Fraunhofer ILT

FRAUNHOFER INSTITUTE FOR LASERTECHNOLOGY ILT

REVIEW AKL'22

Not without my AI

Virtual chain reactions - live, in color and in person

Many industries are ready to break new ground in production with lasers. To do this, users and suppliers must reconcile digitalization and sustainability, ecology and economy. As an important means to this end, lasers can be integrated into the emerging process chains so that they interact with the entire upstream and downstream processes, saving both time and money. The more than 520 participants at the AKL'22 International Laser Technology Congress in Aachen learned how the laser community is already proactively tackling these tasks.

Deep learning, cloud computing, virtual commissioning – three of many new terms at AKL'22 that pointed toward the changing nature of how lasers are and will be used. Digitalization used to come up at the Aachen insider meetings of the laser community, but suddenly it was ever-present: Everywhere, AKL participants discovered the beginnings of what digital photonic production (DPP) of the future might look like.

But what makes manufacturing under the DPP label special – is it particularly efficient, safe, competitive and, at the same time, can it learn? A new term was brought into play by Prof. Constantin Häfner, Director of Fraunhofer ILT: "Sustainability is increasingly becoming an important criterion for how decisions are made in the manufacturing environment. Sustainable digital photonic manufacturing opens doors for technology sovereignty, innovation, resilience, and agility." Sustainable digital photonic production has many advantages: Not only does it help users implement sustainable goals and regulations, but it also strengthens Europe's role as a high-tech location.

Lasers just for fun: Is competition from Google & Co. looming?

The laser industry is facing competition from the big players in the digital industry. Apple, Google and Facebook, for example, are currently said to be hiring laser physicists on a grand scale to build - not only cars, rockets or satellites - but soon lasers as well, all "just for fun." AKL participants learned this astonishing news at the traditional Gerd Herziger Session "Laser Beam Source Development - Quo vadis?"

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This is reason enough for laser manufacturers to improve their market position. At the session, Dr. Christian Schmitz (CEO Laser Technology, Trumpf), Mark Sobey (Executive Vice President and COO, Coherent) and Volker Krause (Managing Director, Laserline) spoke in favor of very extensive digitalization, without which no laser manufacturer could survive. Indeed, their customers show great interest in this and want to use data from laser applications to find the perfect process window to further increase value creation. In the future, the laser must be smarter, easier to integrate and easier to use.

Targeted planning of AI deployment

The subsequent session on "Digitalization in Photonic Production" with Dr. Joachim Döhner (Senior Director Global Sales, KUKA Systems), Dr. Jens Ottnad (R&D Head Data and AI, TRUMPF Machine Tools) and Dr. Tobias Kamps (Corporate Technology, Siemens) also offered startling insights. In unison, the speakers noted that entrepreneurs should no longer ask themselves whether they want to use digital tools such as AI. Now it is only a matter of when and how, because only with targeted, clever digitalization can they continue to exploit how photonic production can be most usefully applied.

The goal is attractive, but the path to it is a dangerous tightrope walk: On the one hand, newcomers should not approach the topic half-heartedly, but should also include upstream and downstream processes when digitalizing their processes. On the other hand, they should not approach the task naively and overdo it. Otherwise, they run the risk of "drowning in a sea of data."

Digitalization is particularly in demand when users break new ground. This is particularly true of additive manufacturing, which is about to clear the biggest hurdle – entry into large-scale automotive production. At the Additive Manufacturing Forum, manufacturers of space engines, automobiles, materials and software, among other things, examined the current situation from a variety of perspectives. Their core message: Additive manufacturing has grown up, but fine-tuning is now the order of the day.

Three tips from 3D printing practice

Close the loop is what Dr. Bart van der Schueren, CTO of Materialise NV, Leuven, recommended: "Although 3D printing is inherently a digital process, often only the 'CAD-to-print' route is used. But if users close the loop, they can effectively engage in a continuous 'plan-do-check-learn' process thanks to feedback."

Lower material usage with simulation is what Keno Kruse, Account Manager of CADFEM GmbH, Hannover, Germany, suggested: "By using simulation, users can identify critical areas in advance and take measures before printing – saving both time and money. Ansys offers world-class simulation software to optimize LPBF, DED and Metal Binderjet Sintering processes."

Pay attention to powder selection and stiffness is what Raphael Koch, Additive Manufacturing Research Engineer at Ford-Werke GmbH in Aachen, said when referring to his initial experience in developing functional LPBF prototypes for the chassis area: "Using powder from the market reduces development time and costs. The printed components should have similar properties to conventional sheet metal for chassis. The yield strength should be 700 to 800 MPa, the elongation more than 10 percent and the density 7.85 g/cm³."

Interaction of EHLA and parallel kinematics

Further progress in laser development provide users with exciting prospects. For example, Fraunhofer ILT's extreme high-speed laser material ablation (EHLA) has already proven itself several times in industrial application since 2015. It is considered as a productive, sustainable and highly precise alternative to conventional coating of rotationally symmetrical components.

High-productivity 3D printing has been made possible with the EHLA technology in a parallel kinematic system (max. feed rate: 200 m/min; max. acceleration: 50 m/s²) from the company Ponticon GmbH and in a modified 5-axis CNC prototype (30 m/min; 20 m/s²). With the Ponticon machine, for example, the first components made of 316L stainless steel could be printed quickly and reliably at 1.7 kg/h and at a feed rate of 40 m/min.

The CNC system has also delivered very impressive results: For example, it produced a component made of the well-known aerospace material Inconel 718 with high density (> 99.7 %) and at a deposition rate of 2.3 kg/h. "The material properties are comparable to conventionally manufactured components or those produced using other 3D printing processes," stated Min-Uh Ko, group manager for systems engineering at Fraunhofer ILT. "The exact material characteristics of the materials examined, including aluminum alloys for lightweight construction applications, are similarly high and even turn out to be higher in some cases than in parts made with the conventional process." Interestingly, collected powder can also be reused with similarly good results.

LPBF: XXL in sight

That large components can also be created on another machine was pointed out by Jasmin Saewe, head of the Laser Powder Bed Fusion (LPBF) department at Fraunhofer ILT: "The prototype machine based on a gantry axis system shows how we have been able to significantly boost not only the productivity but also the scalability of our patented laser-based powder bed process." The Aachen engineers have increased productivity by multiplying the number of laser beams to shorten the time required for the 3D printing process.

Tim Lantzsch, head of the Process & Systems Engineering group at Fraunhofer ILT, explained the design principle: "Instead of a fixed position for the laser scanners, we use a movable processing head with an integrated shielding gas and optical system, moved above the powder bed with a gantry system." The system can be used to print very large components with a size of up to 800 mm by 1,000 mm, and up to 350 mm high. "It is important for us to show that it can also be used in industrial applications and that many other metallic materials can be processed in addition to stainless steel," Lantzsch emphasized. "We now want to develop new applications for the LPBF with industrial partners."

As many industries move into 3D printing, integrating it into conventional production lines is becoming increasingly relevant. But these new hybrid-additive processes are not only promising in terms of supply chain flexibility and resilience – new automation challenges are also emerging. Jan Bremer, Head of Research and Development (R&D) at BCT GmbH in Dortmund, Germany, is focusing on adaptive manufacturing.

When combined with machine-integrated measuring technology, a production plant can be transformed into a measuring machine that records a component's geometry and, parallel to the process, also its process data. It also evaluates the geometry with the aid of optimized algorithms.

Inline quality assurance: analysis during the manufacturing process

The research project "DigitalCMM – Digital Coordinate Measurement Machine" is showing just what such a solution can look like. A consortium of Camaix, Point 8, oculavis as well as BCT and the Fraunhofer Institute for Production Technology IPT have developed a concept for evaluating machine-integrated measurement data in milling technology.

With a joint solution from the partners BCT as software manufacturer and Point 8 as AI specialist in the consortium, the partners have demonstrated that their solution can acquire spatially resolved process data from a 5-axis milling machine at high frequency.

An AI-based analysis of the recorded data allows them to draw conclusions about the process quality of the individual components.

Process properties and component geometry can be automatically recorded and analyzed thanks to the geometric measurement technology – in the project, a measuring probe – which is also connected to the software within the machine.

Current research projects such as the "ProSLAM" project (www.ProSLAM.de) are investigating how to integrate a large number of different sensors for process and geometry and merge them with external measurement data such as CT images of additively manufactured components. Bremer expects great progress for process understanding and the user-friendly automation of development and production processes based on this by establishing machine-integrated sensor networks.

Will costly Big Data analysis soon be superfluous?

But how does one generally deal with the constantly growing volume of data collected by sensor networks, for example? "With suitable data acquisition strategies, the information content that can be evaluated is growing and increasing automation of the evaluation is becoming possible," said the R&D manager Jan Bremer, looking confidently to the future. "Perhaps in the future we will only need significantly smaller amounts of data in production, as suitable algorithms and machine-integrated data acquisition go hand in hand to draw relevant conclusions with increased efficiency."

Intelligent and adaptive detection of the entire process chain could also help make supply chains more reliable, he said. "If every single module in the process chain works adaptively and intelligently, the failure of a casting process, for example, can easily be replaced by an additive process," said Bremer, describing the exciting alternative. "The failure is then unproblematic because the adaptive process chain automatically reacts and adjusts to the replacement to achieve the desired end result."

The EFRE.NRW project MultiPROmobil is also entering hybrid-additive new territory. Under the coordination of Fraunhofer ILT, project partners have developed multifunctional laser tools for cutting, welding and laser material deposition with wire (w-LMD), an innovation that generated a lot of interest during the demonstrations at Fraunhofer ILT during AKL'22: These tools are ultilised in a cell for multifunctional laser robot technology, which is designed to interact with a digital twin to flexibly and economically produce sheet metal assemblies for electric vehicles.

The driving factor is the trend towards small batch sizes, wide variety, and dynamic product life cycles. As a result, the complexity of design and the scope of functions increases. The project partners are, therefore, focusing on the benefits of digital transformation. Fraunhofer ILT scientist Martin Dahmen described the goal as follows: "The whole thing culminates in a work cell that is not only flexible that can be reconfigured with scalable manufacturing systems and Profinet connection to the digital twin."

Multifunctional processing head can adapt

The focus is on a multifunctional processing head that has already proven itself in test production on a semi-bionic lightweight part: The head cuts, welds, and reinforces an optimized wishbone of an electric vehicle. All this happens very quickly without tool changes thanks to the air-cooled combi-head, which quickly adapts to the three different machining processes with autonomous nozzle and adaptive beam shaping optics.

In a virtual commissioning process, the project partners optimized the interaction of the processing steps. According to Dahmen, the advantages of this approach are that – thanks to virtual commissioning – the time required for planning the production process and commissioning can be shortened, costs reduced and the quality of the control software improved. But before that, there is always virtual hard work to be done: In detail Dahmen described the demanding configuration process on the Siemens SIMIT simulation platform. This ranges from PLC and robot programming, mapping of sensor communication, and extensive interface experiments to virtual test runs using simulated test procedures (software/hardware in the loop).

Human interface

The ensemble of humans and robots is a particular challenge because the operation is not only automatic but also partly manual. "We have to bring manual functions together with automatic operation," Dahmen explained. "For this purpose, there is an operator panel in front of the machining cell as a user interface, on which the operating personnel can intervene manually or start the process, for example, when changing workpieces."

Yesterday ILT, today IoL

This simple denominator sums up the latest commitment of Professor Reinhart Poprawe, director of the Fraunhofer ILT until 2019. Five years ago, Poprawe filed a patent application as co-inventor for the laser-based production of plastic lenses (intraocular lenses, or IoL). On this basis, the company AIXLens GmbH was founded in Alsdorf near Aachen, Germany. It manufactures individually adapted lenses from plastic in a fully digitalized and completely laser-based process, independent of the material used. Patients receive their personal lenses just-in-time without storage directly from production in a batch size of one. And the lenses correct all refractive errors specific to the patient.

This is where the strength of the laser comes into play: the precise, productive and sustainable production of components in high complexity and in small quantities. After measuring the eye and generating the data, the lens is created within a few minutes: An ultrashort pulse (USP) laser creates the lens by ablation, which is then polished with a CW laser. Then a USP laser cuts the so-called haptics to attach the lens. "It's a completely digitally controlled process chain where nothing is touched," Poprawe explained. "When someone orders the lens, the delivery date now basically depends only on the shipping time."

Production without employees

The business model is also unusual: There are no employees at AIXLens, because the development of the process and the installation of a demonstration line are done on behalf of Fraunhofer ILT. The key data are impressive: Lenses with a surface roughness in the range of single nanometers and very precisely maintained diopter values are produced in a batch size of one.

However, AIXLens had to solve a special technical problem in the nationally and internationally patented process: Tiny polymer chains form during laser polishing of thermosets, and owing to them, the lenses initially failed the biocompatibility test. The remedy was to irradiate the laser-polished lenses with electrons, which reconnected the broken molecular chains. Since then, the lenses have also passed the biocompatibility test.

The effort was worth it because the resulting new form of IoL production opens up a wealth of completely new possibilities. "In conventional production, manufacturers have to keep 400 different sizes of lenses in stock at all times, which they have to constantly replenish because of the products' expiration dates," Poprawe explained. "That's all eliminated with us."

While IoL lenses are suitable for people with cataracts, patients suffering from glaucoma due to ocular hypertension need micro-stents that drain the aqueous humor into the natural outflow channel. These components, which are only 300 µm thick, can also be produced with the laser: Laser etching of glass (selective laser-induced etching, or SLE) is used at aixtent GmbH, also based in Alsdorf. The former Fraunhofer ILT boss did not reveal details, but laser etching is also likely to be integrated into a process which, like IoL production, is agile and fully digitalized in close cooperation with Fraunhofer ILT.

The physicist did not specifically address one factor that is crucial for success: the price. Because series production has not yet started, entrepreneur and co-inventor Poprawe does not want to give exact figures yet, but he is optimistic in view of the previous complex manufacturing process and the high expense for logistics and storage: "I am sure that our lenses will be significantly cheaper. In the entire process, we benefit extremely from the structure on the RWTH Aachen campus; without it, none of this would be possible."

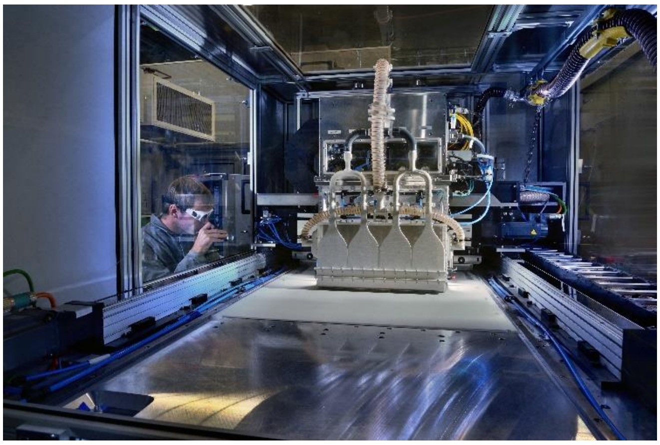

Image 1: XXL on-the-fly: Fraunhofer ILT demonstrated how a gantry system can use the Laser Powder Bed Fusion process to produce large stainless steel components at AKL'22 by 3D printing a 300 mm high Rolls-Royce turbine component with a diameter of 650 mm.
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Image 2: Prof. Dr. Constantin Häfner, Director of Fraunhofer ILT: "Sustainable digital photonic production opens doors for technology sovereignty, innovation, resilience and agility." © AKL e.V., Andreas Steindl.

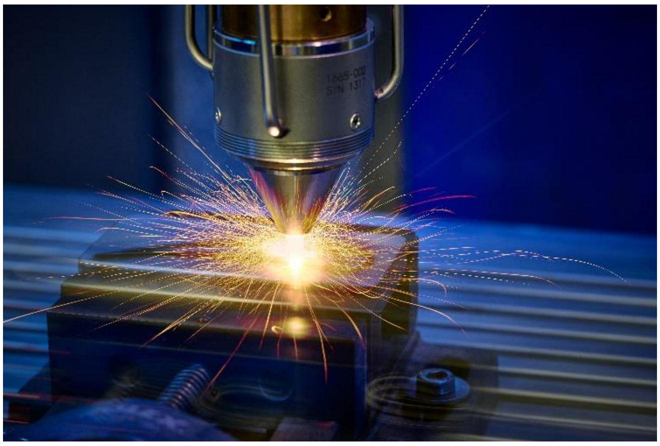

Image 3: High-productivity 3D printing has been made possible by using EHLA technology in a parallel kinematic system and in a modified 5-axis CNC prototype. With the parallel kinematics, for example, the first components made of 316L stainless steel could be printed quickly and reliably at 1.7 kg/h and at a feed rate of 40 m/min. © Fraunhofer ILT, Aachen, Germany.

Image 4: Min-Uh Ko, group manager Systems Engineering at Fraunhofer ILT: "EHLA has already proven itself several times in industrial use as a sustainable and highly precise alternative to conventional coating of rotationally symmetrical components."

Image 5: Tim Lantzsch, group manager Process & Systems Engineering at Fraunhofer ILT: "We want to work with industrial partners to develop new applications for the Laser Powder Bed Fusion (LPBF) process."

Image 6: Jasmin Saewe, Head of the department Laser Powder Bed Fusion (LPBF) at Fraunhofer ILT.
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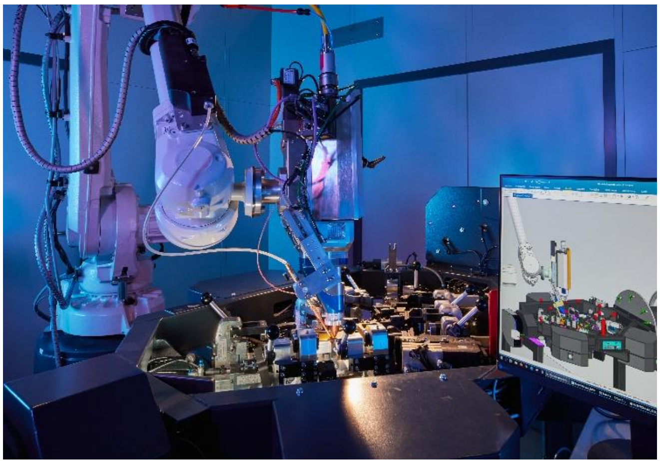

Image 7: In the EFRE.NRW project MultiPROmobil, a flexible work cell is being developed that can be reconfigured with scalable manufacturing systems and Profinet connection to the digital twin.
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Image 8: Martin Dahmen, Macro Joining and Cutting group at Fraunhofer ILT. © Fraunhofer ILT, Aachen, Germany.

Image 9: Prof. Dr. em. Reinhart Poprawe, Director of Fraunhofer ILT until 2019 and co-inventor of a patent for manufacturing plastic lenses (intraocular lenses IoL): "I am optimistic that our lenses will be significantly cheaper. In the whole process we benefit extremely from the RWTH Aachen campus infrastructure; without it, none of this would be possible." © Fraunhofer ILT, Aachen, Germany.

Image 10: "In the future, we may only need significantly smaller amounts of data in production, as suitable algorithms and machine-integrated data acquisition go hand in hand to help us draw relevant conclusions with increased efficiency," says Jan Bremer, head of research and development (R&D) at BCT GmbH in Dortmund, looking to the future.
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Image 11: Prof. Dr. Constantin Häfner, Director of the Fraunhofer Institute for Laser Technology ILT, was pleased to host lively discussions during AKL'22.
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