Micro joining with Laser radiation

Fraunhofer ILT - Short Profile

With about 330 employees and more than 11,000 m² of usable floorspace 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, caving, 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 over 1.6 billion euros.
**Micro Joining with Laser Radiation**

Lasers stand out as excellent tools for microengineering: they can focus down to a few micrometers, thus facilitating high local resolution, they deposit very low heat into the workpiece, and they are highly flexible. Their applications are manifold and vary from areas such as electronics, sensor systems and medical technology, to precision mechanics and microsystems technology. The Fraunhofer ILT develops production techniques along with laser systems and components for use in these fields.

**Bonding**

Laser bonding of silicon and glass is a non-melting solid state joining process. It is based on the formation of oxygen bridges similar to conventional anodic bonding. The selective laser irradiation of the joining area enables bond seam widths below 200 μm at a minimum thermal load for the entire component. Therefore, this process is particularly suited for bonding and encapsulation of microsystems with moving parts and thermally sensitive components. When absorbing interlayers and laser sources with wavelengths in the range from 1500 to 1900 nm are used, even material combinations such as silicon/silicon can be joined.

**Soldering**

Laser soldering and brazing are two joining processes commonly used in electronics, photovoltaics and medical device technology for components which are sensitive to temperature and mechanical impact because joining times can be achieved in the range of a few hundred milliseconds. An outstanding feature of laser beam soldering is its ability to work on pitch dimensions ranging from 100 to 2000 μm by an appropriate choice of focusing optics and irradiation strategy. Solder materials with melting temperatures below 150 °C can be applied as well brazing materials with soldering temperatures > 1000 °C. By detecting the thermal radiation using integrated coaxial pyrometric sensors as well as a closed loop control of the laser power, the temperature can be kept constant even under varying process conditions. Additionally, a position control of the laser beam with respect to the part can be realized by miniaturized CCD cameras integrated into the working head.

**Glass Frit Bonding**

For hermetic sealing of electronic packages or MEMS components in glass, silicon or ceramics laser beam glass frit bonding provides a process where the energy required for the joining can be deposited very locally. Thereby, the total thermal load for the product can be kept below 100 °C. This is essential for thermally sensitive components such as OLEDs or organic electronics. The energy needed for melting, wetting and joining can be deposited and limited to the glass frit between the two glass substrates.

**Micro Welding**

Small seam width and low heat deposition in the component are the outstanding features of laser beam welding as applied in microengineering. Continuous fiber lasers and pulsed Nd:YAG lasers with high beam quality combined with new process techniques enable highly reproducible joining of metals with weld seam widths below 200 μm. Feed rates up to 1 m/s and high quality weld seams can be achieved with innovative irradiation strategies using a temporal and spatial modulation of the laser beam. With this thermal management of the welding process, the total amount of energy deposited in the components can be minimized and the melt pool dynamics can be controlled. Thus, even combinations such as steel/copper, steel/brass or steel/aluminum can be joined whereas conventional welding processes are difficult to implement.

**Welding of Polymers**

Laser beam welding of thermoplastic polymers provides weld seams of high optical and mechanical quality and comes along with various process-specific advantages such as depositing energy contact-free energy, avoiding both process induced vibrations and thermal load of the surrounding material as well as not generating particles. Innovative process techniques based on fast modulated fiber lasers allow seam widths below 150 μm at welding speeds up to 1 m/s. By adapting the laser wavelength to the absorption behavior of the polymers, even transparent materials can be welded without additional absorbers.

**Facilities**

- **Disk laser**, \( \lambda = 1030 \text{ nm}, 1 \text{ kW}, 50/200 \text{ µm fiber} 
- **Nd:YAG laser**, \( \lambda = 1064 \text{ nm}, 60 - 400 \text{ W pulsed, 0.1 - 50 ms} 
- **Diode laser**, \( \lambda = 808/940 \text{ nm}, \text{up to 500 W, 600 µm fiber} 
- **Diode laser**, \( \lambda = 980 \text{ nm}, 100 \text{ W, 200 µm fiber} 
- **Diode laser**, \( \lambda = 1.5 \text{ µm, 600 µm fiber} 
- **Diode laser**, \( \lambda = 800 \text{ nm}, 4 \times 300 \text{ mm, simultanous control} 
- **Fiber laser**, \( \lambda = 1075 \text{ nm}, 20 - 400 \text{ W, TEM00} 
- **Fiber laser**, \( \lambda = 1.5 \text{ µm and } \lambda = 1.9 \text{ µm, 100 W, TEM00} 
- **Laser soldering head with integrated solder wire feeder** 
- **Galvanometer scanner with focal length from 50 - 566 mm** 
- **5-axes micro machining system with accuracy down to 1 µm** 
- **3-axes system with force feedback controled z-axis** 
- **Scara robot and jointed-arm robot** 
- **Automated assembly cell Teamtechnik teams** 
- **Process monitoring system Precitec LaserWeldingMonitor LWMM** 
- **High-Speed Imaging Camera with 10.000 fps** 
- **Universal Tensile testing machine** 
- **Climate test chamber -70° to +180 °C** 
- **Chamber furnace for dustfree vitrifying and tempering, max. 650 °C**

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1. **Hermetic sealing of diffractive optical chips (bonding).**
2. **Joining of enamelled copper wire with electronic components (welding).**
3. **Hermetic sealing of a cavity between two glass substrates (glass soldering).**
4. **Laser welded active electronic components on copper leadframes.**
5. **Ceramic circuit board with laser soldered contacts.**
6. **TWIST®-welded micro fluidic component in polymers with transparent cover sheet.**