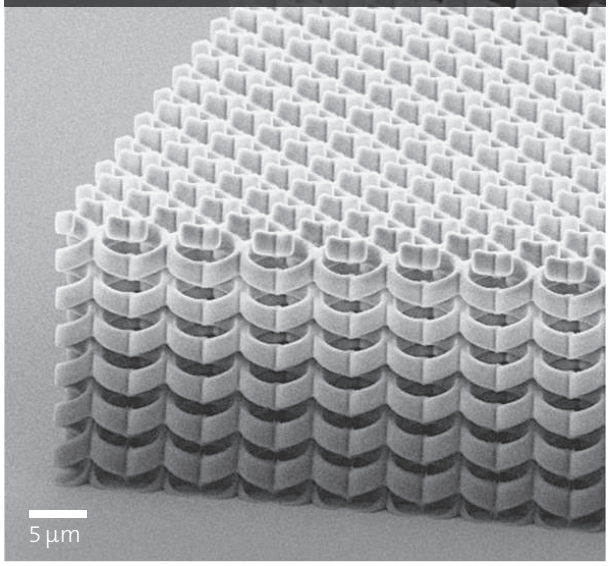
- Feature sizes down to 100 nm
- Low proximity effect
- Low stress
- Little shrinkage
- Good adhesion on glass substrates
- Easy handling:
  drop-casting of the photoresist
  no pre-bake (IP-L)
  no post-exposure bake (IP-L, IP-G)



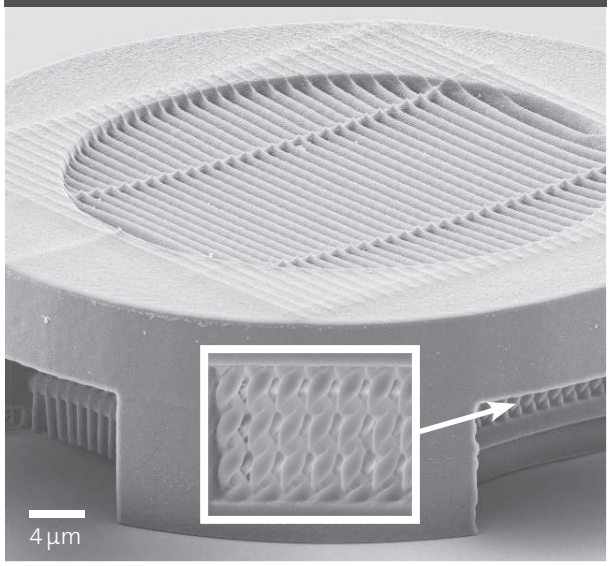
2. SU-8 (25, 50, 100, 3000-series)

The resists of the SU-8 series are common negative-tone resists provided by MicroChem Corp. SU-8 is available in different viscosities, depending on the desired film thickness. The mechanical and chemical properties make it ideally suited for many different applications in the field of microfabrication.

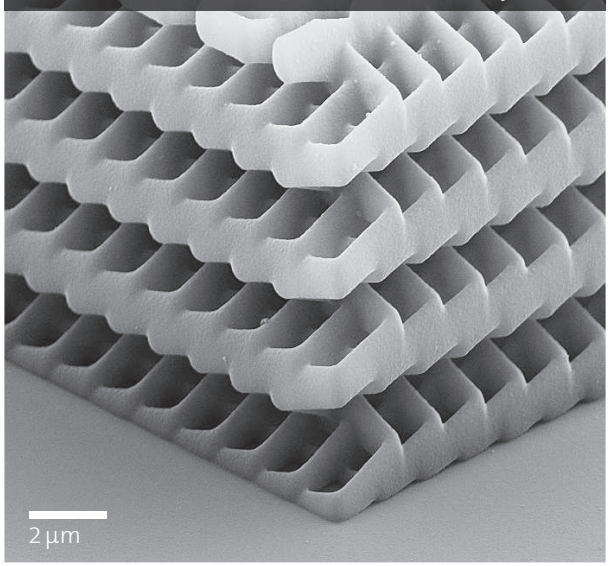
See also: M. Thiel *et al.*, Opt. Lett. **35,** 166 (2010)



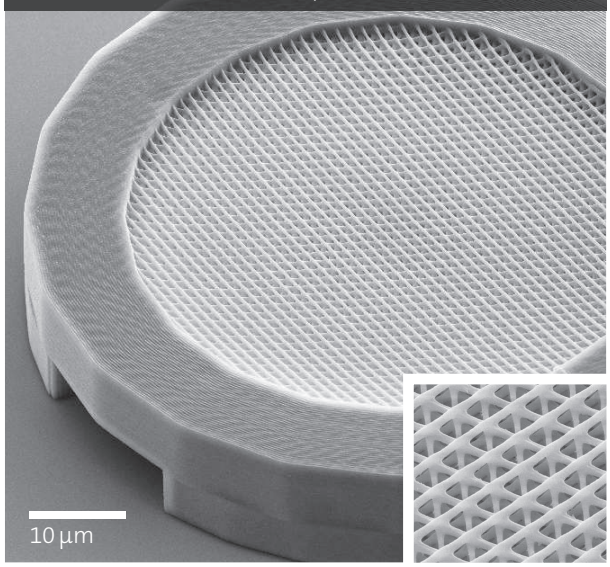
See also: M. Thiel *et al.*, Appl. Phys. Lett. **91,** 123515 (2007)

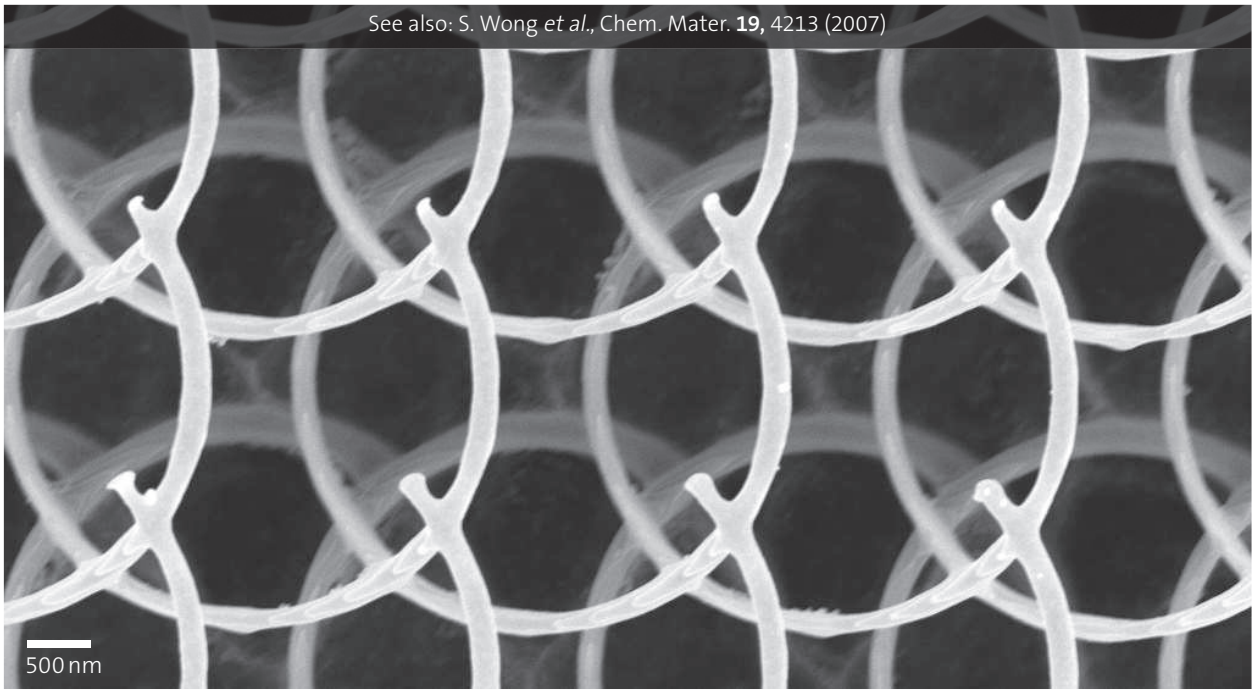


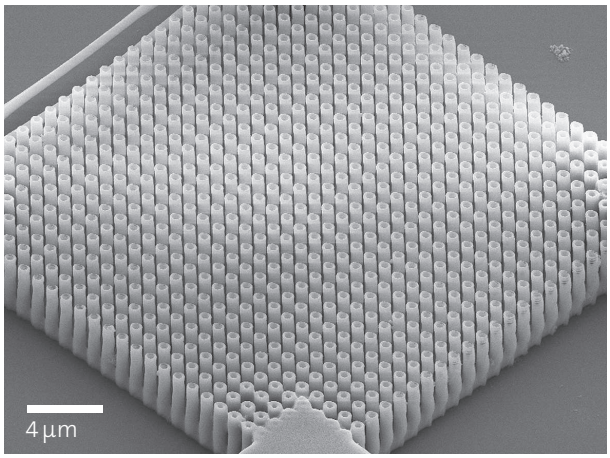
M. Deubel, PhD thesis (2006), KIT (Germany)



See also: M. Thiel *et al.*, Opt. Lett. **32,** 2547 (2007)

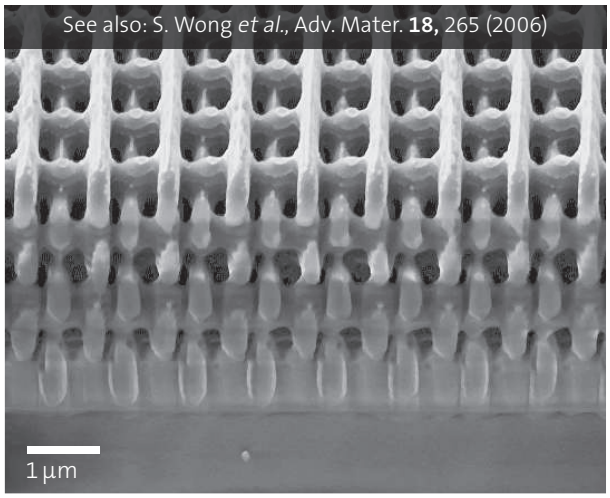






3. Chalcogenide Glass (As_2S_3)

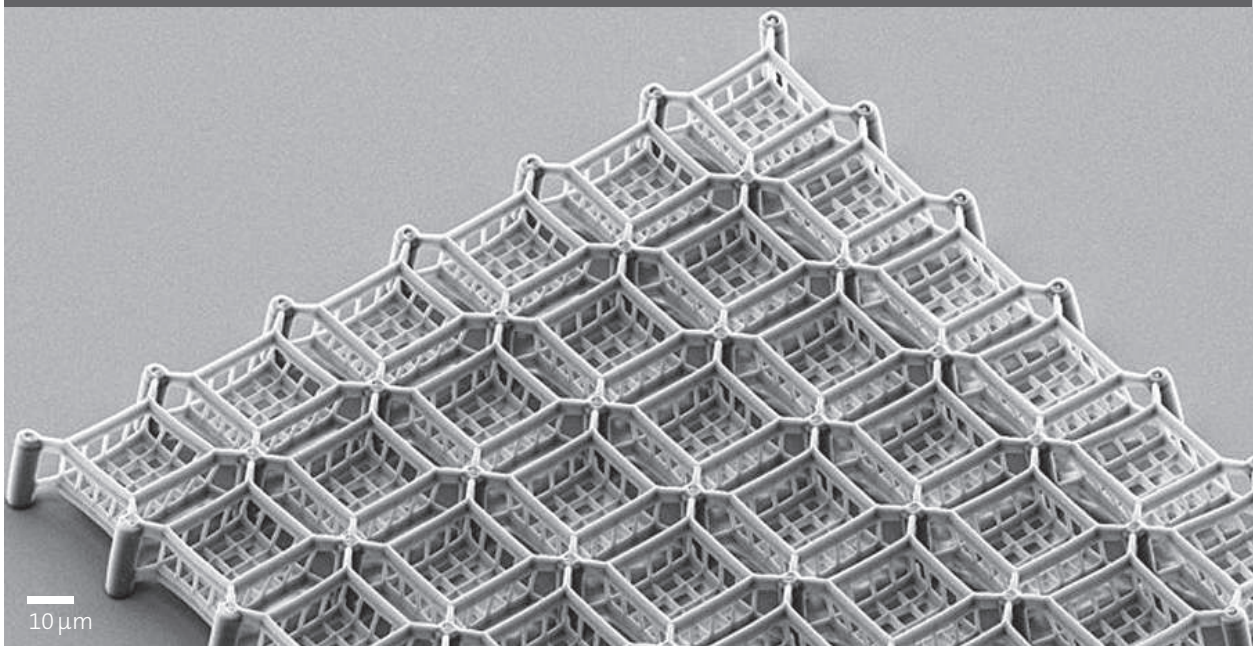
Nanoscribe provides a high refractive index resist system for 3D micro- and nanolithography. This negative-tone photoresist system is based on arsenic trisulfide (As_2S_3) and has a refractive index of 2.45. In combination with the 3D laser lithography system, it enables the fabrication of manifold structures such as photonic waveguides, couplers, splitters, resonators, and 3D photonic crystals, all of which benefit from a material with an inherently high refractive index.



Basic Features:

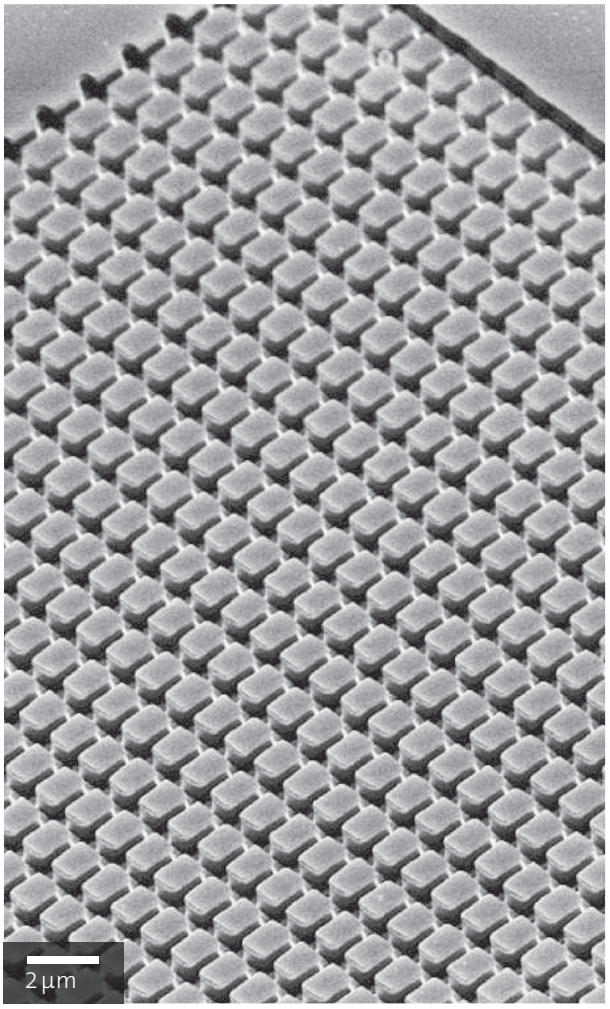
» High refractive index:
  n = 2.45 (at 1550 nm wavelength)
» Feature sizes down to 200 nm
» Low stress
» Little shrinkage

Courtesy of T. Striebel and M. Bastmeyer, KIT (Germany)



4. Ormocere

These organically modified ceramics are developed by the Fraunhofer-Institut für Silicatforschung (ISC) Würzburg, Germany.
Please contact us or refer to www.ormocer.de for detailed information.



5. PEG-DA with PETA

Cell biologists like to use this material combination as scaffolds for cell studies. At low PETA concentrations, this material is protein-repelling. Subsequent filling and polymerization of Ormocere parts (protein binding) allows attachment of cells at only Omorcere polymerized areas.

6. AZ MiR 701, AR-P-3120, AZ 9260

Positive-tone resists used for 2D structuring and electrodeposition in air voids.

7. AZ 5214

Thin film negative-tone resist for 2D structuring.

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