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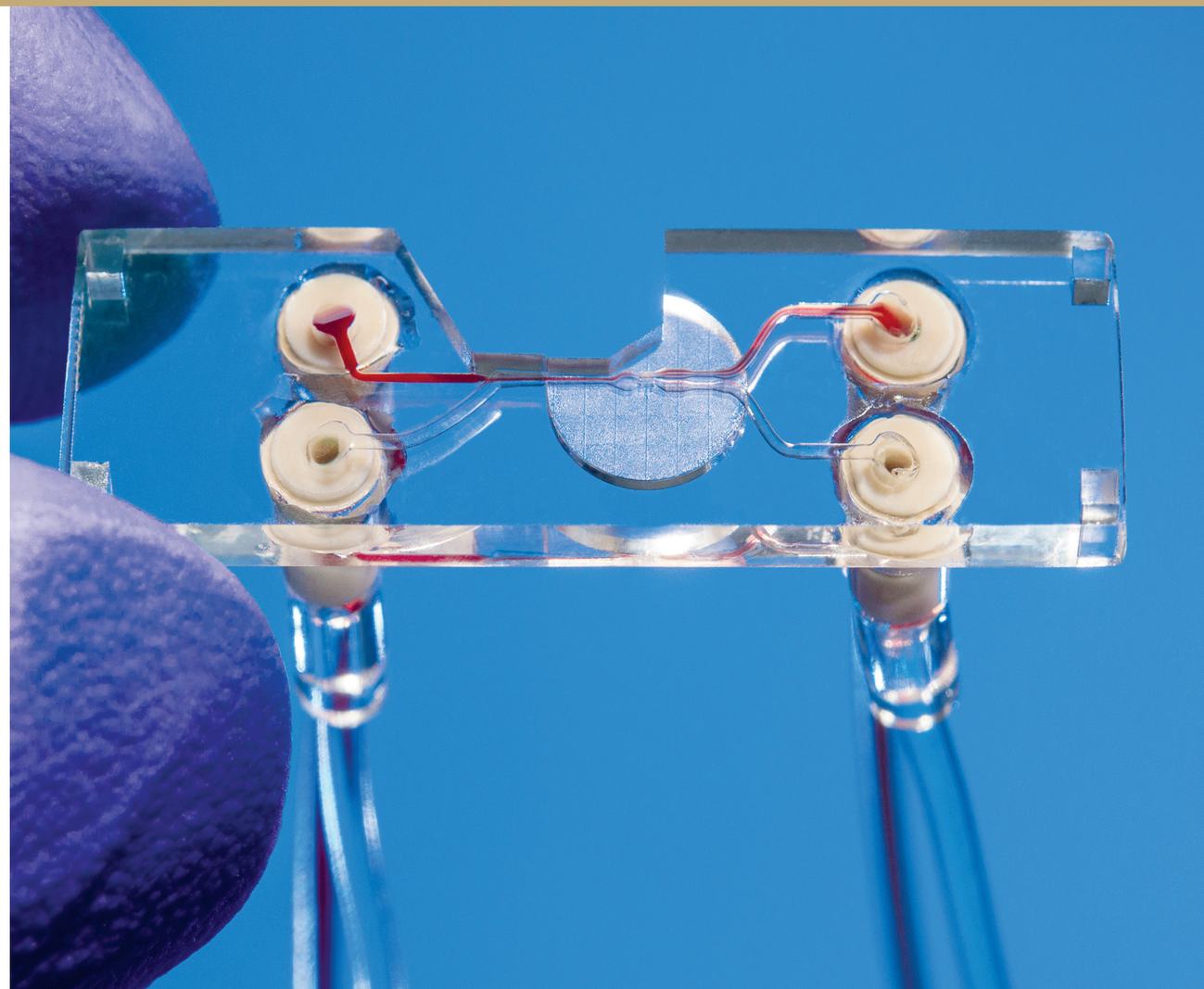
FRAUNHOFER INSTITUTE FOR LASER TECHNOLOGY ILT

PROTOTYPING AND MANUFACTURING OF MICROFLUIDIC CHIPS MADE OF FUSED SILICA



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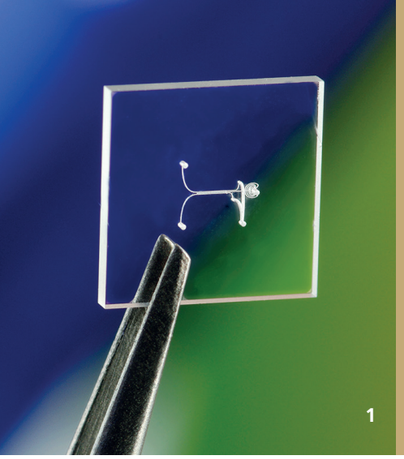
Fraunhofer Institute for Laser Technology ILT

The Fraunhofer Institute for Laser Technology ILT is one of the most important development and contract research institutes in laser development and application worldwide. Its activities encompass a wide range of areas such as developing new laser beam sources and components, laser-based metrology, testing technology and industrial laser processes. This includes laser cutting, ablation, drilling, welding and soldering as well as surface treatment, micro processing and additive manufacturing. Furthermore, Fraunhofer ILT develops photonic components and beam sources for quantum technology.

Overall, Fraunhofer ILT is active in the fields of laser plant technology, digitalization, process monitoring and control, simulation and modeling, AI in laser technology and in the entire system technology. We offer feasibility studies, process qualification and laser integration in customized manufacturing lines. The institute focuses on research and development for industrial and societal challenges in the areas of health, safety, communication, production, mobility, energy and environment. Fraunhofer ILT is integrated into the Fraunhofer-Gesellschaft.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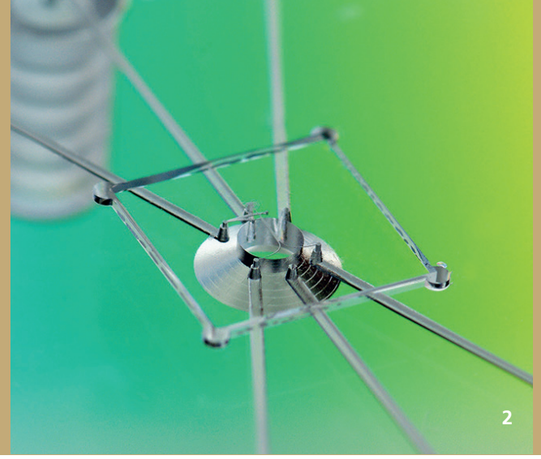
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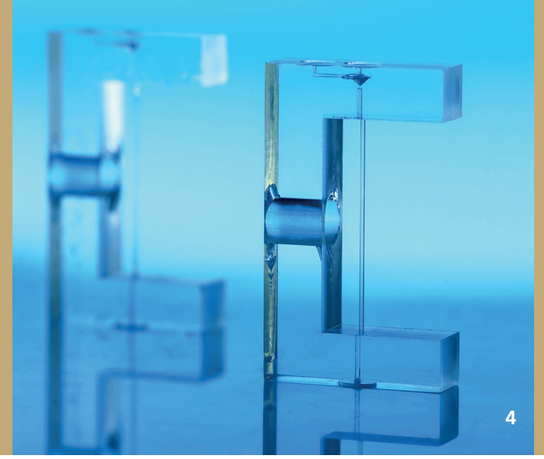
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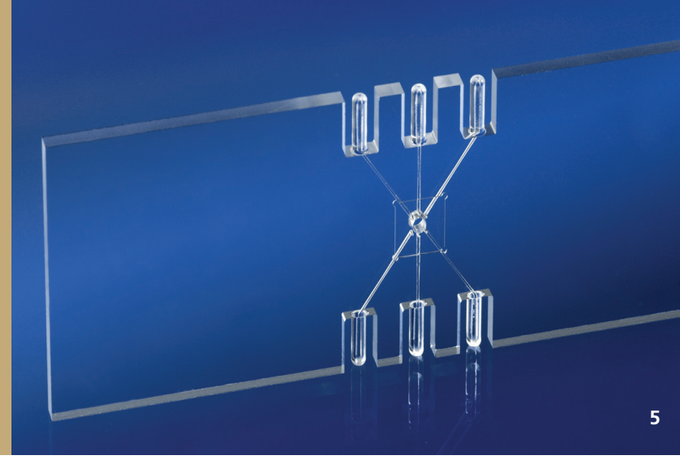
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PROTOTYPING AND MANUFACTURING OF MICROFLUIDIC CHIPS MADE OF FUSED SILICA

Microfluidic systems are used in a diverse range of application, often specific to an individual customer. For these reasons, the Fraunhofer Institute for Laser Technology ILT provides a process for manufacturing 3D channel structures, a process that uses digital design data to write complex structures with ultrashort pulsed laser radiation directly into fused silica. Among other things, this maskless direct process has been used to develop glass chips for tasks such as: droplet generation for segmented flows, marker molecule detection in clinical diagnostics or high-throughput screening for biotechnology.

Manufacture of 3D Freeform Channels

Selective laser-induced etching (SLE) is a manufacturing process that Fraunhofer ILT uses to generate microchannels, holes and cuts in transparent components made of fused silica, borosilicate glass, sapphire and ruby. It can produce micrometer-accurate structures in the volume and on the surface with dimensions of up to several centimeters directly from 3D CAD data.

Ultrashort pulsed focused laser radiation is absorbed in a transparent workpiece only in the focus volume due to multi-photon processes. In the focus volume, the transparent material undergoes a change in its optical and chemical properties without cracking, whereby it can then be selectively and chemically etched. Structures to be produced are exposed with the ultrashort pulse laser and then etched wet-chemically. This process can be used to produce microchannels, mold holes, functional components and complex mechanical and optical systems.

Segmented Flow – High-throughput Screening

The formation of single droplets allows a fluid to be divided into many million segments made up of microdroplets. Each droplet can have its own chemical or biological conditions, which makes it possible to carry out many experiments in the segmented flow at the same time. Core elements are microfluidic chips that reproducibly generate uniform droplets with defined fluid composition and guide the droplets within a carrier fluid in a controlled manner. On the chip they are stored and available for optical measurements as well as further experiments. Microfluidic silica chips were developed and tested in biological applications for the generation and screening of segmented flows made of the smallest of droplets with diameters of 5 µm and larger.

Hydrodynamic Focusing

If particles and molecules of a solution in the laminar flow are examined optically, the quality of the measurement results depends largely on the stability of the sample stream. In hydrodynamic focusing, the sample stream is injected through a nozzle into a sheath stream, allowing the position, velocity, and sample volume at the location of the optical measurement to be accurately adjusted. ILT has developed and tested micro-structures in order to achieve this hydrodynamic focusing for the optical measurement within the microfluidic chip or for fluidically connected flow cells in the smallest possible space.

Opto-Fluidic Systems

Thanks to the CAD-based design and the precise manufacturing in volume, fluidic channels can be produced and optical elements positioned within a single device in a very compact and cost-effective manner. Fraunhofer ILT designed and built, among others, multispectral screening systems with scatter and fluorescence light detection and integrated fiber optic connections as well as fluidic interfaces to commercial components.

Surface Modification and Polishing

The application-specific requirements for the surface of microfluidics are wide-ranging. The properties of the microfluidic channel can be specifically adapted to the specific application by binding of silanes to the surface. To generate and process aqueous droplets in hydrofluoroethers, for example, the Fraunhofer ILT has established a two-step plasma activation process for hydrophobic surface modification. For areas of particularly demanding optical accessibility, surfaces can be polished with thermal processes.

Range of Services

- Prototype development of microfluidic chips from CAD designs (2D/3D)
- Dimensioning, design and manufacture of customized microfluidic chips in small batches all the way up to series production
- Development of microfluidic systems with optical functional elements
- Development of compact sensor units for fluorescence and scattered light measurement in the microfluidic chip
- Feasibility studies for customer-specific measurement and screening tasks

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Cover: Diagnostic chip with integrated sorting structure

1 Sorting chip for screening and sorting droplets.

2 Carrier structure for plug & play connection of microfluidic chips via connectors made of fused silica.

3 Generation of droplets with 10 µm diameter.

4 Capillary holders with hydrodynamic focusing for flow cytometry.

5 Chip with lateral ports for hose connections.