FRAUNHOFER INSTITUTE FOR LASER TECHNOLOGY ILT

LASER PROCESSES FOR HYDROGEN TECHNOLOGY

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Fraunhofer Institute for Laser Technology ILT

Director
Prof. Constantin Häfner

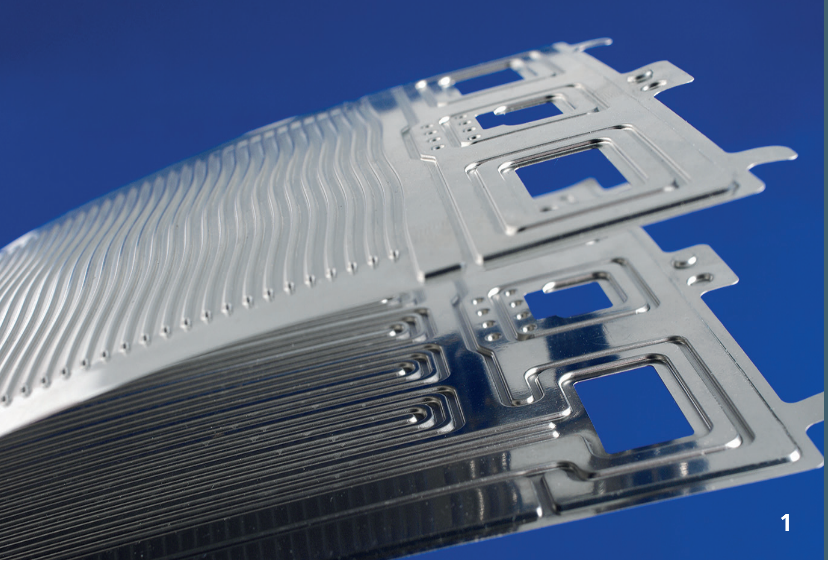
Steinbachstraße 15
52074 Aachen, Germany
Telephone +49 241 8906-0
Fax +49 241 8906-121

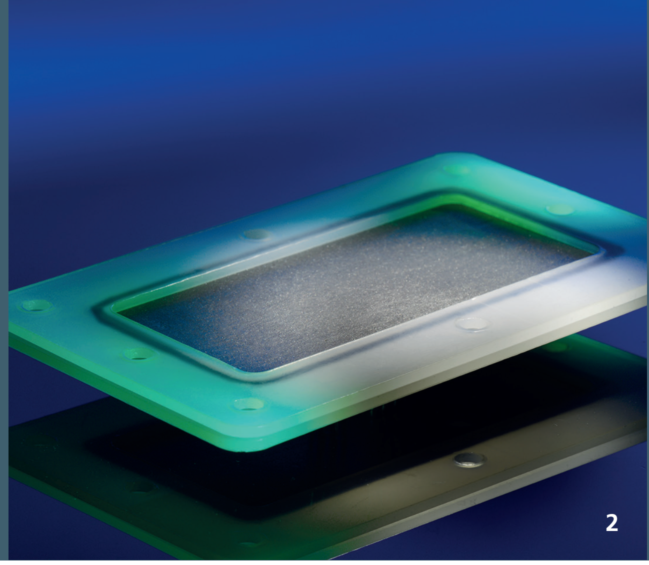
info@ilt.fraunhofer.de
www.ilt.fraunhofer.de

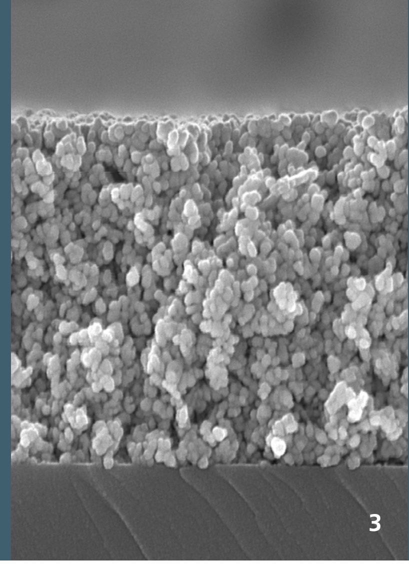
Fraunhofer Institute for Laser Technology ILT

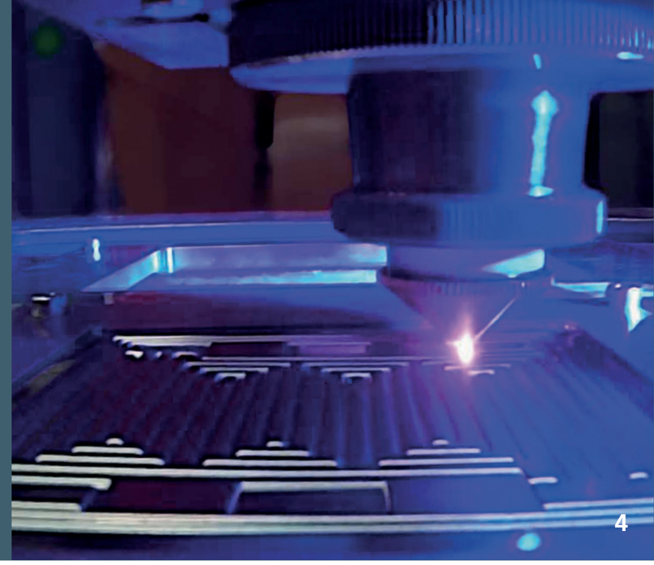
The Fraunhofer Institute for Laser Technology ILT is one of the most important development and contract research institutes in laser development and application worldwide. Its activities encompass a wide range of areas such as developing new laser beam sources and components, laser-based metrology, testing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

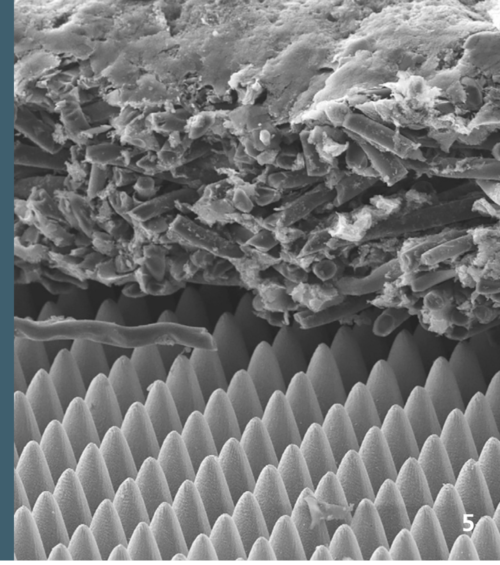
Overall, Fraunhofer ILT is active in the fields of laser plant technology, digitalization, process monitoring and control, simulation and modeling, AI in laser technology and in the entire system technology. We offer feasibility studies, process qualification and laser integration in customized manufacturing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











1 Metallic bipolar plate.

2 Thermoplastic bipolar plate laser welded with a frame.

3 Laser-sintered functional layer.

4 Laser cutting of bipolar plates.

5 Gas transport layer on microstructured steel.

LASER PROCESSES FOR HYDROGEN TECHNOLOGY

Green hydrogen is the energy carrier of the future as it shows great potential for applications in mobility and domestic energy supply based on fuel cells. While further technological developments are required, hydrogen can only penetrate these markets when costs are reduced along the value chains of electrolyzers, fuel cells and their components. To accomplish this, highly productive laser processes play a decisive role in scaling up manufacturing processes.

Joining metals

The core element of a fuel cell is the bipolar plate, which as a metallic variant usually consists of two formed thin-walled stainless steel or nickel sheets. Laser-beam welding can join these with high process stability in a hydrogen-tight and reproducible manner. Process errors can be prevented and thermal distortion of the plates kept low since complex, but modular clamping devices have been developed and the welding geometries adapted in terms of arrangement and sequence. By means of adapted shaft lengths and beam modulations, feed rates of up to 1 m/s can also be reached without humping (deposits of melt on the workpiece surface). In combination with inline process control for monitoring and documentation, laser-beam welding constitutes an efficient and reproducible high-rate manufacturing process for metallic bipolar plates.

Joining plastics

Laser-beam welding of thermoplastics generates optical and high-quality seams and offers numerous advantages: Energy can be applied without contacting the joining partners and, thus, without causing thermal stress on the surrounding area. Innovative process technologies also allow large component geometries to be joined in a reliable manner, such as welding a compound bipolar plate to a frame for fuel cells or redox flow batteries. In addition to scanner-based approaches with a large working field, fixed optics are used, which can simultaneously apply the necessary joining pressure. Since the process joins material directly to material, no additional seals need to be inserted. For high welding speeds, advantageous intensity distributions are calculated and implemented in special optics, and process control is made possible by integrated pyrometry and thermography.

Reducing contact resistance

One of the main causes for efficiency losses of PEM (Proton Exchange Membrane) fuel cells is the contact resistance between the bipolar plate and gas transport layer. Especially with graphite-filled thermoplastic compound materials, a plastic film forms on the surface of the bipolar plate, preventing the electrical connection to the gas transport layer. Laser-assisted removal of this plastic matrix can expose conductive graphite filler material in the contact area to the gas transport layer, which promotes electrical bonding. In contrast to mechanical grinding processes, ultra-short pulsed laser radiation can be used to selectively remove the plastic without damaging the filler material. For metallic bipolar plates, the contact resistance can also be reduced when microstructures are selectively introduced where the plate contacts the gas transport layer.

Cutting

The reliable high-speed laser cutting could serve as an economical substitute for conventional punching processes. As a process variant, either fusion cutting designed for thin materials is used, in which the melt is expelled by a gas jet, or remote cutting, in which the laser beam is guided through a scanner without support of the melt expulsion by a cutting gas. The high flexibility and precision as well as process speeds of several meters per second predestine laser cutting in both process variants for tool- and, thus, wear- and contact-free contouring of metallic bipolar plates for the on-demand production of prototypes and for small to full series.

Thermal laser post-treatment of active coatings

Coatings enable surfaces to be functionally enhanced with specific features such as corrosion resistance or electrical conductivity. In the form of multilayers, these coatings form functional units such as the MEA (Membrane Electrode Assembly) of an electrolysis or fuel cell. In contrast to furnace processes, laser technology makes it possible to selectively post-treat individual wet-chemically deposited layers of a substrate-layer system. High layer temperatures can be generated in a short time without damaging the substrate material. Other advantages include increased energy efficiency and reduced equipment sizes when electrodes are dried, producing anti-corrosion coatings on bipolar plates or multilayer thin-film MEAs.

Coating, repair and additive manufacturing using laser material deposition.

With laser material deposition, metal tracks with layer thicknesses between 0.01 mm and 2 mm can be applied at high precision to almost any metallic base material in a very short period of time. By superimposing several weld beads, this process can generate two-dimensional coatings, e.g. for wear and corrosion protection of highly stressed press tools for the production of bipolar plates or functional coatings on electrolyzers. If several layers are welded on top of each other, the process can also be used for repair and additive manufacturing. Since this process is flexible, can be easily adapted for different fields of application (coating, repair, additive manufacturing) and integrated into existing process chains, it is attractive for applications in series production at large companies as well as for small- and medium-sized enterprises.

Contact

Dr. Alexander Olowinsky
Telephone +49 241 8906-491
alexander.olowinsky@ilt.fraunhofer.de

Prof. Arnold Gillner
Telephone +49 241 8906-148
arnold.gillner@ilt.fraunhofer.de