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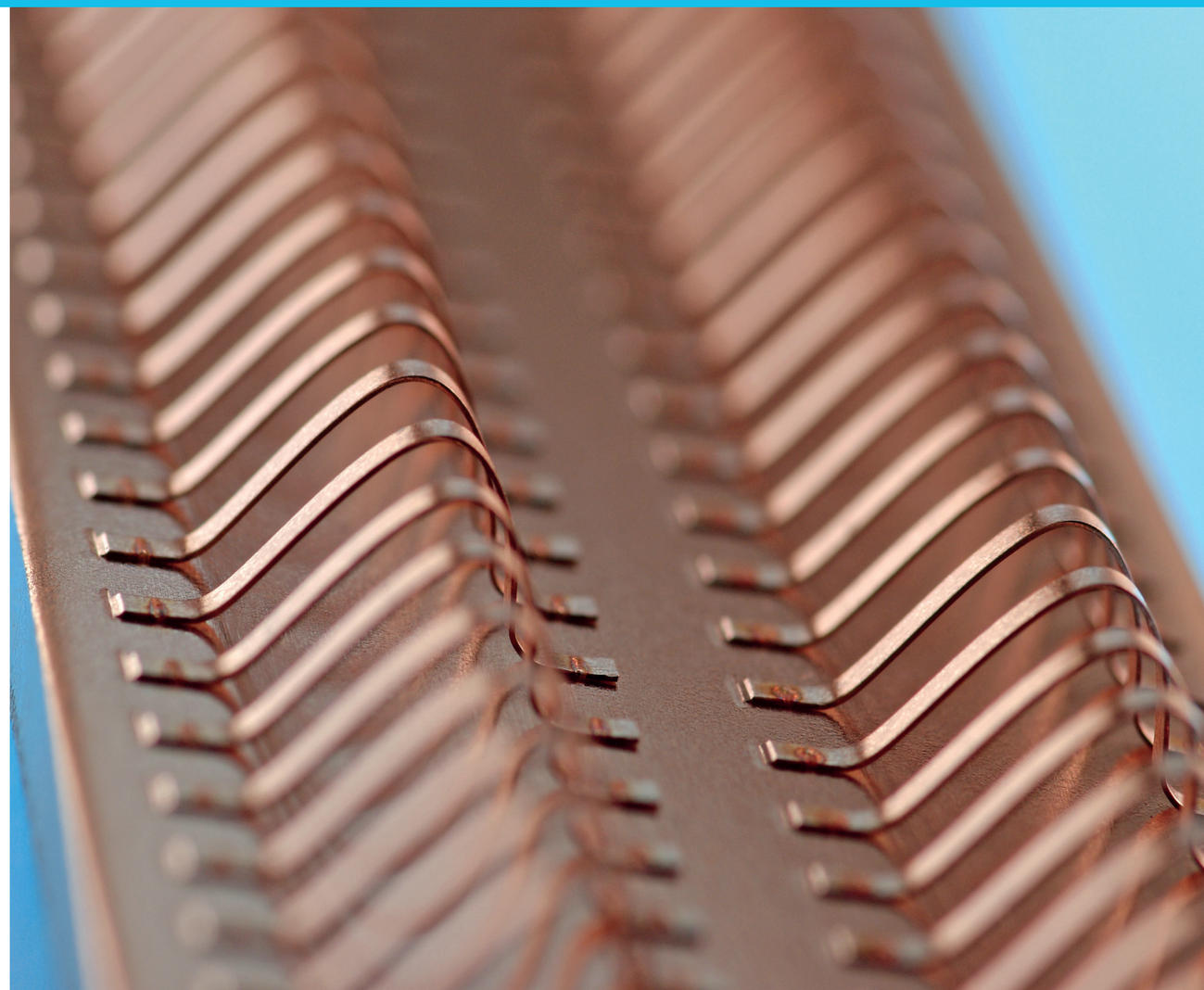
FRAUNHOFER INSTITUTE FOR LASER TECHNOLOGY ILT

LASER-BASED CONTACTING OF BATTERIES AND POWER ELECTRONICS



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

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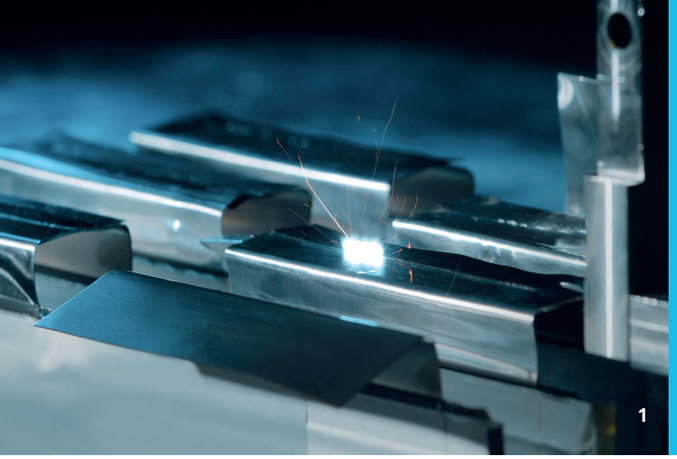
Fraunhofer Institute for Laser Technology ILT

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. 04/2019



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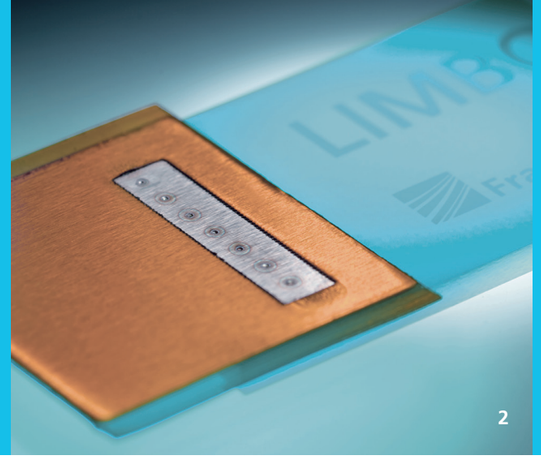

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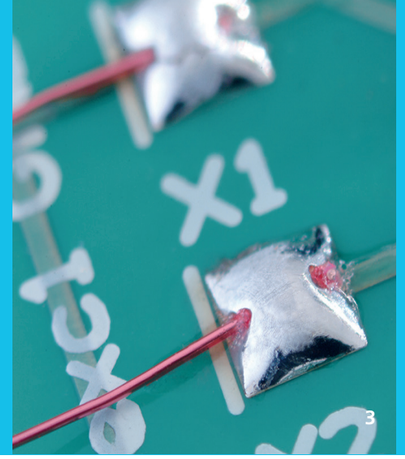

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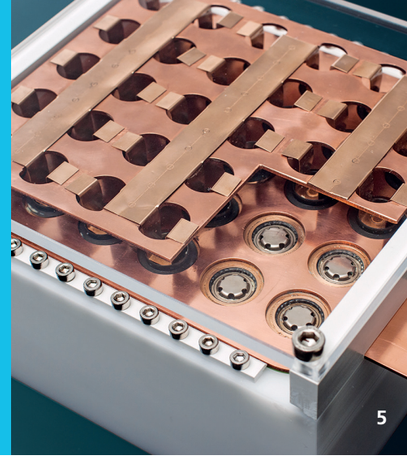

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LASER-BASED CONTACTING OF BATTERIES AND POWER ELECTRONICS

As regenerative energy sources expand and hybrid and electric vehicles continue to be refined, new demands are being placed on power electronics. Higher currents and powers require larger connection areas and cross-sections to reduce contact resistance. To help fulfil the requirements of such new technologies, the Fraunhofer Institute for Laser Technology ILT is developing robust connecting technologies to join conductive elements such as copper or aluminum.

Laser Beam Micro-welding

High-brilliance beam sources are increasingly being used for the laser beam micro-welding of thermally and electrically highly conductive materials, such as copper and aluminum. Thanks to fiber lasers that can be focused very precisely (diffraction factor $M^2 \approx 1$), focus diameters of a few 10 µm can be achieved. The power they provide, a few kilowatts, generates an intensity at which even materials such as copper and gold, which have a high reflectance at a wavelength of approx. 1 µm (≥ 90 percent), can be joined reliably. Local power modulation – a circular oscillation movement superimposed on the feed – can be used to compensate for the disadvantages of a small connection width due to the small focus diameter. Such beam modulation leads both to an increase in process efficiency and to stable process management. In order to keep the welding depth as constant as possible, the laser power can also be modulated in time to compensate for any fluctuations in the energy input or path energy. In addition to applications in power electronics, others sectors can also use this process, such as in battery technology.

Laser Impulse Metal Bonding (LIMBO®)

Laser Impulse Metal Bonding (LIMBO®) is a laser gap-welding process that can bond, for example, a 200 µm thick copper sheet and a 105 µm thick copper board without damaging the underlying printed circuit board. In the LIMBO® process, at its core, the focus diameter is modulated to adapt the laser beam intensity to the workpiece. This leads to the melting and deflection of the melt as well as the contacting of the upper and the lower joining partner by a pulse. This innovative process makes it possible to significantly reduce the penetration depth and the thermal energy input into the lower material. The upper joining partners can be made thicker in terms of their component geometry, in comparison to those in conventional welding processes, and thus ensure better current carrying capacity. Thanks to the low penetration depth and the reduced energy input into the lower material, the LIMBO® joining technology also goes very easy on the component, especially with regard to sensitive layers such as FR-4 or ceramics.

Laser Bonding

Laser beam micro-welding is used in laser bonding as the joining process. In contrast to conventional ultrasonic bonding, the microwelding process places lower demands upon surface qualities and cleaning processes. In addition, this process provides greater independence from the substructure and vibration behavior of the workpiece. Moreover, existing bonders can be converted to combine the laser-beam bonding process with conventional bonding technology.

Especially for copper materials, the use of combined bonding technology opens up new possibilities. Thanks to the use of modern laser beam sources with a very good beam quality, copper and aluminum materials, for example, can be precisely and reproducibly joined. In addition, the laser process can be expanded with an oscillation welding process, which allows for higher bonding forces when processing wires and ribbons, thus opening up new applications for the process.

Laser Brazing

When laser radiation is used for soldering and brazing, components sensitive to touch and temperature – such as those for electronics, photovoltaic and medical technology – can be joined with low energy input within a few hundred milliseconds. An outstanding feature of laser beam soldering is the processing of pitch sizes between 100 and 2000 µm through a suitable choice of the focusing and irradiation strategy.

The melting temperature can be reduced to below 150 °C by using low-temperature solders; for high-temperature applications, brazing alloys with melting temperatures above 1000 °C are also suitable. The temperature of the joining process can be kept constant even under changing process conditions with online detection of the heat radiation, which uses pyrometric sensors coaxial to the laser radiation and a laser power control based on them. Likewise, position control via integrated, miniaturized CCD cameras is possible.

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Cover picture: Copper ribbons joined with laser beam micro-welding.

1 Laser beam micro-welding of pouch cells.

2 Gap-welding using the LIMBO® process on a printed circuit board.

3 Laser-beam soldering of wires on a circuit board.

4 Single contacting of 18650 battery cells.

5 Laser battery module made of 18650 battery cells.