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FRAUNHOFER INSTITUTE FOR LASER TECHNOLOGY ILT

LASER PROCESSING OF COMPOSITES

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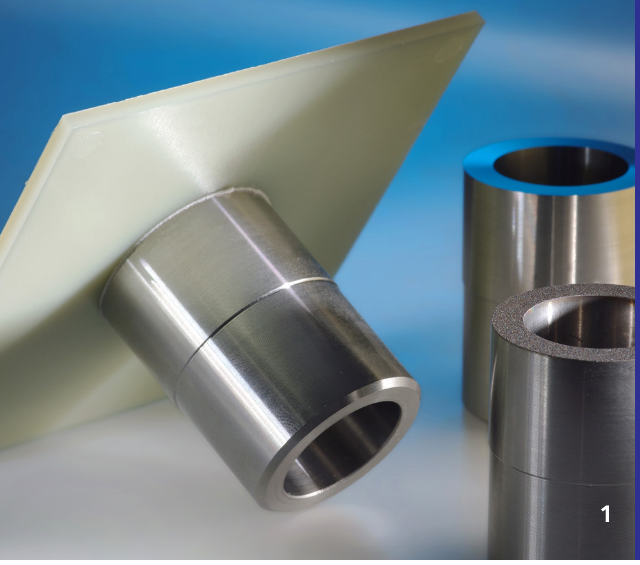
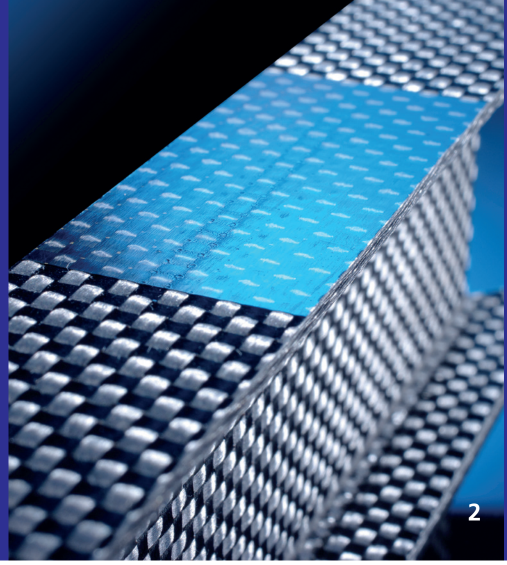
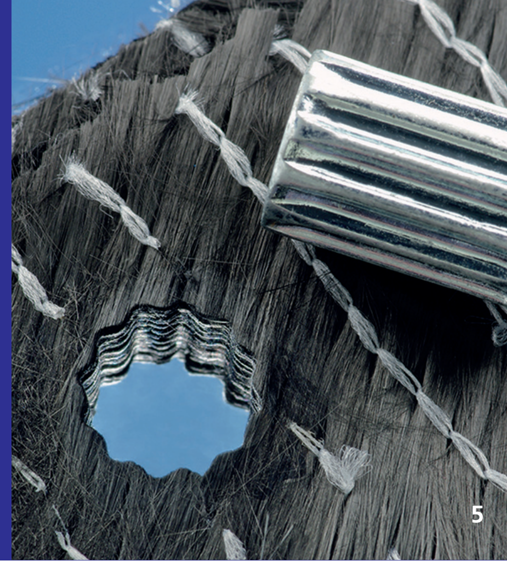
Fraunhofer Institute for Laser Technology ILT

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.


LASER PROCESSING OF COMPOSITES

Low production costs and short cycle times are a priority if the large-scale application of fiber-reinforced plastics (FRP) is to become reality. Working with these inhomogeneous materials requires processes adapted to the anisotropic characteristics of the material itself. Due to its flexibility, wear-free operation and high processing speeds, the laser is an ideal tool for this application. In the Center for Laser Lightweight Design the Fraunhofer ILT develops laser processes which do not change the specific characteristics of the material and preserve the advantages of FRP components optimally.

Cutting

Since they can be operated with excellent temporal and local control, lasers have great potential to reduce processing times and to automate the production of FRP components. This is true for various steps within the process chain – from cutting of prepegs, tapes and organic sheets to trimming and cutting of FRP components. High processing speed or the use of short pulsed laser radiation ensures that damages to the cut edges can be reduced to a minimum in spite of different absorption, heat conduction, melting and decomposition temperatures of fiber and matrix.

Structuring and Drilling

In comparison to isotropic and homogeneous materials, composite materials are particularly difficult to process, since the different mechanical and thermal characteristics of the individual material components often lead to uneven processing results. Ultra-short pulsed lasers in the pico and femtosecond regime enable highly precise and simultaneously selective processing, independent of the thermo-physical and mechanical properties of the material. On account of the high pulse power in the megawatt range and the concomitant high intensities, the evaporation threshold for matrix and fibers is instantaneously exceeded. Furthermore, the ablation can fully be controlled via the evaporation threshold fluence of the material due to the short interaction time and the low thermal effect involved. In this manner, composite materials can be drilled without thermal damage to the adjacent matrix on the one hand, and, on the other, a selective removal and structuring of the matrix can occur, without destroying the fiber structure.

Joining

Laser penetration welding lends itself well to manufacturing complex fiber composite materials out of several individual elements, as well as to producing hollow structures. Thanks to this contact-free process, closed reinforcement structures can be produced to increase the component stiffness at high processing speeds. Local attachment points and connecting elements can be integrated without complicated process steps. Laser welding has the advantage of depositing the necessary energy directly into the contact zone without otherwise influencing the component. Joining preparations and long hardening times can be omitted so that the process can be directly integrated into the production chain. When radiation propagation is adapted, even materials with high fiber content can be joined such that the demands for robust processes in series production can be fulfilled. With an adapted machining and gap bridging strategy, large components with inherent tolerances can be joined securely as well.

Plastic-Metal Connections

Lightweight components are generally composed of different materials for reasons of cost and stability. With this mix of materials, the specific characteristics of the materials applied are exploited specific to their load-bearing capacity. To join these materials, a technology is required that connects dissimilar materials securely and does so in short process times. The joining of plastic with metal poses a particular challenge since this combination cannot be welded directly and with high-strength. Assistance is provided either by a joining process which utilizes high-speed laser micro structuring to furnish the metal surface with undercut structures and a defined roughness or the creation of a spongy, porous surface by means of ultrashort pulse lasers. In the subsequent laser-based joining process, the plastic is melted selectively on the joint between the metal and plastic, such that the latter can cramp reliably on the metal surface processed before. Thanks to a load-optimized dimension of the direction, form and number of structures, a large bandwidth of possible hybrid connecting structures for a multitude of material combinations results.

Equipment – Center for Laser Lightweight Design

In the Center for Laser Lightweight Construction an extensive amount of machinery and equipment is available, such as various beam sources and handling systems combined with comprehensive equipment for process analysis and diagnosis, which is kept up to date continuously with the latest developments:

- Fiber and disk lasers with powers up to 12 kW (multi-mode) and 5 kW power (single-mode)
- Diode lasers with powers up to 12 kW power
- CO_2 lasers cw with powers up to 10 kW and cw up to 10 kW power and pulsed with average power up to 1.5 kW
- Ultrafast fs and ps lasers with average power up to 1 kW
- Robotic-, multi axis- and portal plants for 3D processing
- 2D cutting plant, 300 m/min, 5g
- Remote processing system with galvanometric scanner, focal lengths from 50 - 810 mm
- UV, VIS, NIR and FTIR-spectrometers
- Process monitoring systems
- High speed and thermography cameras
- Universal tensile testing machine 10 N - 100 kN
- Climatic chamber

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1 Hybrid test specimens made of steel with USP structuring and PA6.6/GF25.
2 Exposed fiber structure made of CFRP.
3 Laser welded and cutted truck seat component made of GFRP.
4 CFRP cut edge, 8 mm material thickness.
5 Laser-beam drilled CFRP preform for a form locking insert.
6 Laser based hybrid connection between a car door and GFRP reinforcement brace.