FRAUNHOFER INSTITUTE FOR LASER TECHNOLOGY ILT

MICRO JOINING WITH LASER RADIATION

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

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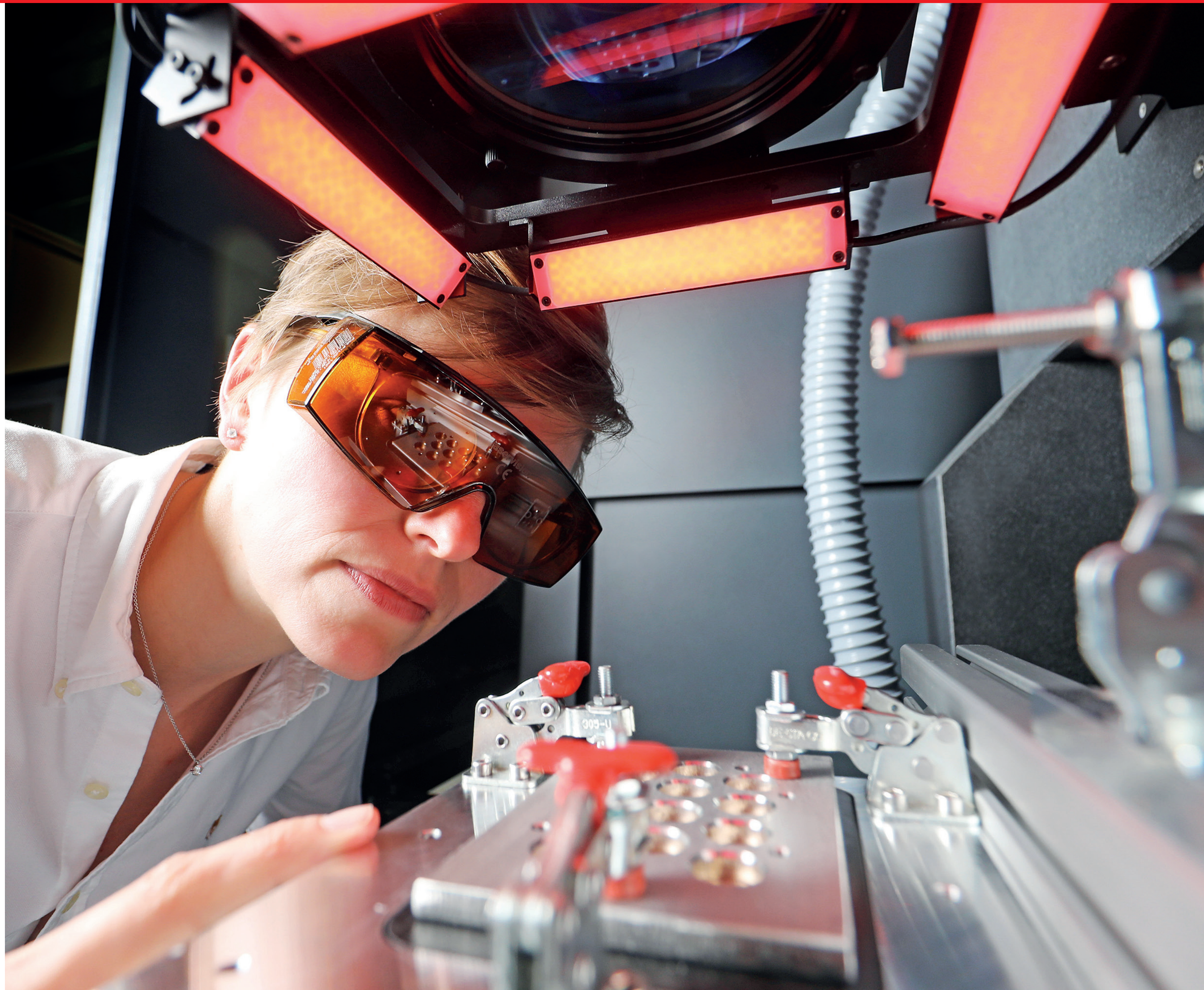
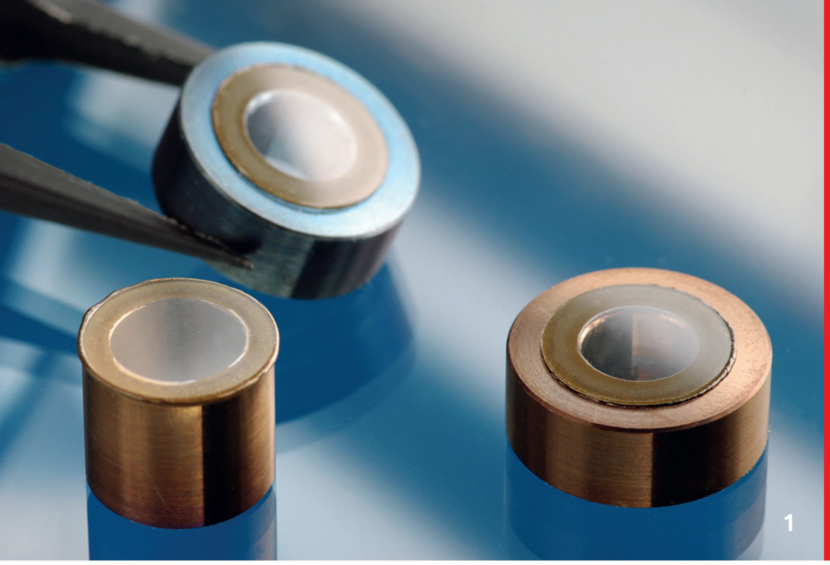
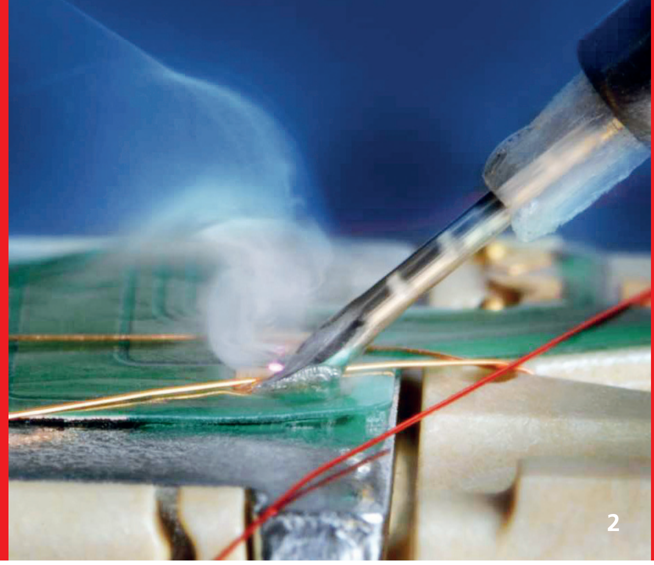
Fraunhofer Institute for Laser Technology ILT

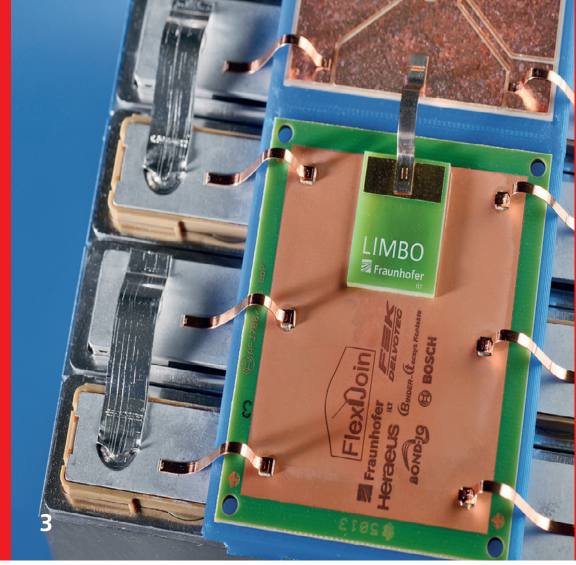
The Fraunhofer Institute for Laser Technology ILT is one of the most important development and contract research institutes in laser development and application worldwide. Its activities encompass a wide range of areas such as developing new laser beam sources and components, laser-based metrology, testing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

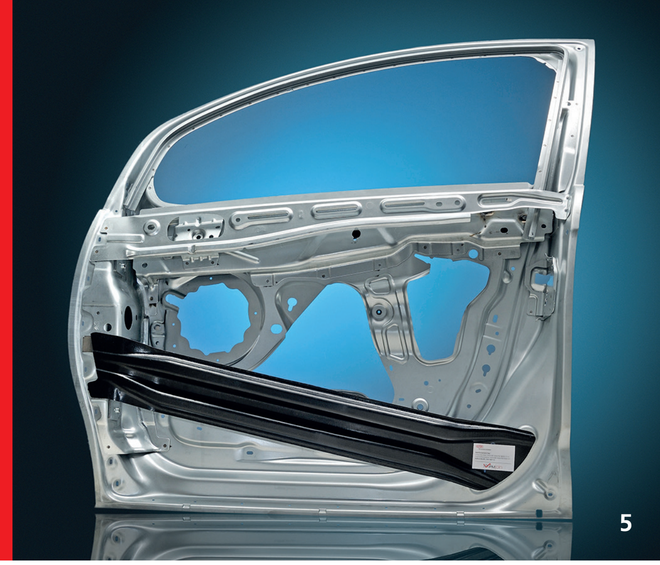
Overall, Fraunhofer ILT is active in the fields of laser plant technology, digitalization, process monitoring and control, simulation and modeling, AI in laser technology and in the entire system technology. We offer feasibility studies, process qualification and laser integration in customized manufacturing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











MICRO JOINING WITH LASER RADIATION

Micro joining with laser radiation is already used in many areas such as electronics, medical technology, micro-optics, precision engineering and microsystems technology. The Fraunhofer Institute for Laser Technology ILT applies its many years of experience and comprehensive know-how to develop innovative manufacturing processes and systems for customers in industry and research. As a tool in micro-joining technology, the laser beam has great promise since it is extremely flexible, has low heat input and can be focused down to a few micrometers at high spatial resolution. Metals and plastics as well as material combinations such as silicon-glass or plastic-metal can be joined with laser radiation.

Micro welding

Laser beam micro welding of metals is characterized, in particular, by a low and controlled heat input into the component. For this application, highly brilliant beam sources are used to generate focus diameters < 40 µm, which enable a deep welding effect at low laser powers < 500 W, even at a wavelength around 1 µm in highly reflective materials such as copper or aluminum. The small cross section of the joint resulting from the small focus diameter can be offset by suitable irradiation strategies such as spatial and temporal power modulation. Furthermore, thermal management can also be adapted by using sources that emit radiation in the visible wavelength range. In this way, the thermal load on the components can be minimized and the dynamics of the common melt controlled.

Cover: Laser beam micro welding of battery cells for electric drives.

1 Glass-to-metal joints consisting of borosilicate glass lids and Kovar sleeves.

2 Soldering of enameled wire.

Soldering

For electronics and medical technology, soft and hard soldering using laser radiation with a low energy input can join touch- and temperature-sensitive components in a few hundred milliseconds. An outstanding characteristic of laser-beam soldering is the processing of pitch dimensions between 100 and 2000 µm by suitably choosing a focusing and irradiation strategy. The temperature of the joining process can be kept constant even under changing process conditions with online detection of the heat radiation coaxial to the laser radiation with pyrometric sensors and a laser power control based on it. Position control via integrated, miniaturized CCD cameras is also possible.

Welding of polymers

Laser beam welding of thermoplastics produces high-quality seams and provides numerous process-specific advantages, such as the contact-free application of joining energy without thermal stress on the joining environment and processing without particle release. Innovative process technologies based on fast modulated fiber-laser radiation can generate seam widths < 150 µm at welding speeds of up to 1 m/s. Even transparent plastics can be welded without the use of absorbers when the laser wavelength is adapted to the absorption behavior of the plastics.

Joining plastics with dissimilar materials

Joining dissimilar materials poses a particular challenge for many applications. In multi-material lightweight construction, for example, plastics and metals must be joined securely and quickly. To accomplish this, laser microstructuring can be used to create undercuts in the metal surface, which enable the plastic, when molten, to claw into the metal surface as it cools in the subsequent joining process. This produces very stable, hybrid joints without needing additional materials. A comparable approach is also used for joining plastics and glass by creating corresponding microstructures in the glass surface. These hybrid joining technologies can be applied in the automotive and aerospace industries as well as in display and medical technology, among others.

Glass frit bonding

Laser-based glass frit bonding is commonly used as a reliable method to encapsulate various applications and material combinations and is particularly suitable for enclosing and encapsulating temperature-sensitive components. The glass-based joining material makes it possible to produce resilient connections of glass and ceramic materials. Even dissimilar material combinations such as metal-glass or metal-ceramics can be joined, provided that the materials are adapted to thermal expansion. In glass frit bonding, the necessary energy input results from the absorption of the laser radiation in the glass solder. The laser process is adjusted in such a way that the joining parts are wetted reliably and vaporization of glass solder components is avoided. The bond thus achieved forms a hermetic barrier that prevents the penetration of moisture and gas.

Laser beam bonding

Widely used in microsystems technology, silicon and glass can be joined locally with laser beam bonding. Thanks to selective laser irradiation of the joining area, oxygen bridges are formed in a melt-free solid state joining process, analogous to conventional anodic bonding. This way, joining zones with bond seam widths < 200 µm can be achieved with very low temperature stress on the entire component. The process is, therefore, particularly suitable for encapsulating microsystems with moving structures and thermally sensitive components. Material composites such as silicon-silicon can also be joined when using absorbing intermediate layers and laser beam sources with a wavelength in the range of 1500–1900 nm.

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3 Battery module with laser-based joining technology.

4 Laser beam welding of transparent plastics for microfluidic applications.

5 Car door with plastic-metal hybrid connection joined with a laser.