Lasers in Plastic Technology

Fraunhofer Institute for Laser Technology ILT

With about 330 employees and 11,000 m² of usable floor space, the Fraunhofer Institute for Laser Technology ILT is worldwide one of the most important development and contract research institutes of its specific field. The activities cover a wide range of areas such as the development of new laser beam sources and components, precise laser based metrology, testing technology and industrial laser processes. This includes laser cutting, drilling, welding and soldering as well as surface treatment, micro processing and rapid manufacturing. Furthermore, the Fraunhofer ILT is engaged in laser plant technology, process control, modeling as well as in the entire system technology. We offer feasibility studies, process qualification and laser integration in customer specific manufacturing lines. The Fraunhofer ILT is part of the Fraunhofer-Gesellschaft with more than 80 research units, 18,000 employees and an annual research budget of 1.65 billion euros.

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LASERS IN PLASTICS TECHNOLOGY

Machining processes in the field of plastics technology have wide-ranging requirements. The Fraunhofer Institute for Laser Technology ILT has developed and qualified customized processes through to turnkey production systems for welding, cutting, drilling, structuring and marking of plastics.

Laser Transmission Welding of Plastics

Laser transmission welding of plastics produces concealed joints with a minimal impact on the components. Laser radiation is transmitted through the first joining partner, with the energy absorbed by the second joining partner at the interface between the two. The plastic melts and joins the two components by means of heat conduction. Process development is closely linked to the material selection and the adapted energy deposition strategies. Through a sophisticated selection of laser source, beam form and adapted irradiation strategy, the standard combination of transparent and laser-absorbing plastics as well as other combinations can be joined. Glass fiber reinforced thermoplastics in particular can also be welded reliably by means of suitable irradiation strategy and system technology.

TWIST® High-Speed Welding

TWIST® combines the characteristics of contour welding and quasi-simultaneous welding. The beam movement is superimposed perpendicular to the traversing direction, enabling seam widths of 100 μm and larger to be produced. The selective welding process with homogeneous energy deposition produces a flat heat affected zone. Fiber lasers support weld speeds up to 1 m/s, paving the way for invisible, distortion-free welding - especially of microfluidic components - that boosts high process reliability.

Welding Transparent Plastics

By matching the laser wavelength to the optical properties of the plastics, sufficient energy deposition can be achieved even for optically transparent plastics without the use of absorption enhancing pigments or additives. Special focusing optics with a high numerical aperture allow the energy to be concentrated in the joining plane so that the threshold level required to melt the plastics is reached. The radiation intensity on the component’s surface is so low that the laser does not damage the components. The use of new laser beam sources facilitates laser transmission welding of transparent or opaque plastics, as frequently used in medical engineering, without the need for additional absorbers. The combination of adapted wavelength with the ultraprise TWIST® process enables transparent lab-on-a-chip systems to be joined.

Plastic-Metal Joints

Enhanced functionality in many products, and the trend toward lightweight components, increasingly calls for a mix of different materials with specific properties, coupled with the need for a permanent, strong mechanical bond. The ability to join plastics and metallic components is therefore becoming increasingly important in this respect. Laser microstructuring of the metal surface creates undercuts into which the plastic can reliably flow in the subsequent joining process. Lightweight design potential can be leveraged extensively in this respect by joining appropriately pretreated metal with fiber-reinforced plastic. The LIFTEC process developed at Fraunhofer ILT provides a flexible solution for components with complex geometries or for those which involve thermally sensitive materials. Laser microstructuring on the metal surface generates a solid, mechanically strong bond with the plastic.

Process Control and Simulation

Process control and monitoring is indispensable for reliable high-performance manufacturing processes. Fraunhofer ILT uses various pyrometric, CCD and thermal camera-based systems, which are integrated into the purpose-built optical processing head. The acquired process data provide insights into the machining process and can be used for simulations aimed at optimizing the speed and quality of the welding and ablation processes.

Cutting, Drilling, Structuring and Marking

Thanks to its small heat affected zone and high process speed, the laser is an ideal solution for cutting, drilling, perforating, structuring and marking of thermoplastics, elastomers and many other non-metallic materials such as glass, paper, thermosets or composite materials. Depending on the type of material, CO₂ lasers as well as frequency-converted solid-state lasers and excimer lasers with adapted wavelengths are used to reduce the thermal influence to a few micrometers. Based on process developments and qualification studies, industrial manufacturing equipment and components are being planned and built which will find their way into applications in the automotive industry, medical engineering, the paper industry, filter technology, packaging technology, and custom machine production.

Plastics Technology Equipment

- Fiber laser, $\lambda = 1.075 \text{ nm}$, $P = 1,000 \text{ W}$, cw, TEM$_{00}$
- Fiber laser, $\lambda = 1.080 \text{ nm}$, $P = 20 \text{ W}$ cw and pulsed
- Fiber laser, $\lambda = 1.567 \text{ nm}$, $P = 120 \text{ W}$, cw
- Fiber laser, $\lambda = 1.940 \text{ nm}$, $P = 120 \text{ W}$, cw
- Diode laser, $\lambda = 808/940 \text{ nm}$, 500 W, cw, 600 μm fiber
- Diode laser, $\lambda = 808/940 \text{ nm}$, 2,000 W, cw, 1,000 μm fiber
- Diode laser modules with output powers up to 70 W and wavelengths of 808, 940, 980, 1,490, 1,710 and 1,908 nm
- 6-axis robot
- Galvanometer scanner with focal lengths of 50 - 810 mm
- CO₂ laser, $\lambda = 10.6 \mu\text{m}$, $P = 120 \text{ W}$ average output power, $P = 600 \text{ W}$ pulse
- UV-VIS-NIR spectrometer
- Process control systems
- High-speed camera with 10 kHz frame rate
- Thermographic camera
- Universal tensile testing machine 10 N - 100 kN
- Climate chamber

Front page: Welding transparent plastic without IR absorber (PMMA)