PRESS RELEASE

Igniting inspiration for e-mobility

One of the crucial questions of transforming mobility is "how can e-vehicles be manufactured sustainably and economically at the same time?" The Fraunhofer Institute for Laser Technology ILT in Aachen, Germany, which has developed electrifying solutions for laser technology together with industrial partners, has several answers. nLight Plasmo, Precitec and 4D Photonics, among others, will be presenting the monitoring of laser-welded joints at the LSE - Laser Symposium Electromobility 2024 on 23 and 24 January, 2024. The companies will be demonstrating live on site how their process monitoring ensures flawless welding processes.

Herbert Diess, the former CEO of the Volkswagen Group, described the battery as the "heart of the electric car and the key to the future of mobility." This is also reflected in the price: According to the German Federal Ministry for Economic Affairs and Climate Action (BMWi), the battery accounts for up to 40 percent of the added value of an electric vehicle. No wonder, then, that 40 battery gigafactories are currently under construction or in planning in Europe alone.

Now, the industry needs to reduce the already significantly lower battery costs of just under 100 US dollars per kilowatt hour even further. Prof. Arnold Gillner, head of the Business Development department at Fraunhofer ILT, named two important tasks in January 2023 at the Laser Symposium Electromobility LSE'23: "In addition to reducing energy consumption in the production of batteries, it is important to increase their energy density through new materials in the long term."

In the ILT's own Battery Lab, the Fraunhofer team has access to state-of-the-art technology and a wide range of equipment for laser-based battery production on an area of almost 140 square meters to research new materials and processes. There are electrical and mechanical test stands that allow users to directly evaluate the laser processes both of today's standard lithium-ion batteries with liquid electrolytes and future solid-state batteries.

The Battery Lab has an argon-powered glove box system that integrates vacuum-based PVD coating technology and a high-temperature furnace. This makes it possible to coat solid-state cell materials sensitive to air and then assemble them into test cells.

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Drying with diode laser halves energy consumption

At the Hannover Messe in 2023, the Aachen researchers demonstrated how energy consumption can be drastically reduced when the graphite electrodes of lithium-ion batteries are dried. Until now, continuous ovens operated with gas have dried the copper foils coated with graphite paste at a temperature of 160 to 180 degrees Celsius in a roll-to-roll process. The researchers from Aachen are replacing this high-energy process with a system using a diode laser that heats the electrode over a large area using special optical system. Samuel Fink, group leader for thin-film processes at Fraunhofer ILT, says: "Drying with the diode laser reduces energy requirements by up to 50 percent and the space required for an industrial-scale drying system by at least 60 percent."

The researchers also have their sights set on energy density: In Hanover, the institute presented a high-power ultrashort pulse laser that splits the infrared pulsed laser beam into 24 partial beams to structure the battery electrodes. The multi-beam optical system was developed and implemented in close collaboration with Pulsar Photonics GmbH, a Fraunhofer ILT spin-off founded in 2013.

Channels are formed that act as ion highways, shortening the distance travelled by the ions and, thus, accelerating the charging process. This prevents defects from occurring, increases the number of charging cycles and extends the service life of the battery. The process is not new, but the Fraunhofer researchers have succeeded in transferring it from laboratory scale to a scalable, industry-ready process. "In the next step, we will scale the technology from the prototype to an industrial production line," explains Matthias Trenn, team leader Surface Structuring at Fraunhofer ILT.

Inspirations from the Arctic

Using lasers to weld batteries is a central aspect of industrial battery production and, thus, also for the Aachen researchers. The spectrum of their projects ranges from a joining process suitable for large-scale production for current busbars of fast-charging and discharging batteries, a system for laser welding of large cylindrical lithium-ion cells for high-performance applications (40 to 50 ampere hours), to integrated solutions such as for Aurora Powertrains from Finland.

The Lapland-based start-up has developed a waterproof and dustproof battery with IP67 classification for its electric snowmobile eSled, which has a high energy density of more than 190 Wh/kg. The customized laser technology developed at Fraunhofer ILT connects the aluminum cell conductor with the copper conductor for this purpose.

"Because the aluminum is on top in production, the advantage of absorption at green or blue laser wavelengths is not as considerable as it is with copper," says Dr. Alexander Olowinsky, head of department Joining and Cutting at Fraunhofer ILT, explaining the details of the laser solution. "The single mode infrared laser with a small beam diameter is the more elegant, faster and significantly more cost-effective solution, because the beam quality is currently even worse with green or blue due to the system."

DESY: Deep insights into the welding process

This example shows how the choice of the right beam source depends on the specific application. In order to deepen the basic know-how, the Fraunhofer researchers, together with researchers from the Chair of Laser Technology LLT and the high-tech company Trumpf, collaborated at the German Electron Synchrotron DESY in Hamburg to investigate which wavelength can be used to laser weld electrical copper contacts of high-performance electronics for e-vehicles reliably, stably and quickly. The answers were provided by the highly brilliant radiation of the PETRA III synchrotron ring at DESY, which can record up to 20,000 images per second.

Supported by the experts from the Helmholtz Center Hereon, the team used an X-ray beam to look through the molten copper in the laser beam. The experiments not only proved that the non-ferrous metal can best be welded with green laser light. The razor-sharp X-ray videos of the laser processes also showed, for the first time, how the smallest changes in the laser parameters affect weld penetration depth, pore formation and spatter formation.

By evaluating this data, the partners can better understand laser welding processes more deeply and optimize them accordingly in the projects. But the Fraunhofer ILT is going one step further: In Aachen, preparations are already underway for the next beam era. "In addition to cutting, welding and drilling, we want to take a closer look at 3D printing of metals at DESY in the future," reveals Alexander Olowinsky.

Interested parties can learn about the results of Fraunhofer ILT's research and development in the field of electromobility at the LSE - Laser Symposium Electromobility 2024 on January 23 and 24, 2024. There, nLight Plasmo, Precitec and 4D Photonics will be demonstrating how their process monitoring systems ensure flawless welding processes.

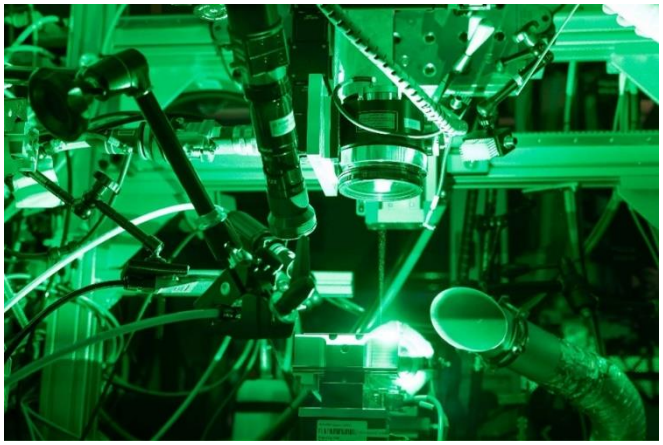

Image 1:
Teamwork: Trumpf and Fraunhofer ILT investigated how laser welding of copper connections of high-performance electronics for e-cars works at a particle accelerator of the German Electron Synchrotron (DESY) in Hamburg. © Trumpf.

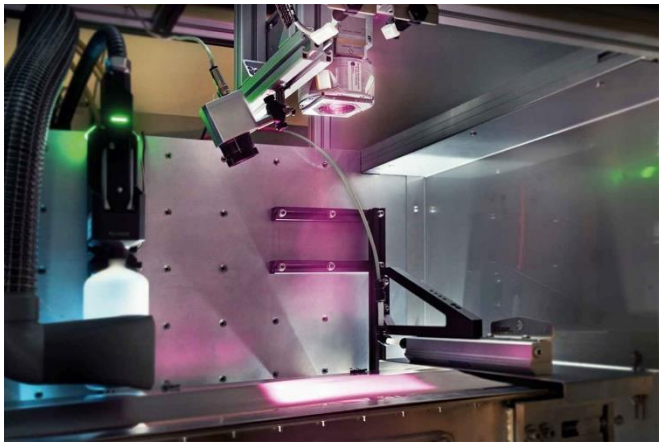

Image 2:
Drying with diode laser: Thanks to special optics, the laser heats a larger area on the copper foil coated with graphite paste.
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Image 3:
Dr. Alexander Olowinsky, Head of department Joining and Cutting at Fraunhofer ILT: "We evaluated the idea, produced the first samples and supported the Finnish start-up Aurora Powertrains in its further development. Now we are supporting them in implementing it for large-scale production."
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Image 4:
Prof. Arnold Gillner, Head of Business Development at Fraunhofer ILT: "It is not only important to reduce the energy consumption in the production of batteries in the long term. We need to increase their energy density through new materials."
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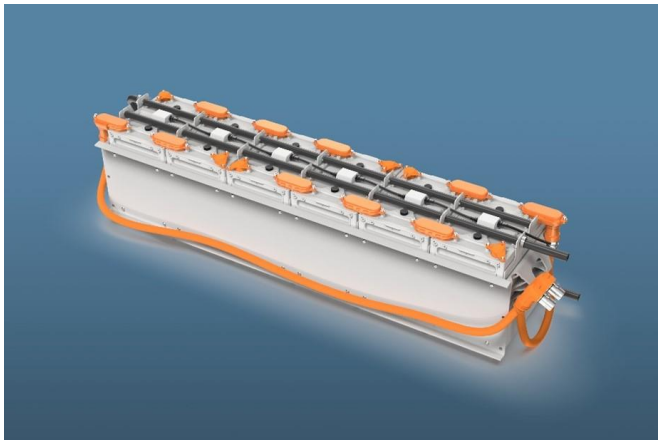

Image 5:
Inspiration from the Arctic: Finnish start-up Aurora Powertrains has developed a completely new battery concept for its electric snowmobile, which is attracting interest from companies in a wide range of industries due to its high energy density and IP67 classification.

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