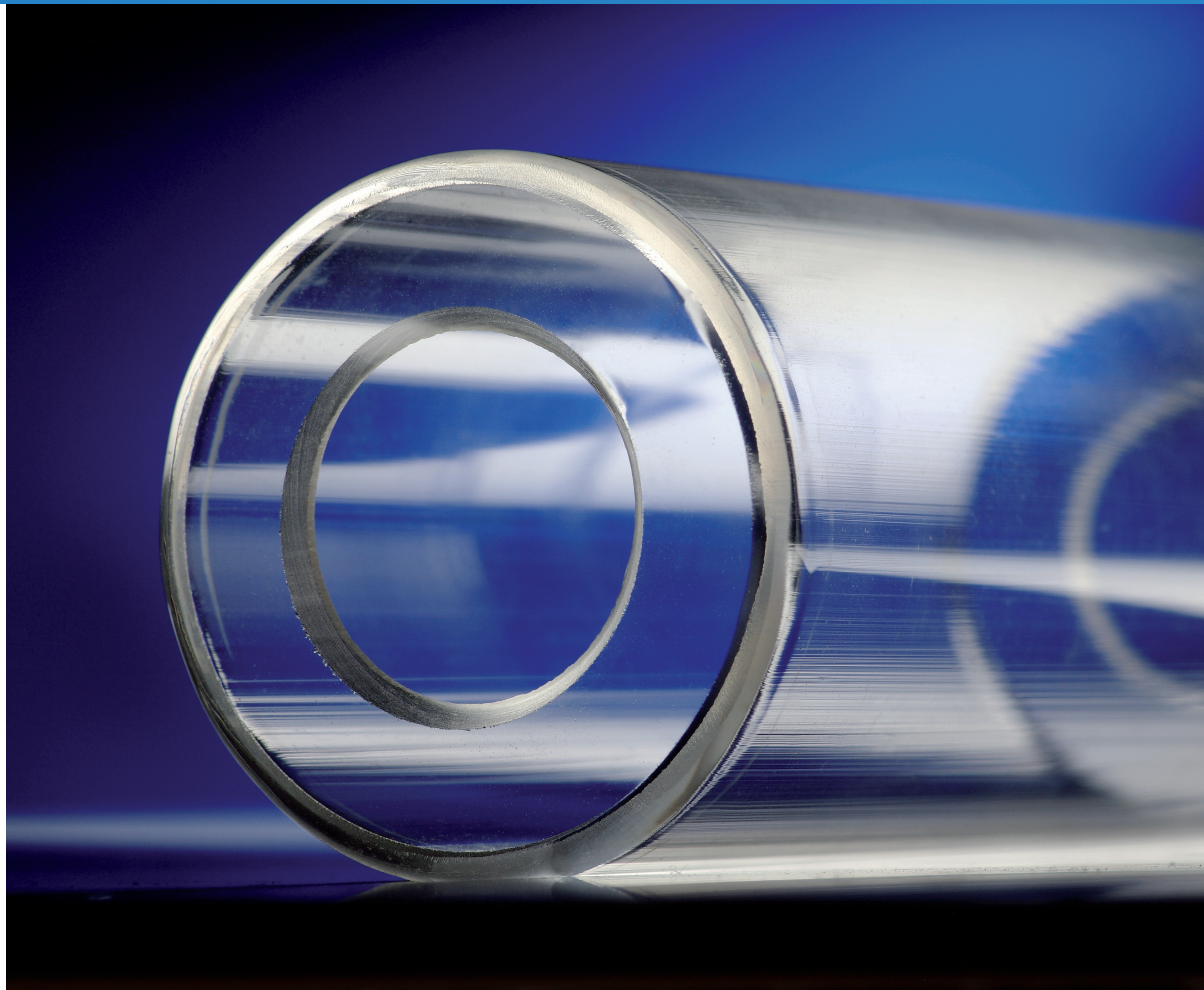
Fraunhofer ILT

FRAUNHOFER INSTITUTE FOR LASER TECHNOLOGY ILT

PROCESSING GLASS WITH LASER RADIATION



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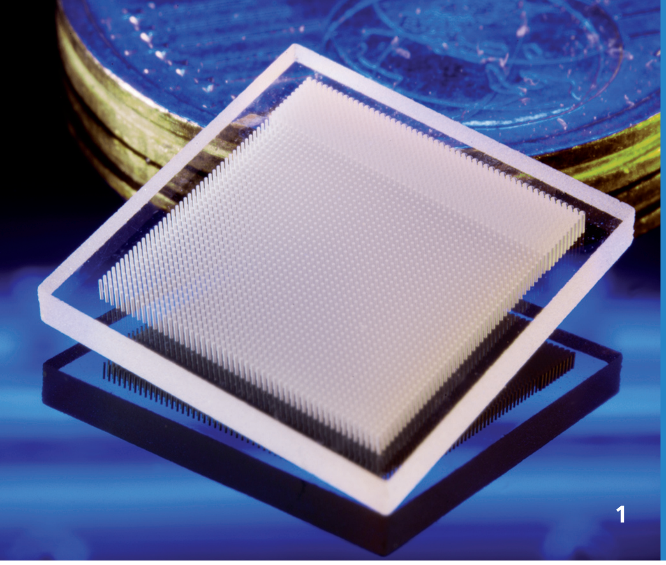
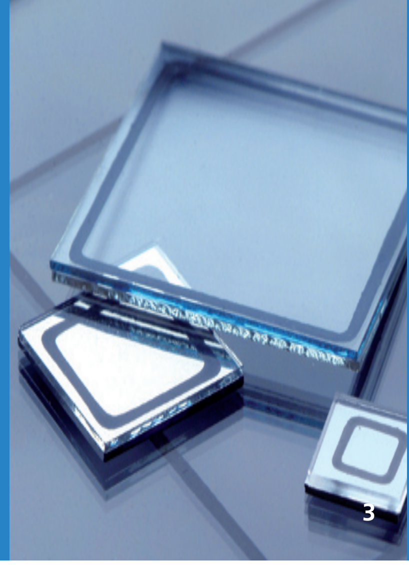
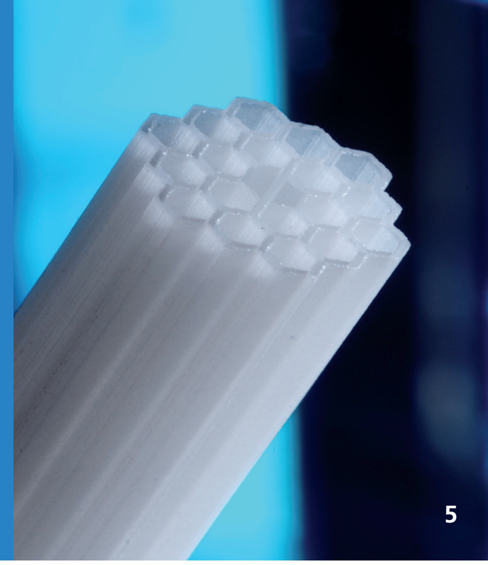
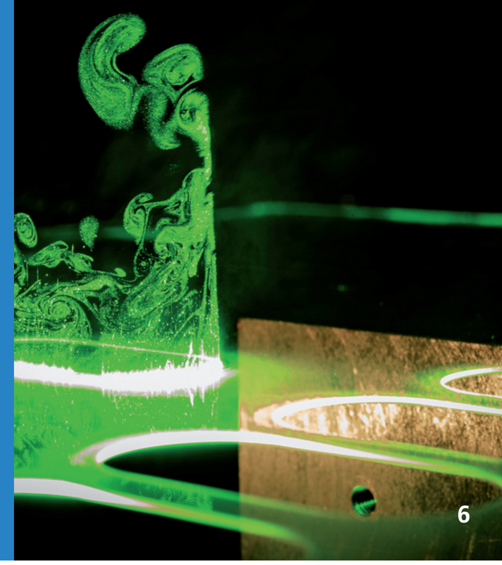
Fraunhofer Institute for Laser Technology ILT

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.





PROCESSING GLASS WITH LASER RADIATION

With laser radiation, a wide range of materials can be processed. In particular, laser radiation can be used for glass processing in many different ways to significantly improve established processes or to create completely new ones. Along with the Chair for Laser Technology LLT of the RWTH Aachen University, the Fraunhofer Institute for Laser Technology ILT is developing laser processes for glass polishing and welding and for enabling 3D in-volume structuring underneath the surface.

Laser Polishing and Molding

When glass and plastics are polished with CO_2 laser radiation, the surface to be polished is heated to just below its evaporation temperature. As a result, the viscosity at the surface is reduced, enabling the roughness to flow, thereby smoothening the surface. In comparison to conventional polishing processes, laser polishing allows the quick processing of aspherical objects with complex surface geometries. In addition to the laser polishing, an ablation process can be used to generate the surface form of the optics in a preceding step according to individual requirements. Together with a third step to correct form deviations, ablation and polishing step constitute a laser-based process chain for manufacturing optics. This process should enable flexible and efficient production of individualized optics with non-spherical surfaces in small lot sizes.

The main advantages of laser polishing and this new process chain – as compared to conventional manufacturing methods – lie in the significantly reduced manufacturing time and the great flexibility of forms which can be generated or polished.

In-volume Structuring

Focused, ultra-short pulsed laser radiation can be used to modify glass and crystals underneath the surface. The refractive index of the material is changed locally by direct laser structuring. In this manner, optical components such as waveguides and in-volume markings can be realized. If a subsequent wet chemical etching process is added, three-dimensional micro components and micro fluidic components can be fabricated with nearly arbitrarily geometry. Such components can be applied in micro engineering and medical technology applications. The laser manufacturing process is called In-volume Selective Laserinduced Etching (ISLE). The material modified by the laser radiation is etched, while the unmodified material remains almost untreated by the acid. The ISLE process is characterized by the highest precision (structures < 500 nm) at simultaneously large structuring speeds (v > 0.1 m/s).

When a laser is used to drill a transparent component from the rear side, the material ablated is removed layer by layer, whereas each layer is scanned with ultra-short pulsed laser radiation with single shots. This process has several advantages: no conicity of the drilling channel, no impurities within the drilling channel and the possibility of greater aspect ratios. Currently, drill holes with diameters ranging from 0.35 to 8 mm and a depth of 120 mm in BK7 can be realized. In quartz glass drill depths of up to 60 mm with diameters ranging from 0.6 to 8 mm are possible. Furthermore, freely definable structures, such as twisted polygons and very filigree structures can be generated, which are not possible with conventional processes.

Laser Drilling and Cutting

Increasingly, micro drill holes are needed in medical and engineering applications as venting or dosage holes. By means of ultra-short pulsed laser radiation, holes can be fabricated with diameters of < 50 µm in materials with thicknesses of 100 µm, whereas the number, arrangement and diameters of the holes are variable and can be adjusted to the customer's requirements. For cutting of glass with utrashort pulsed lasers several parallel lines are ablated, each with a depth of several micrometers. The number of lines has to be adapted till the glass is cut through.The interaction between laser radiation and the glass material can be simulated in advance and the process parameters are adjusted to the desired result.

Laser Soldering

Packaging glass components poses a great challenge as the integration density progressively increases. This is the case, on the one hand, for hermetically sealed microsystems and, on the other hand, for large format OLED productions in a long-term stable, hermetically sealed atmosphere. One promising approach is glass soldering with laser radiation in the near infrared wavelength range. This process provides a means of concentrating the energy needed to join glass components, to depose it spatially limited to the glass solder itself and to minimize the overall heating of the entire system to be joined.

Laser Welding

Currently, conventional gas burner systems are typically used to weld quartz glass. A characteristic of this joining process is a low absorption of the energy emitted by the burner, which leads to a great demand of process energy and thus to low efficiency. By contrast, laser beam welding uses CO_2 laser radiation to deposit the energy needed to heat the material to the required process temperature. This energy is almost completely absorbed on the component surface such that the efficiency, in comparison to conventional processing, can be increased significantly.

Laser Transmission Bonding

Laser transmission bonding of glass is a melt-free solid state joining process and is based on the build-up of oxygen bridges, analogous to conventional bonding processes. By selective laser irradiation of the area to be joined, joining zones with bonding seams of < 100 µm can be attained at the lowest temperature loads of the entire component. Therefore, the process is suitable for bonding and encapsulating micro systems with moveable structures and thermally sensitive components. By using absorbing intermediate layers and laser beam sources with a wavelength in the range of 1500 - 1900 nm, other material combinations such as silicon to silicon can be joined.

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1 Cutting of micro holes in 1 mm fused silica.
2 Laser polished sphere out of fused silica.
3 Samples of glass/glass, glass/MAM, glass/silicon and glass/ITO bonds.
4 Mounted gear wheel fabricated in fused silica by ISLE process (Ø 3 mm, height 500 µm).
5 Photonic structure in BK7 glass.
6 Cutting of thin glass with a ps-laser.