FRAUNHOFER INSTITUTE FOR LASER TECHNOLOGY ILT

MICRO- AND NANOSTRUCTURING WITH LASERS

DQS certified by
DIN EN ISO 9001:2015
Reg.-No. 069572 QM15

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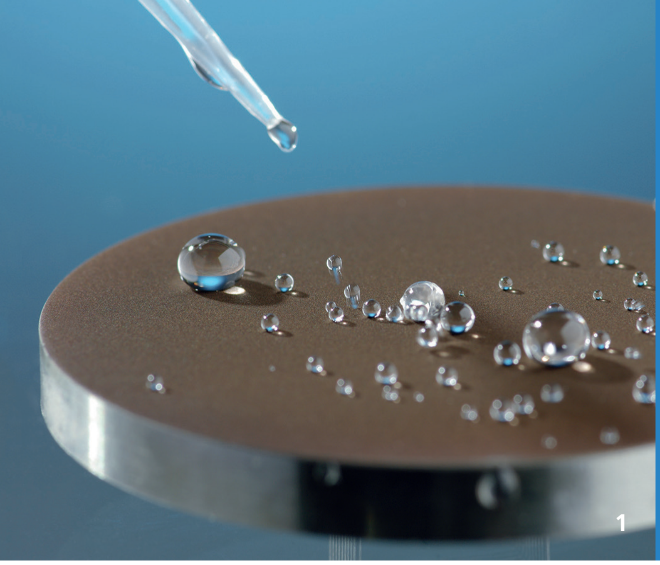
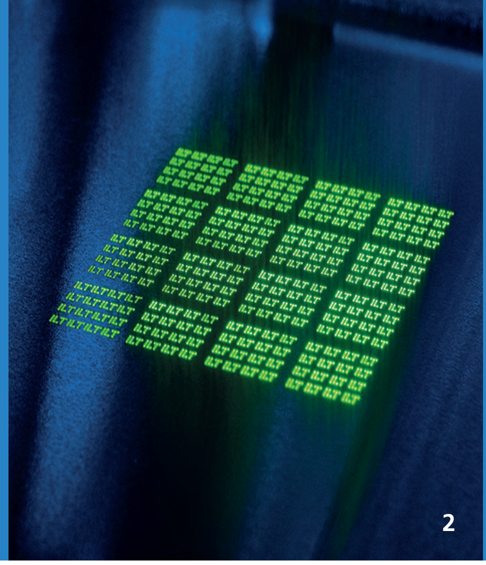
Fraunhofer Institute for Laser Technology ILT

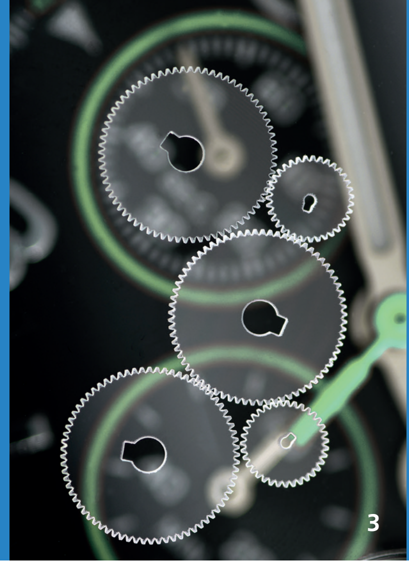
The Fraunhofer Institute for Laser Technology ILT is one of the most important development and contract research institutes in laser development and application worldwide. Its activities encompass a wide range of areas such as developing new laser beam sources and components, laser-based metrology, testing 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.

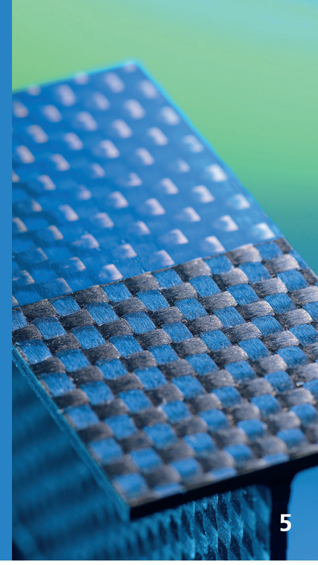
Overall, Fraunhofer ILT is active in the fields of laser plant technology, digitalization, process monitoring and control, simulation and modeling, AI in laser technology and in the entire system technology. We offer feasibility studies, process qualification and laser integration in customized manufacturing 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.

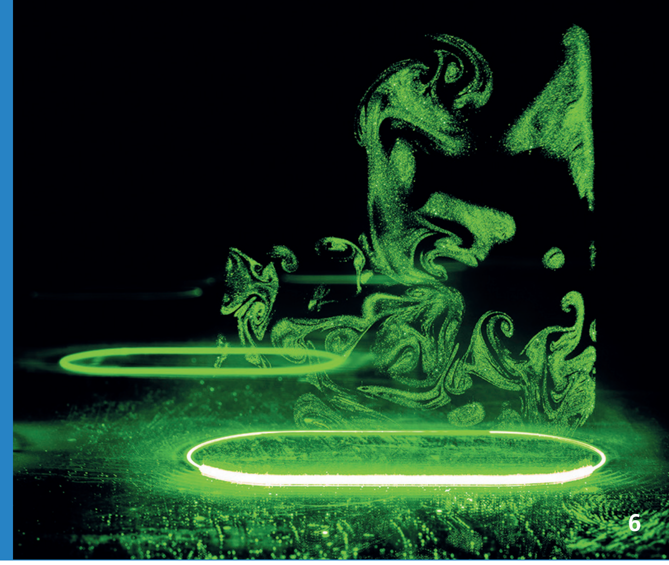
Subject to alterations in specifications and other technical information. 06/2017.











MICRO- AND NANOSTRUCTURING WITH LASERS

When surfaces need to be functionalized or parts structured with great precision, lasers and laser-based processes offer great advantages: low heat input, high flexibility and high lateral resolution since they can be focused down to a few micrometers. Thanks to these properties, the laser can be used for numerous applications in electronics, display technology and automobile construction as well as energy and medical technology. The Fraunhofer Institute for Laser Technology ILT develops laser-based micro-technological manufacturing processes and production systems that can be specifically adapted to a particular application.

Laser Ablation

As products in electronics and sensor technology become smaller and smaller, components are required with structure sizes in the micrometer range. Highly precise laser ablation processes are a suitable means to reach such sizes for metals, ceramics and polymers. Here, ultrashort pulse lasers, for ablation, make it possible to process all types of materials at sub-micrometer accuracy. For mass manufacturing of micro components by injection molding, embossing and stamping, tools can be produced with structure sizes in the range of 5 to 10 µm with surface precision < 200 nm. Laser ablation with ultrashort pulsed lasers is a flexible complement to conventional processes such as EDM and high-speed cutting for the production of tools and components.

In addition, direct processing of components lends itself well to small to medium lot sizes. Here, since ultrashort pulse lasers evaporate material directly, they can be integrated into existing process chains simply and enjoy great flexibility due to their parameter diversity. Functional surfaces often require structures that enhance the intrinsic properties of the materials; optical, biological and analytical functions require micro- and nanostructures that can be reproduced at high speed. For these applications, Fraunhofer ILT has developed a new multi-beam interference technology that can produce periodic surface structures in the range of 100 to 1000 nm in a process that is safe and has high throughput.

Cover: Chessboard with nanostructures and chessman in silica glass.

1 Superhydrophobic surface.

2 Multibeam ablation.

3 Microgear-wheels in sapphire.

Laser Beam Drilling and Cutting

Drilling with laser radiation is used as a manufacturing technology for geometries and materials that cannot be processed with conventional processes. Thanks to special drilling technologies, such as helical drilling, hole geometries can be generated in the tens of micrometers at drilling depths of up to 2 mm without thermally impairing the base material. For applications in filter and sieving technology or also in coating masks, novel laser drilling processes are available with drilling rates of up to 10,000 holes/s. With new ultrashort pulsed lasers and innovative approaches, multi-photon absorption can be applied to generate hole diameters even < 1 µm. Hybrid processes can be applied to structure dielectric materials such as glass, sapphire and other difficult to process materials like semiconductors. Here, laser induced material modifications and subsequent echting are applicable to generate 3D-structures with nanometer precision even in volume of the material.

Laser beam cutting of precise metal parts is a well-established process for industrial manufacturing of micro components. The contactless processing with cutting kerfs < 20 µm allows the manufacturing of very intricate parts that cannot be produced by conventional technologies.

Thanks to precise ultrashort pulse lasers and new process approaches, e. g. helical cutting, high quality cuts are possible, even in hard/brittle materials. Due to the significant increase to production flexibility, conventional embossing or EDM processes can be replaced at small and medium lot sizes.

Processes with High-power Ultrashort Pulsed Laser Radiation

Meanwhile, beam sources with powers of 100 to 1000 W are also available in the ultrashort pulse range. In order to meet the high demands on quality and accuracy even with the smallest beam diameters, intensities close to the ablation threshold are necessary to avoid undesirable, thermally induced quality losses. Nevertheless, to make use of the high power available, Fraunhofer ILT has developed new approaches in which the laser beam is either divided into several partial beams or deflected at the highest speed. The separation of high-energy laser radiation can be achieved by means of diffractive optical elements with the highest precision and stability. Fraunhofer ILT has already developed several processes and the necessary system technology at an industrial level, with up to 200 partial beams. The high-dynamic deflection of rapidly repetitive beam sources can be accomplished by fast optical deflectors or by polygon scanning systems. Demonstration models show that even scanning speeds of more than 1000 m/s are possible and thus beam sources with repetition rates in the range of several MHz can be used without causing thermal damage to the workpiece.

Facilities (Extract)

Laser Beam Sources:
- 100 fs laser (P = 1.5 W, λ = 800 nm)
- 200 fs to 20 ps laser (P = 10 W, λ = 1030/515/343 nm)
- 1 ps laser (P = 400 W, λ = 1030 nm)
- 7 ps laser (P = 50 W, λ = 1030 nm)
- 10 ps laser (P = 100 W, λ = 1030 nm)
- 10 ps laser (P = 36 W, λ = 1064/532/355 nm)
- 10 ns excimer laser (λ = 193 nm)
- 40 ns laser (P = 10 W, λ = 355 nm)
- 100 ns laser (P = 100 W, λ = 1064)

Machines and Plants:
- DMG LT50 five-axis machine
- DMG DML 40 three-axis machine
- GF L1000 five-axis machine
- Kugler MICROGANTRY NANO 3X, three-axis machine
- Helical drilling optics v 6s
- Polygon scanner
- Multi-beam optics
- Synova Laser MicroJet

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4 Embossed stamp.

5 Exposed CFRP component.

6 Ablation of thin glass.