# Mission "In-depth Look"

E-mobility requires fast and reliable laser processes in order to produce economically and on a large scale: High-precision, high-speed welding of copper connections with green laser light is one of the key applications. The Fraunhofer Institute for Laser Technology ILT and TRUMPF are joining forces to study laser welding more deeply than ever before. Together they are preparing a series of experiments in which they use special X-ray light to take a look inside the process. However, the necessary quality of X-ray light is only available in a few places in the world, because the process requires a particle accelerator with tubes that are kilometres long. One of these places is the German Electron Synchrotron DESY in Hamburg. It is no longer just scientists who are allowed to conduct basic research there, but also teams from industry. Fraunhofer ILT and TRUMPF are among the first to rent the laboratories. It takes two whole years to meticulously prepare for the three crucial experimental days at DESY. But the effort is worth it. The team finds completely new, surprising parameter combinations that laser systems can now use to weld with optimum speed and accuracy.

## Fraunhofer Institute for Laser Technology ILT

www.ilt.fraunhofer.de

The Fraunhofer Institute for Laser Technology ILT in Aachen is one of the world's leading developers of laser technology. Together with partners from industry, the ILT conducts practical research on new production processes and technical components. Its activities also include business consulting and the training of highly specialised professionals. The ILT is a legally non-independent institution of the Fraunhofer-Gesellschaft zur Förderung der angewandten Forschung e.V. [Fraunhofer Society for the Promotion of Applied Research., Reg. Assoc.].

| INDUSTRY | NUMBER OF EMPLOYEES | LOCATION |
|---|---|---|
| Contract research | 481 | Aachen (Germany) |

### Challenges

One of the things that the ILT and TRUMPF team want to take a close look at under the high-brilliance X-ray light is the welding of metal-ceramic substrates (MCS). These MCS's connect electronic components in a high-voltage environment, such as the performance electronics of an electric car. A wafer-thin layer of copper is applied to an insulating ceramic plate. The car manufacturers want to use the green laser to weld another copper component onto the MCS for contacting. A copper-to-copper connection is involved. The question is now: How can everything be optimised in the welding process? The copper plates should be as thin as possible, the process should be extremely fast, the seam should hold 100% and the ceramic must not be affected by the laser. In short: How does one find the perfect laser setting for the most productive process?

"Just a few weeks after testing, we transfer the results to practice. This is how we find the fastest and best laser welding processes for all types of copper connections for our customers."

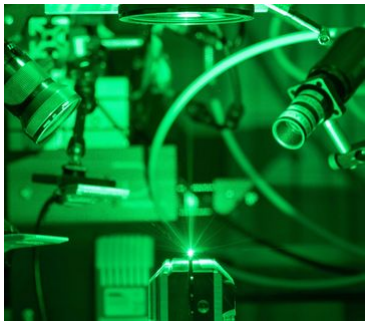
**DR MAURITZ MÖLLER**
AUTOMOBILE INDUSTRY MANAGEMENT AT TRUMPF

**Solutions**

Together, Fraunhofer ILT and TRUMPF decide on an unusually complex investigation of the problem: They want to see pin-sharp X-ray videos of the ongoing laser process and - using all analysis tools - they want to observe with their own eyes what effects the smallest changes in laser parameters have on the welding depth, pore formation and spatter formation. In Germany, this is only possible at the DESY electron synchrotron, where basic scientific research is normally carried out. As one of the first industrial projects, the ILT and TRUMPF secure a spot in one of the laboratories at the facility where such X-ray videos are possible.

**Implementation**

Three days of laboratory work at DESY are booked - the preparation for this takes two whole years: The team develops a test methodology and defines the exact scientific queries. For them it is very important to forge a precise plan in advance, to explore how the findings can later be implemented in specific industrial applications. In December 2022 the time has come: Both teams pack up laser technology, optics and other technology and meet at DESY. In the laboratory there at the Beamline P07, the teams set up the TruDisk 2021 disk laser for the green laser light and the test configuration: The X-ray light falls on the sample from the side and records the image sequences inside, a laser welds from above, and a robot changes the samples to speed up the process. The idea is to make optimal use of the three days. The prepared tests are run in shifts, 24 hours a day. Cola and crisps help the scientists keep their focus. The MCS alone accounts for more than a hundred experimental runs.



**Forecast**

Terawatts of data are generated on welding precision, welding speeds and so on. At DESY, the scientists from ILT and TRUMPF are already starting to analyse the first impressions. But the main work of the evaluation does not start until the weeks after the DESY experiments. In Aachen at the ILT and in Ditzingen at TRUMPF, analysts are poring over the tables, videos and sensor data. Thanks to the precise planning, it soon becomes clear how laser welding will look once it has been optimised in every respect, for example by MCS in power electronics for e-mobility. The automobile manufacturers are waiting.