Fraunhofer ILT

Fraunhofer Institute for Laser Technology ILT

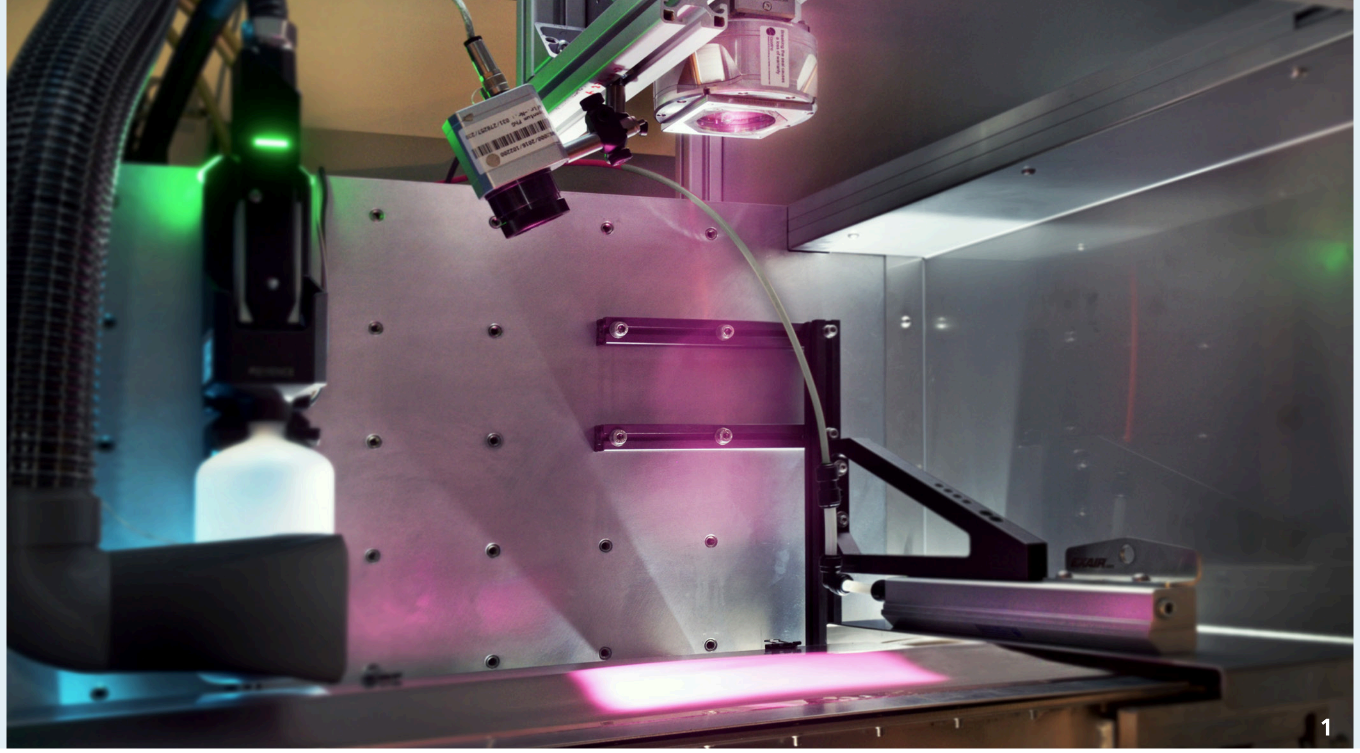
Laser Processes for Battery and Hydrogen Applications

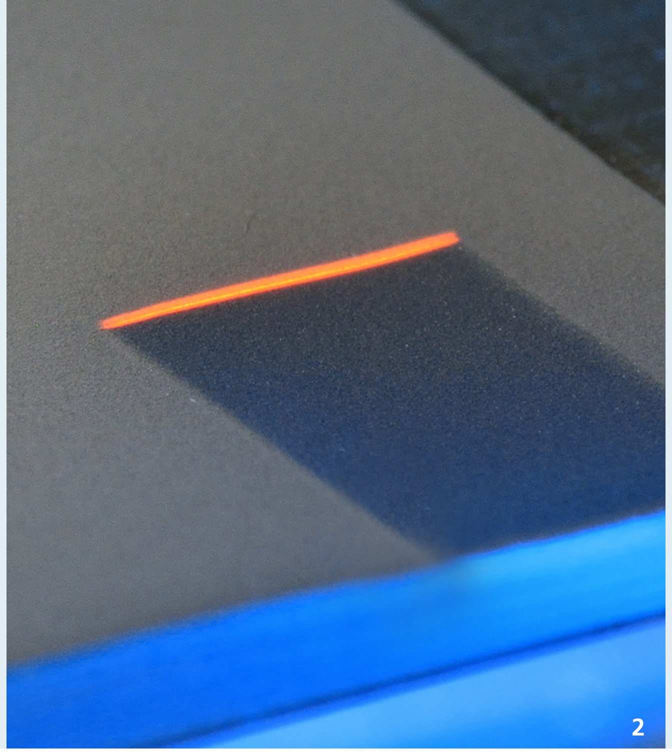
If we want to stop using fossil fuels in the near future, we have to develop cost-effective and powerful energy systems to replace them. To accomplish this, research has focused, internationally, on improving batteries and fuel cells or electrolyzers. Fraunhofer ILT develops energy-efficient, laser-based manufacturing processes for the production and processing of functional layers in battery and fuel cell production.

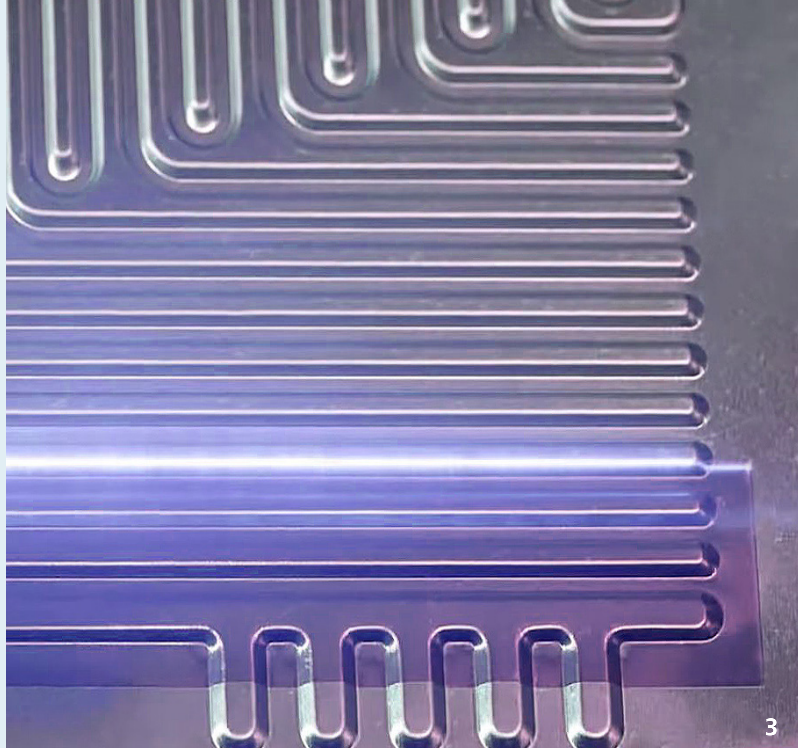
Laser-based drying of battery electrodes

To introduce competitive energy storage systems into the mass market, industry needs to reduce the production costs for battery cells significantly. One cost driver here is the energy-intensive manufacturing process. A promising approach to reduce such costs is substituting conventional furnace processes by innovative laser processes. When battery electrodes are dried, a laser process opens up a large potential for energy savings since its energy input is far more efficient than that of conventional drying in a continuous furnace.

Laser-dried battery anode layer.







New material combinations and energy savings through laser processes

In addition, the space required to install lasers can be reduced considerably thanks to their compact design. For example, laser-based drying can easily be integrated into existing roll-to-roll (R2R) manufacturing plants.

Sintering solid state batteries

Electromobility is regarded as climate-friendly and sustainable. It requires adequate battery systems that, for example, have energy densities high enough to power vehicles over long ranges while complying with high safety standards. Compared to conventional lithium-ion batteries (LIB), ceramic solid-state batteries have a higher theoretical energy density and do not contain any liquid electrolytes. Thus, they have a high potential for the future of electromobility. Possible ceramic materials are, for example, lithium cobalt oxide (LCO) as cathode material and lithium lanthanum zirconate (LLZ) as electrolyte material.

Thin film battery cells based on these materials, however, cannot be sufficiently sintered in a furnace since the materials not only require long interaction times, which results in diffusion effects, but also temperature incompatibilities. For this reason, laser-based processes are being developed to sinter particulate ceramic thin films from LCO and LLZ in the µm range. In contrast to oven-processed coatings, high crystallinity of the base materials can be achieved while reducing undesired intermediate phases in a battery cell.

Coatings for bipolar plates

A primary cost driver in the production of fuel cells and electrolyzers are the bipolar plates. In the metallic version, these plates consist of two formed and welded metal sheets. Compared to bipolar plates made of graphite-filled thermoplastic compound materials, the metallic versions can be produced more cost-effectively. However, since the base material is a metal, they are susceptible to corrosion. They must, therefore, be provided with a corrosion-resistant and electrically conductive protective layer. This is conventionally deposited by means of a vacuum process. An alternative process is the wet chemical deposition of a precursor material and subsequent thermal functionalization with laser radiation. Compared to the conventional process, this approach promises better inline capability and scalability and, thus, shorter cycle times.

Crystallization of thin films for ceramic high temperature fuel cells

For the energy transition to succeed, efficient and cost-effective power-to-power technologies are needed to compensate for power peaks and lulls caused by fluctuating renewable energies. High-temperature fuel cells or electrolyzers are a suitable technology for this purpose, as they have the highest theoretical efficiency compared to other cell types. The use of a proton-conducting electrolyte and a metallic carrier is a promising approach to overcome still existing restrictions of this technology such as insufficient cycling stability and high operating temperatures.

When laser radiation is used to crystallize the electrodes and the electrolyte, process times can be significantly reduced. This avoids un-desirable reactions with the metallic carrier, and saves on costs and time in production.

1 Drying of battery anodes with laser radiation.
2 Laser processing of solid-state battery layers.
3 Laser processing of anti-corrosion coatings for bipolar plates.

The advantages at a glance

- Increasing energy efficiency on an industrial scale
- Opening up new material combinations that cannot be processed conventionally
- High degree of control over the process due to integrated sensor technology and fast controllability of laser beam sources
- Possibility of subsequent integration of laser-based processing modules into existing process chains

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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.

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