PRESS RELEASE

Sustainable Solutions for a Future with Green Hydrogen

For many, hydrogen is not only number 1 in the periodic table, but also as the green energy source of the future. To attain this top position, however, energy-efficient and powerful technology is needed to produce and use green hydrogen. Lasers are playing an important role in this, as current activities of the Fraunhofer ILT prove.

They want to get serious about green hydrogen: Indeed, the term hydrogen appears 28 times in the German coalition agreement between the SPD, Bündnis 90/Die Grünen and the FDP dated December 7, 2021. The government wants to accelerate the expansion of the hydrogen industry and install at least ten gigawatts of electrolysis capacity in Germany by 2030. But that's not all: It also plans to set quotas for green hydrogen in public procurement, to establish a "European Union for Green Hydrogen" and to implement the German government's National Hydrogen Strategy.

The plans are ambitious because green hydrogen is still rare. Just five percent of the hydrogen produced and consumed in Germany in 2021 (around 60 terawatt hours) came from sustainable production. The need for competitive technology to produce green hydrogen is correspondingly high.

Leading role of German companies

The prospects for Germany are very good. According to the European Patent Office (EPO) and the International Energy Agency (IEA), several German companies are leaders in hydrogen technologies, such as BASF, Bosch, Linde and Siemens.

In the summer of 2020, the German Engineering Federation (VDMA) published a study forecasting a market potential of over 10,000 billion euros for the German mechanical and plant engineering industry by 2050. The long-term market potential is estimated to be 300 billion euros per year.

This is where the Fraunhofer Institute for Laser Technology ILT comes in, developing highly productive laser-based processes for the series production of fuel cells and electrolyzers. Laser have great advantages over other systems since they are not only extremely precise and flexible, but also can be scaled and integrated into existing production facilities. In addition, laser beam processes are known to be sustainable because they reduce CO_2 emissions and the consumption of resources.

Press contact
Petra Nolis M.A. | Head of the Communications Group | Telephone +49 241 8906-662 | petra.nolis@ilt.fraunhofer.de
Fraunhofer Institute for Laser Technology ILT | Steinbachstraße 15 | 52074 Aachen, Germany | www.ilt.fraunhofer.de

Humping limit pushed: Welding hydrogen-tight with the laser

The fuel cell poses particular challenges: Apart from the membrane electrode unit, it requires 300 to 400 bipolar plates (BPP) each. New manufacturing processes are needed here to replace the current production processes, which are too slow and too expensive. Using adapted wavelengths and targeted beam modulation, the Aachen scientists have succeeded in welding sheet metal into BPP extremely quickly and reliably. Despite feed rates of up to 60 meters per minute, there is no humping effect – when the molten pool lifts up, beads and the seam becomes leaky. Dr. Alexander Olowinsky, head of the Joining and Cutting department at Fraunhofer ILT: "In combination with inline process control for monitoring and documentation, laser welding is an efficient and reproducible manufacturing process for high-rate production of metallic bipolar plates."

BPPs made of thermoplastic materials, which can also be joined by laser, are a completely new development in fuel cells. Because transparent components have only low absorption, they are often blackened with carbon black before welding to enable the energy deposition. As an alternative, the two-stage Clearweld process was developed at Fraunhofer ILT: Thanks to an infrared absorber layer, the polymer-based BPP can be cut with a CO_2 laser and then welded with an NIR diode laser. "You get a transparent joint with this process," explains Maximilian Brosda, group manager for joining polymers and transparent materials at Fraunhofer ILT. "The process is particularly well suited for building bipolar plate stacks."

Increase efficiency of PEM fuel cells

Another challenge arises with PEM (proton exchange membrane) fuel cells. There, for example, a plastic film forms on the surface of the bipolar plate in graphite-filled thermoplastic compound materials; the film prevents the electrical connection of the gas transport layer. Fraunhofer ILT developed a process that uses ultrashort pulse lasers to remove the insulating plastic matrix. In contrast to mechanical grinding, this is a gentle process in which the ultrashort-pulse laser beam selectively removes the plastic without damaging the filling material.

Cutting instead of punching: Wear-free cutting at high speed

Lasers are an economical alternative to mechanical cutting processes such as shear cutting. High-speed laser cutting can replace conventional punching processes in many cases. Olowinsky: "The high flexibility, precision and process speeds of several meters per second make laser cutting the optimal tool for producing metallic bipolar plates. It is fast, safe and wear-free and is just as suitable for prototype production as for large-scale production."

The process has proved ideal in CoBiP, a joint project with the neighboring Fraunhofer Institute for Production Technology IPT to create continuous roll-to-roll production of metallic, double-walled BPPs. Fraunhofer ILT has developed a roll-to-roll module for laser welding and cutting, which now cuts burr-free at high speed (well over 100 m/min) and welds defect-free under argon gas (max. 30 m/min) in the CoBiP plant at the neighboring facility.

Metallic 3D printing is also an option for applications in the hydrogen industry. One of the established processes is laser material deposition (LMD), which ILT has been researching intensively for over 30 years and consistently enhancing for various fields of application and industries. LMD has proven its worth in the manufacture of electrolyzers, which often consist of different material combinations. For example, Fraunhofer ILT has developed an LMD system that can be used to coat a plate of mild steel with an extremely thin, porous nickel-aluminum alloy.

Hydrogen laboratory offers practical diversity

The 70 participants saw this system in Aachen in the fall of 2022 at the 3rd Laser Colloquium Hydrogen LKH_2, which has been an insider event for the hydrogen community since 2020. The Fraunhofer ILT event once again focused on the series production of electrolyzers and fuel cells in the 300 square-meter hydrogen laboratory. Although there are similar facilities throughout Germany, according to Dr. Alexander Olowinsky, initiator of LKH_2 and head of the Joining and Cutting Department at Fraunhofer ILT, this laboratory has a special unique selling point: "In terms of the variety of practical possibilities, our new hydrogen lab is unique." Guests at the LKH_2 were able to see this for themselves, experiencing live demonstrations at the testing facilities in September of how the laser can be used to precisely cut ultra-thin metal plates 70 to 100 micrometers thick and reliably weld them into gas-tight stacks.

The highly interesting demonstrations focused on how typical problems can be prevented not only in the laboratory but also under series production conditions. Here, artificial intelligence (AI) has already proven itself many times over. Two examples among many: Dr. Frank Schneider, from the Macrojoining and Cutting Group at Fraunhofer ILT, presented the digital process online optimizer for intelligent laser machines (DIPOOL), in which researchers are combining the temporal and spatial programmability and controllability of laser tools with machine learning for the first time. In this project, the institute is working closely with a completely new type of multispectral sensor technology from 4D Photonics GmbH in Isernhagen as part of the

BMBF DIPOOL project, which Managing Director Christoph Franz is using as a "Weldwatcher" in the welding of bipolar plates.

Siamese neural network compares clippings

Christian Knaak, from the Process Sensors and Systems Engineering Group at Fraunhofer ILT, on the other hand, relies on a so-called Siamese neural sensor network for the rapid detection of splashes during BPP laser microwelding. This network does not analyze the entire image, but only compares characteristic sections with each other. With a view to further research, Knaak suggests that not only should the actual laser process be monitored with the help of AI in the future, but also upstream and downstream process steps should be targeted.

Interested parties can find out what the future holds for hydrogen and lasers at the Laser Colloquium Hydrogen LKH_2 in Aachen on September 19 and 20, 2023, the long-standing insider event of the Fraunhofer ILT's hydrogen community.

Image 1:
Insider event of the hydrogen community: 70 participants saw series production of electrolyzers and fuel cells at the 3rd Laser Colloquium Hydrogen LKH_2 in the 300-square-meter hydrogen lab in fall 2022.

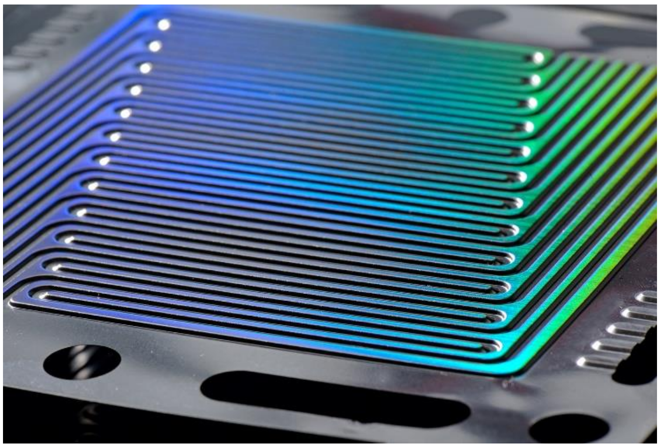

Image 2:
In the CoBiP project, a system for continuous roll-to-roll production of metallic, double-walled bipolar plates was created with a module for laser welding and laser cutting.
© Fraunhofer ILT, Aachen, Germany.

Image 3:
Dr. Alexander Olowinsky, head of the Joining and Cutting Department at Fraunhofer ILT: "When combined with inline process control for monitoring and documentation, laser-beam welding is an efficient and reproducible manufacturing process for high-rate production of metallic bipolar plates."
© Fraunhofer ILT, Aachen, Germany.

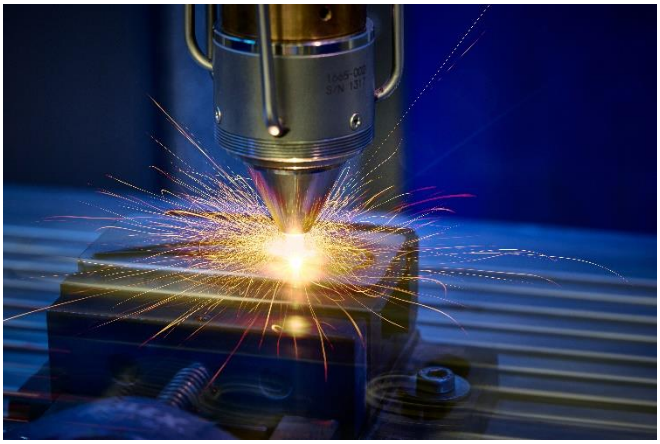

Image 4:
Laser material deposition (LMD) is suitable for applications in the hydrogen industry – for example, for the production of electrolyzers, which often consist of a wide variety of material combinations.
© Fraunhofer ILT, Aachen, Germany.

Professional contact

Dr. Alexander Olowinsky
Head of the Joining and Cutting Department
Telephone +49 241 8906-491
alexander.olowinsky@ilt.fraunhofer.de

Katharina Schulte
Group Marketing
Telephone +49 241 8906-420
katharina.schulte@ilt.fraunhofer.de

Fraunhofer Institute for Laser Technology ILT
Steinbachstraße 15
52074 Aachen, Germany
www.ilt.fraunhofer.de