Fraunhofer ILT

Research for a Sustainable Future

Annual Activity Report 2025

Foreword

Dear Readers,

2025 was a challenging year: Global competition is intensifying – and this affects photonics in particular. Yet we see a bright future for photonics in Germany and Europe: Together with partners from industry and research, we are turning innovative ideas into technologies with real commercial potential – giving industry strong future prospects.

Many of these ideas are directly related to a trend in which Fraunhofer ILT is a key player: The average power of ultrashort pulse (USP) and continuous-wave (cw) lasers is breaking into new territory. Among other initiatives, we are co-developing and applying such high-power picosecond and femtosecond lasers in the kW range within the Fraunhofer Society's Cluster of Excellence Advanced Photon Sources (CAPS). A key factor in boosting efficiency in USP material processing is our ability to split lasers into dozens of individual beams, thereby enabling parallel processing. Additionally, we are developing new beam-shaping approaches to adapt beam shapes to specific components and processing steps. This includes the use of optical neural networks, which allow us to generate virtually any (3D) beam profile.

For continuous-wave (cw) lasers, average power levels have reached the three-digit kW range. With such beam sources, photonics is entering markets that were previously out of reach. In the future, lasers could be used in mining or for tunneling and deep drilling to shatter rock without wear, or to cut and join centimeter-thick steel plates for ships or wind turbine towers. Defense research is also showing great interest in high-power lasers.

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At the same time, we are advancing the development of high-energy lasers. They pave the way to future fields with enormous market potential: fusion power plants and secondary sources for generating neutron, X-ray, or EUV radiation. In research projects with industry partners, we are currently developing compact neutron and X-ray sources capable of analyzing the contents of containers and drums through their walls for security applications. Together with academic and industrial partners, we are also laying the technological foundation for fusion power plants: high-power diodes for pumping high-energy lasers, robust optical components, additively manufactured wall modules, or fuel capsules; or powerful simulations of subsystems or the modeling of complete fusion power plants. We are ready to expand powerful development consortia and supply chains – and bring our concentrated expertise to the table!

Data science and AI help ensure that high-performance laser applications are run reliably and precisely. Our institute has developed outstanding expertise in this field, which we use across departments to inject fresh momentum into the industry. Digital tools are driving progress in photonics.

Whether it's a fusion power plant or a quantum system, it all starts with the digital twin. And where testing is essential, AI-based planning and evaluation tools reduce the number of tests to a minimum, helping us reach our goals faster and more reliably.

In quantum technology, we installed the first network node for the quantum internet of the future here in Aachen in 2025. The project is part of the strategy of the European Quantum Internet Alliance and is funded by the state of North Rhine-Westphalia. We are connecting this node to the fiber-optic-based open-access facility ALICE on our campus. Here, it will bring together stakeholders from industry and research starting immediately. Along with them, teams at our institute are developing optical data transmission hardware designed to reduce the power consumption of data centers. Others are researching how lasers can render forever chemicals (PFAS) obsolete or drill the finest pores in films to filter viruses and bacteria out of drinking water. Such projects are paving the way for the technological future. Our diode-pumped alexandrite laser – at the heart of a portable LIDAR system – can target atoms at altitudes of up to 100 km. The system delivers exactly the precise wind and temperature data that climate and atmospheric researchers had hoped for at the start of the project.

In light of such ideas and successes, we are confident that our future will be bright. See our work for yourself – in this report or in a direct conversation. We look forward to hearing from you!

Cordially,

Dr. Jochen Stollenwerk

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Declaration of Principles

We conduct applied contract research and turn original ideas into innovative and disruptive solutions.

Mission

We conduct applied contract research. This means: we turn original ideas into innovative and disruptive solutions, enable our partners to develop competitive solutions to complex technological challenges and thus increase the competitiveness of our customers. We train excellent and competent experts and thus contribute to the competitiveness of Germany as a location for industry and science.

Customers

We focus on what our customers need. We place great emphasis on discretion, fairness and partnership in our customer relations. According to the requirements and expectations of our customers, we develop solutions and implement them. We want our customers both to be pleased and pleased to return to us.

Opportunities

By concentrating on our core competencies, we expand our knowledge in our networks strategically. We strengthen our network consisting of industrial and institutional partners with complementary services and establish strategic partnerships. We increasingly operate on international markets.

Fascination laser

We are fascinated by the unique properties of laser light and the diversity of applications resulting from them. We are excited by the possibility of setting international standards through leading technological achievements and first-time industrial implementation.

Staff

Our success is based on the interaction of the individual and the team. Each one of us works independently, creatively and oriented toward a specific goal. All the while, we proceed reliably, with attention to detail and are aware of the need to conserve resources. We place our individual strengths in the team and treat our colleagues with respect and fairness. We work together, across disciplines.

Strengths

Our broad spectrum of resources enables us to offer one-stop solutions. We deliver innovative and cost-effective solutions and offer you R&D, consulting and integration. We solve our customers’ tasks in multi-disciplinary teams using diverse and innovative facilities.

Management style

Cooperative, demanding and supportive. Our management style is based on knowing the value of our employees as individuals, of their know-how and commitment. We have our employees formulate targets and make decisions. We place great value in effective communication, goal-oriented and efficient work as well as in making clear decisions.

Position

Our expertise extends from developing beam sources, processing and measuring technologies, via applying them all the way to integrating a plant within the customer’s production line. We work in a dynamic equilibrium between applied basic research and development. We actively formulate and design research policy goals.

Facts and Figures 2025

6
Patent Applications

8
Granted Patents

48,6
Million €
General Budget

491
Employees

59 %
Permanent staff
Science, Technics,
Administration

41 %
Student Assistants,
Student Employees,
Trainees

Profile of the Institute

Fraunhofer ILT stands for combined know-how in the field of laser technology for 40 years.

Partner for innovations

Innovative solutions for manufacturing and production, development of new technical components, competent consultation and education, highly specialized personnel, state-of-the-art technology as well as international references: these are guarantees for long-term partnerships. The numerous customers of the Fraunhofer Institute for Laser Technology ILT come from branches such as automobile and machine construction, the chemical industry and electrical engineering, the aircraft industry, precision engineering, medical technology and optics. With about 490 employees and more than 19,500 m² of net floor area, the Fraunhofer Institute for Laser Technology ILT is among the most significant contracting research and development institutes in its sector worldwide.

Under one roof, the Fraunhofer Institute for Laser Technology ILT offers research and development, system design and quality assurance, consultation and education. To process the research and development contracts, we have numerous industrial laser systems from various manufacturers as well as an extensive infrastructure. In the nearby Research Campus Digital Photonic Production DPP, companies cooperating with Fraunhofer ILT work in their own separate laboratories and offices. This special form of technology transfer is based on a long-term cooperation agreement with the institute in the field of research and development. The added value lies in the use of the technical infrastructure and the exchange of information with the experts on site.

In addition to established laser manufacturers and innovative laser users, start-ups from the fields of special plant engineering, laser manufacturing technology, laser measurement technology and quantum technology can find a suitable environment here for implementing their ideas in industry.

Fraunhofer ILT is part of the Fraunhofer-Gesellschaft, which is one of the leading research institutes in Germany with 74 institutes, more than 30,000 employees and an annual research budget of 3.6 billion euros.

We open up perspectives

The services offered by Fraunhofer ILT cover a wide range of topics in laser technology. Customers from research and industry can benefit from our extensive expertise and valuable know-how in the fields of lasers, optical systems, quantum technology, laser measurement technology, additive manufacturing, surface technology, joining, cutting, digitalization, EUV and plasma technology, and medical technology.

Our scientists develop optical components, laser systems and laser beam sources adapted to specific applications and with tailored output powers as well as with spatial, temporal and spectral properties. The spectrum ranges from free-form optics, tunable lasers, diode and solid-state lasers to fiber and ultrashort pulse lasers.

Qualitätsmanagement ISO 9001
www.dekra-siegel.de
DEKRA zertifiziert

Certified by
ISO 9001:2015
Reg. No. 90126024

Services of Fraunhofer ILT

- Development of laser beam sources
- Components and systems for beam guiding and forming
- Packaging of optical high power components
- Modeling and simulation of optical components as well as laser processes
- Process development for laser materials processing, laser measurement technology, medical technology and biophotonics
- Process monitoring and control
- Solutions for digital production
- Model and test series
- Development, set-up and testing of pilot plants
- Development of X-ray, EUV and plasma systems
- Photonic components and systems for quantum technology
- Laser beam sources and processes for fusion technology

Cooperations

The Fraunhofer Institute for Laser Technology ILT has partnerships with domestic and foreign companies and research centers in the field of laser technology so that it can offer its customers solutions from a single source. sFraunhofer ILT also maintains close contacts to universities, associations, chambers of commerce and trade, testing institutes and research ministries.

Alumni network

Fraunhofer ILT and the associated chairs and subject areas of RWTH Aachen University significantly contribute to the qualified training and advanced training of young scientists in the field of laser technology. Thanks to their practical experience and in-depth insight into innovative developments, these employees are equipped with the best prerequisites to take up work in science and industry. They are, therefore, junior staff in demand.

Since 2000, Fraunhofer ILT has been operating the alumni network Aix-Laser-People, which has over 500 alumni, to promote contact both with ILT employees and with each other. More than 80 percent of the alumni work in the manufacturing industry, many of them in laser-related industries, while 20 percent continue to work in science. Over 40 companies have been founded by former employees in the last 30 years. By transferring innovative minds to industry and science, Fraunhofer ILT provides a direct benefit to society. In addition to the alumni network Aix-Laser-People, the association Arbeitskreis Lasertechnik AKL e.V., founded in 1990 by ILT executives, bundles the thematic interests of those who continue to work in the field of laser technology.

With approx. 490 employees and more than 19,500 m² of net floor area, the Fraunhofer ILT is among the most significant research institutes in the field of laser technology worldwide.

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Board of Trustees – Well Advised!

The Board of trustees advises the bodies of the Fraunhofer-Gesellschaft and the institute management and promotes contacts with industry and organizations interested in research. In 2025, the Chancellor of RWTH Aachen University Thomas Trännapp, was newly appointed to the Board of Trustees.

Members 2025

Dr. Joseph Pankert	aiXscale Photonics GmbH (Chairman)
Dr. Nicole de Boer	Bayern Innovativ GmbH
Dipl.-Volksw. Isabel Hartung	Multi-Advisory and Supervisory Board Member, Senior Advisor
Prof. Ursula Keller	ETH Zürich
Dipl.-Ing. Volker Krause	Laserline GmbH
Dipl.-Ing. (BA) Michael Lebrecht	Mercedes-Benz AG
Dr. Stefan Ruppik	Coherent Corp.
Dr. Torsten Scheller	JENOPTIK AG
Dr. Ulrich Steegmüller	ams-OSRAM International GmbH
Dr. Jan Suhren	Federal Ministry of Research, Technology and Space
Ulla Thönnissen	Region Aachen Zweckverband
Thomas Trännapp	RWTH Aachen University
Dr. Hagen Zimer	TRUMPF SE + Co. KG

The 40th Board of Trustees meeting was held on November 13 and 14, 2025 at Fraunhofer ILT in Aachen.

Fraunhofer ILT in Figures

Personnel 2025

	number
Permanent staff	**292**
Scientists and engineers	184
Technical staff	44
Administrative staff	64
Other employees	**199**
Student assistants	186
Student employees	9
Trainees	4
Total number of employees at Fraunhofer ILT	**491**

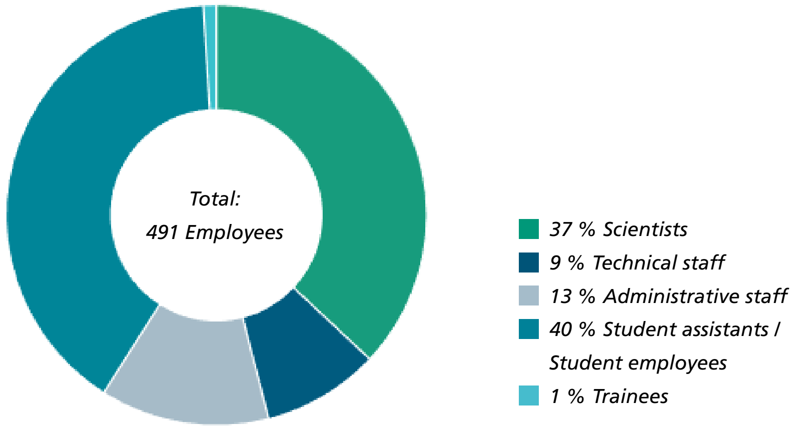
Expenses 2025

	Mill €
Staff costs	36.0
Material costs	9.1
Expenses operating budget	**45.1**
Investments	**3.5**
Expenses general budget	**48.6**

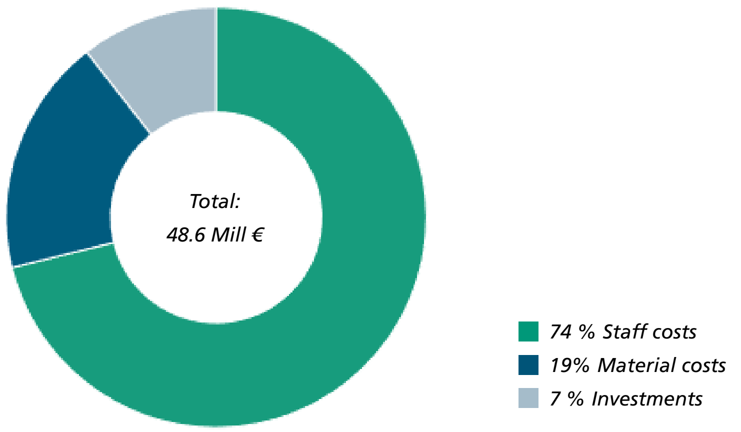
Revenues 2025

	Mill €
Industrial revenues	14.0
Additional financing from Federal Government, States and the EU	19.2
Basic financing from the Fraunhofer-Gesellschaft	15.4
Revenues general budget	**48.6**
Fraunhofer Industry ρ_{Ind}	**31.1 %**

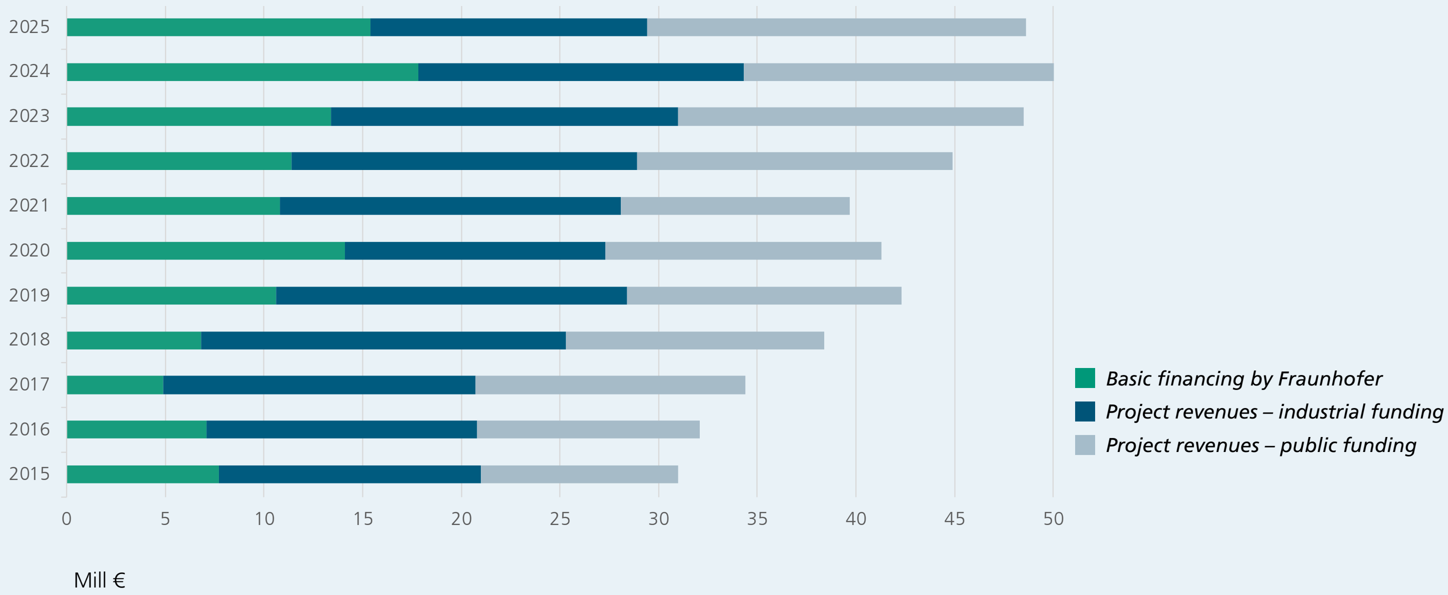
Personnel 2025



Expenses 2025



Revenues over the last 10 years



40 Years of Fraunhofer ILT

For 40 years, scientists at Fraunhofer ILT have been contributing to the success story of the laser, always with the goal of effectively transferring research ideas into practical applications.

Since its founding in the 1980s, Fraunhofer ILT has become one of the world's leading centers for applied laser technology. From the very beginning, our aim was to bring lasers from research into industrial applications. The institute's founder, Prof. Gerd Herziger, pursued a specific vision – establishing a national institute for laser technology research. Its activities focused on both new developments and systematic optimizations of laser beam sources and applications.

New beam sources for industry

From an early stage, the institute focused on developing high-power laser sources for material processing. In close cooperation with industry partners, Fraunhofer ILT played a key role in establishing CO_2 lasers for industrial use. Under the leadership of Gerd Herziger, Eckhard Beyer, Peter Loosen, and Reinhart Poprawe, it developed high-performance systems that laid the foundation for the global success of laser-based machine tools. To this day, they are used in semiconductor lithography and many other applications.

Technologically, Fraunhofer ILT played a pioneering role in the transition from gas to solid-state lasers. By developing diode-pumped laser sources and the INNOSLAB laser, the Aachen-based engineers created a technology that combines high power with excellent beam quality. This technology found broad application in micro- and precision machining, metrology, and scientific applications – and formed the basis for several successful spin-offs.

Tailored Light

Another key research area is laser optics and beam shaping. At Fraunhofer ILT, innovative optical concepts have been developed that allow laser beams to be optimally adapted to the respective process. Multi-beam optics make parallel processing possible and significantly increase productivity. This decisively advanced the shift from the universal laser tool to application-specific, optimized Tailored Light.

Always at the forefront: Lasers in additive manufacturing, medical and space technology

Additive manufacturing with lasers has also gained industrial significance. With laser powder bed fusion (LPBF), patented by Fraunhofer ILT, the institute laid the foundation for metal 3D printing as early as the mid-1990s. This enables industry to cost-effectively produce highly complex components starting from a batch size of one, particularly in medical technology, aerospace, and turbomachinery engineering. In addition, our researchers developed the award-winning extreme high-speed laser material deposition (EHLA), a process that significantly accelerates additive processes and makes them resource-efficient.

In addition to material processing, laser technology from Aachen is used in environmental, climate, and space research. Highly stable laser systems from Fraunhofer ILT provide important data for climate and weather models and contribute to satellite-based atmospheric measurement.

In medical technology, researchers at Fraunhofer ILT are developing a laser-based system for skull surgery on awake patients that removes bone quietly and without vibration while measuring the remaining bone thickness with micrometer precision. Lasers are also at the heart of digital process chains in which personalized implants can be additively manufactured.

AI as a driver of innovation

Fraunhofer ILT was an early pioneer in developing the concept of Digital Photonic Production: here, laser processes are planned, simulated, and monitored entirely digitally. Sensor technology, modeling, and AI-based analysis pave the way for adaptive processes, predictive maintenance, and efficient, quality-assured manufacturing. A key focus is AI-supported automation. Using sensor and process data the institute is designing adaptive and self-learning laser systems to detect deviations during the ongoing process and adjust parameters and beam profiles in real time, in order to achieve first-time-right production.

Quantum technology from Aachen

Lasers are key enablers of quantum technology – for example, for cooling and manipulating atoms, ions, and photons. For years, Fraunhofer ILT has been advancing key photonic technologies, ranging from the manufacture of highly complex optics and ion traps to hardware development for the quantum internet of the future. Photonics is thus becoming a key technology for quantum computing, communication, and sensing. Fraunhofer ILT recently put the first quantum internet node into operation in Aachen. These activities are integrated into international networks, in which Fraunhofer ILT often plays a leading role.

Fusion: Energy of the future

In December 2022, the National Ignition Facility at the Lawrence Livermore National Laboratory (LLNL) in California achieved the first plasma ignition that released more energy than the laser energy put into the process. Since then, Fraunhofer ILT – initiated by Prof. Constantin Häfner – has been developing core technologies for fusion in cooperation with industry partners. In addition to rugged optical components, the institute is designing high-power laser diodes to pump the high-energy lasers of future fusion power plants. This research yields valuable byproducts: secondary sources for novel laser-based electron, proton, X-ray, and neutron beam sources.

The institute today

Four decades after its founding, Fraunhofer ILT – currently led on an interim basis by Dr. Jochen Stollenwerk – has grown to approximately 500 employees, spawned over 40 successful spin-offs, and remained true to its role as a driving force for innovation in photonics. Our high level of patent activity and unique infrastructure demonstrate that our institute is firmly rooted in the future.

Link to jubilee video

AI as a Driver of Photonic Innovations

Prof. Carlo Holly heads the Department of Data Science and Measurement Technology at Fraunhofer ILT as well as the Chair for Technology of Optical Systems (TOS) at RWTH Aachen University. In both roles, he and his teams are working to unlock the potential of artificial intelligence (AI) for optics and photonics.

Professor Holly, what role does data-driven innovation play at Fraunhofer ILT?

Fortunately, we recognized years ago that this is where we can find the solutions needed to optimize photonic processes. As a result, data-driven innovation and the use of AI are now standard practice across all departments at our institute.

What is it all about, and what are the benefits?

Among other things, it involves AI-based monitoring, modeling, and, in the next step, the optimization of ongoing processes. Today, FEM models, ray tracing, and CAD tools are widely used to design photonic processes—increasingly in conjunction with AI. Process monitoring and quality inspection are also data-driven. Inline monitoring reveals more and more about processes, potential errors, and physical deviations measurable in SI units. However, so far this has only been done after the process. The ever-deepening understanding of the causes of errors paves the way for models that make the further course of the process predictable. This opens up the possibility for active, corrective interventions.

Are we talking about closed-loop control systems?

Yes. Our vision is a photonic first-time-right manufacturing process whose operations autonomously adjust themselves as needed. The path to this vision leads from data-informed machine learning to data- and physics-informed machine learning. Pure language models that extract technical content from language fall short in photonics. We can, however, build on a deep understanding of processes and physical knowledge. For example, in laser material processing, once the optimal intensity distribution on a workpiece is known, the only remaining task is to implement it in the process.

My RWTH chair is conducting research to automate optical design using AI methods as well. This would allow laser beam paths to be adapted quickly, efficiently, and cost-effectively to specific manufacturing processes. In addition, we are driving data-driven innovations at the International Center for Networked Adaptive Production – ICNAP Aachen. As an open network, it brings together digital enablers, manufacturing companies, research institutes, and universities so that they can translate these new approaches into industrial practice.

Since the term AI encompasses a wide variety of methods and tools, we are also developing a continuously updated map of available models, methods, and application areas. Interested companies can access this information. As INCAP members, they also have a say in our research questions and topics.

Prof. Carlo Holly during his presentation at the AI in Photonics conference in Berlin, © SPECTARIS, Regina Sablotny.

Where is the journey in AI headed?

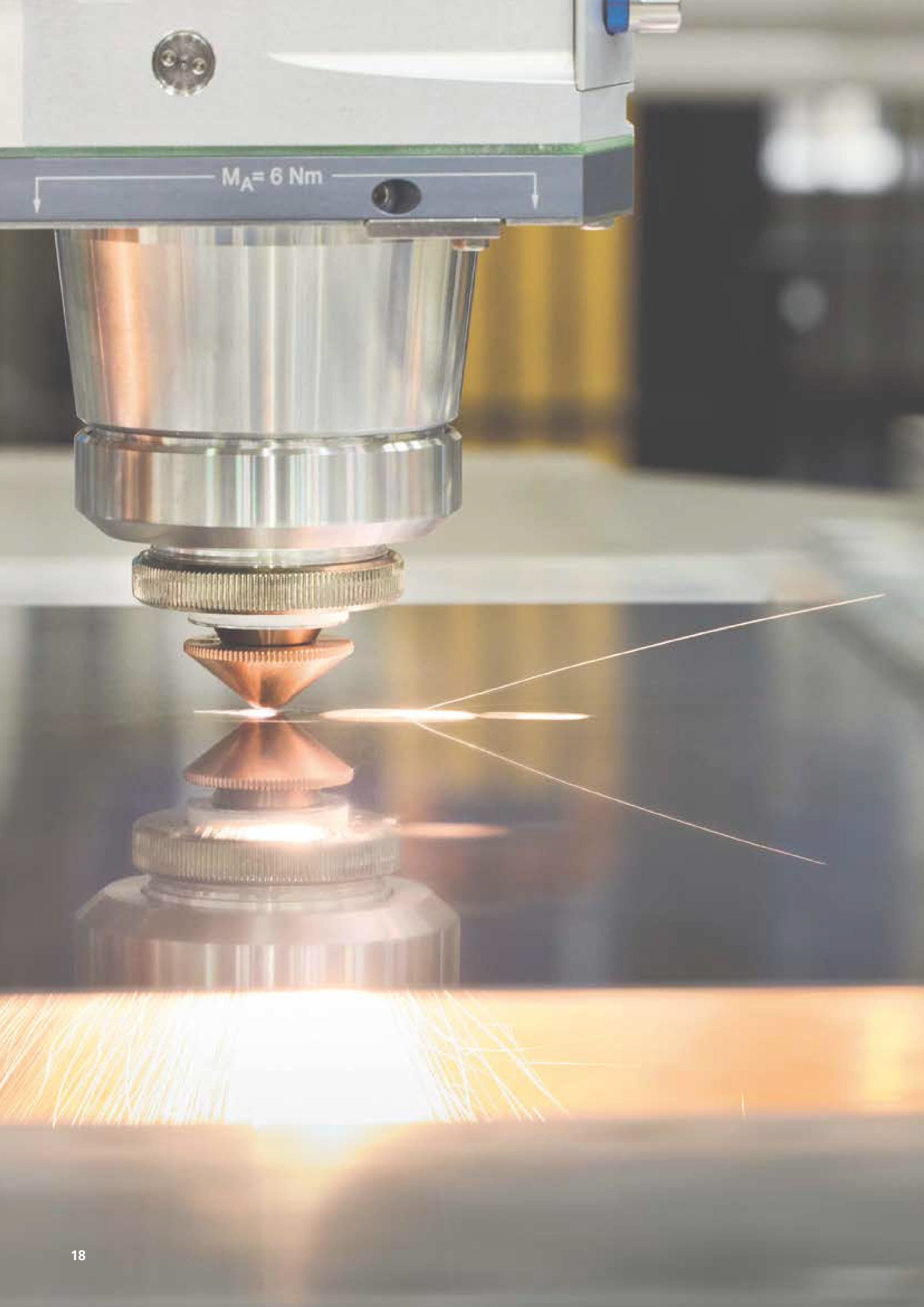
We are working on how to best transfer these methods and tools. Another approach involves surrogate models. These are highly simplified representations of real-world processes that enable us to rapidly analyze models, rather than spend hours on numerical simulation or time- and cost-intensive experiments. Furthermore, they provide not only retrospective results but also highly precise targets for optimized process control. Many users require such forecasts.

In what way?

Take, for example, extreme high-speed laser material deposition (EHLA). Here, optimal parameterization is crucial. Initially, this was a months-long iterative process involving hundreds of experiments, analyses, cross-sections, etc., which caused high material and labor costs. Today, we determine parameters through a systematic comparison of input parameters and quality output, supported by AI-optimized quality metrics. AI assists with data collection and analysis of experimental results, and surrogate models help with experimental design. We conduct half a dozen experiments, evaluate them, and feed the results into an algorithm that then automatically determines which parameters we should test next. Instead of iteratively testing all laser powers against all feed rates, we get by with a fraction of the experiments and reach our goal much faster. In addition, the surrogate model learns as it goes through this loop.

For the next parameter optimization, we sometimes no longer need to go to the machine. We provide the model with a target specification, which it approximates inversely: Based on the target, it predicts the optimal process parameters. To prevent outliers, we set tight constraints so that the algorithm focuses on optimizing these scenarios meaningfully. In this way, we use AI to find optimal settings for processes within 15 minutes and after only drilling a dozen test holes—a task that previously took two to three days and dozens of sheets of metal. The AI iteration can be applied to laser pulses and their sequence, to repetition rates, or to beam shapes. Despite the complexity of the interactions, the model iterates at breakneck speed through a cycle of experimentation, measurement, analysis, and targeted parameter adjustment.

AI accelerates the LIBS process for the pure recovery of refractory materials.


M_A= 6 Nm

Research Markets of the Fraunhofer ILT

Laser technology provides attractive solutions for demanding tasks in various markets and sets standards in terms of quality, flexibility and productivity. Whether as a tool or measuring device, as a diagnostic or therapeutic instrument or as a communication medium, lasers can be used in a wide range of applications in a wide variety of industries.

Thanks to its successful research and forward-looking developments, Fraunhofer ILT has been a preferred innovation partner for industry for around 40 years. Its core activities cover a broad spectrum: from the development of new laser beam sources and optical components, laser measurement technology and laser material processing all the way to medical technology and quantum technology. The several hundred customers of Fraunhofer ILT come from various sectors of the manufacturing industry, from metal processing to the plastics industry, from semiconductor to energy technology, from automotive engineering to the aerospace industry and, of course, from photonics to quantum technology. What all customers have in common is that the results of our R&D projects provide an effective solution for practical tasks or targeted objectives such as new or cheaper products or more efficient or better quality production processes. To better understand our research markets and thus our clients' needs, we have defined six industry sectors that we analyze with particular intensity and support with laser technology solutions. These include:

- Energy industry
- Automotive technology and mobility
- Aerospace
- Microelectronics
- Medical technology and health
- Quantum technology
- Fusion

Since we conduct intensive research and develop specific applications, we make a significant contribution to overcoming the challenges of our time and actively shaping the future of the economy and society. Fraunhofer ILT combines the expertise of its departments and is very well networked internationally. Our clients benefit from the resulting synergies. Convince yourself of the innovations and expertise of Fraunhofer ILT in selected markets relevant to our future!

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Energy Industry – The Backbone of Every Industrial Society

The energy industry is facing a huge transformation: renewable energies, storage technologies and hydrogen are the keys to a climate-neutral future. How can research accelerate this change?

The energy industry is undergoing radical change. The expansion of renewable energies, the storage of electricity and the efficient use of resources are crucial to future-proofing the energy supply. In addition to solar and wind energy, battery technologies and hydrogen are becoming increasingly important as energy storage systems. At the same time, existing infrastructure needs to be modernized and digital solutions developed to make energy use more flexible. Fraunhofer ILT is making an important contribution to the energy transition with innovative laser technologies. New processes are improving the production of battery modules, increasing the efficiency of photovoltaic cells and optimizing the production of hydrogen components. Laser-based manufacturing and repair methods are also ensuring that turbine construction is not only more sustainable but also more cost effective. By working closely with industry, Fraunhofer ILT is accelerating the application of pioneering technologies – for a reliable, climate-friendly and affordable energy supply.

Research Market Energy Industry at Fraunhofer ILT

- Battery technology
- Hydrogen technology
- Turbine construction
- Photovoltaics

https://s.fhg.de/energy-industry

Laser Processes for Batteries and Hydrogen

Laser technology makes key components of the energy industry future-proof. Not only does it improve quality and reduce waste in batteries, for example, but it also makes electrolyzers more efficient and less expensive.

Energy Industry

- Battery technology
- Hydrogen technology
- Turbine construction
- Photovoltaics

Precision and efficiency thanks to micro-welding

The future of battery manufacturing in Europe can only be secured through applying state-of-the-art technologies. Laser technology offers solutions to meet the requirements for efficiency, precision, and sustainability, whether in material processing, electrode production, or recycling.

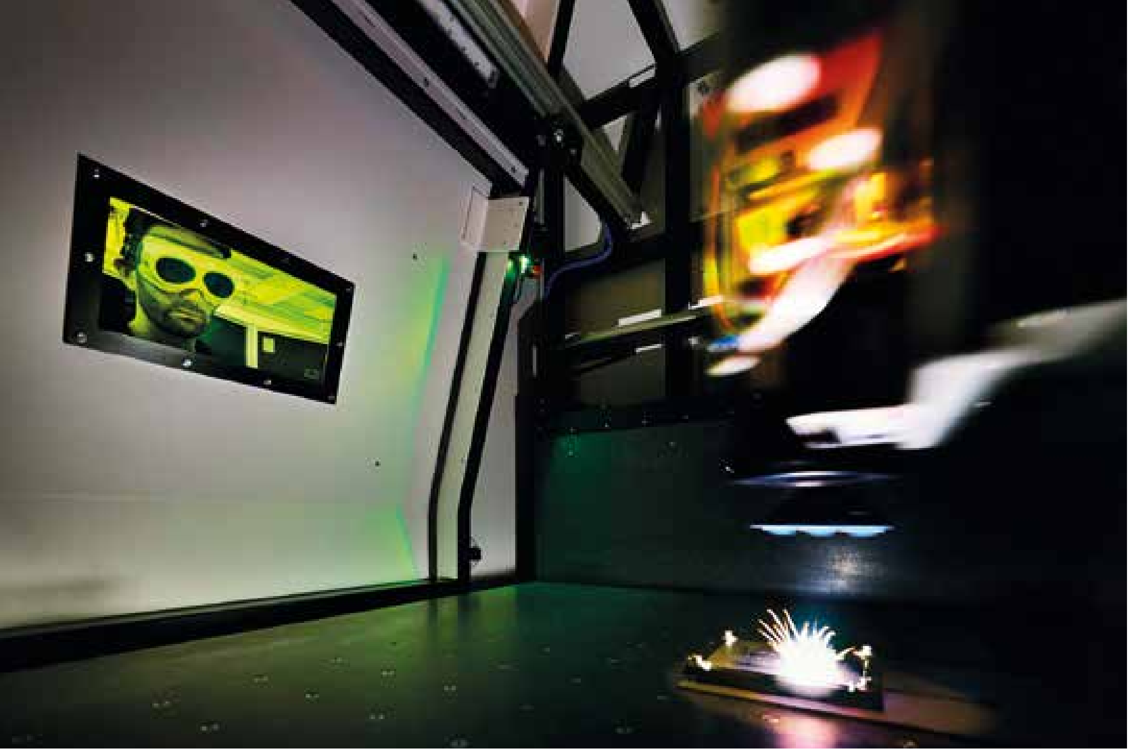
The precise bonding of electrode materials plays a crucial role in the performance and reliability of batteries. In this context, Fraunhofer ILT has developed a key innovation: a process that makes it possible to safely and precisely join aluminum and copper, two materials with very different physical properties. Using state-of-the-art laser beam guidance, the institute is able to control the penetration depth to prevent damage to sensitive cells.

Laser micro-welding has now established itself as a key technology in this field. It enables users to join materials contactless and at high-precision. The low thermal stress protects the sensitive cell chemistry, while simultaneously reducing contact resistance and increasing electrical conductivity. Laser micro-welding offers a combination of flexibility and efficiency that traditional welding processes cannot match.
https://s.fhg.de/4Ew

Structuring electrodes

A key starting point for new battery technologies is material refinement at the nanoscale, in which raw materials are specifically processed and functionalized to maximize their performance in batteries. Surface texture is a decisive factor for high performance. A multi-beam optical system developed at Fraunhofer ILT splits the laser beam into several sub-beams and processes the 250-millimeter strip of a lithium-ion battery anode in parallel; in this way the system creates defined structures that increase energy density and fast-charging capability.

Electrode manufacturing also benefits when artificial intelligence is integrated into the production process. At Fraunhofer ILT, researchers are developing AI-supported approaches that evaluate process data and systematically optimize parameters. This increases quality and throughput while bringing largely autonomous manufacturing closer to reality.
https://s.fhg.de/t56R



Laser processing of bipolar plates for fuel cell production at Fraunhofer ILT.

Laser replaces precious metal coating

But it is not only electrochemical energy storage systems that will play a decisive role in the energy sector of the future. Especially in industrial applications, there is no way around hydrogen as an energy carrier. Currently, however, there is a shortage of sufficient electrolyzers to efficiently convert green electricity into hydrogen.

For this reason, the research project AI-Assisted Welding and Cutting of Expanded Metal for the Efficient Production of Electrolyzers (KISSSEs) was launched In October 2025. This joint project aims to develop a technology that makes producing electrolyzers more cost-effective.

Many electrolyzers have grids coated with precious metals that conduct electricity into the cell while allowing water and gases to pass through. Instead of coating the grids as has been done in the past, the partners are using lasers to directly improve the contact points. AI helps identify suitable points within the irregular grid structures. The laser precisely connects these points, reducing electrical resistance and thereby increasing efficiency. This is intended to create grids with high conductivity without the need for a precious metal coating.
https://s.fhg.de/buwx

Porous zones from metal 3D printing

Another building block for improving electrolyzers comes from metal 3D printing. Using the laser powder bed fusion (LPBF) process, Fraunhofer ILT can selectively create local porosity, enabling a component to feature both gas-tight and permeable areas with clear or graded transitions in a single step.

Since electrolyzers consist of complex stacks of cells with various functional layers, scientists at Fraunhofer ILT are currently investigating whether these layers can also be manufactured directly using additive manufacturing, including specifically permeable areas. This eliminates the need for separate metal foams or fabrics, which would otherwise have to be manufactured and installed separately. The goal of the research is to reduce the number of individual parts and thereby improve the efficiency, material usage, and production costs of the electrolyzers.
https://s.fhg.de/35Cq

»Without innovative laser processes, competitive and sustainable battery production in Europe is hardly conceivable.«

Dr. Tim Lantzsch

New Routes for Mobility

Automotive technology is changing rapidly – new drive systems, sustainable materials and smart production methods are shaping the future. Research plays a decisive role in making this possible.

The mobility of the future must be environmentally friendly, efficient and safe. In addition to sustainable drives such as electric motors or hydrogen drives, digital technologies and new materials are becoming increasingly important. Autonomous driving, networked traffic structures and smart production methods are fundamentally changing the industry. This is where research comes in: New battery technologies are improving the range of electric vehicles, while lightweight materials are reducing energy consumption. Manufacturing processes are also evolving – including innovative laser processes enable industry to produce quickly, precisely, automatically, and sustainably.

Fraunhofer ILT is working with industrial partners on solving these challenges. Whether it's about efficient battery assembly, innovative joining techniques for lightweight construction or advanced sensor technologies for autonomous driving – laser technology can make a decisive contribution to the mobility transition. The result is safe, sustainable and powerful vehicles for the future.

Research Market Automotive Technology and Mobility at Fraunhofer ILT

- E-mobility
- Lightweight construction
- Lighting technology

https://s.fhg.de/automotive-technology

Additively manufactured aluminum die-casting tool at Fraunhofer ILT for the production of the Toyota Yaris Hybrid transmission housing, © Toyota Europe.

»Competitive and sustainable mobility requires manufacturing processes that combine precision, efficiency, and consistent quality.«

Dr. Alexander Olowinsky

Additively manufactured die-casting tools for large aluminum parts

Large structural components require die-casting tools that can withstand high temperatures while simultaneously dissipating heat in a targeted manner. In collaboration with MacLean-Fogg, Fraunhofer ILT has manufactured a complex tool insert for this purpose using laser powder bed fusion (PBF-LB/M).

The additively manufactured tool for producing the transmission housing of a Toyota Yaris Hybrid features cooling channels that closely follow the housing contours, channels that cannot be produced using conventional machining methods. A conventional preform served as the basis, and additively manufactured sections were then used to create a high-performance die-casting tool. As it turned out, the new process reduces both time and costs, while also allowing variants to be produced on a shared tooling platform.

To ensure the process can be scaled for very large applications in mega- and giga-casting, Fraunhofer ILT has continued to develop a gantry-based 5-laser PBF-LB/M machine with a movable processing head and local shielding gas supply. The result was a heatable substrate module that heats the build platform to 200 °C to prevent stresses in the structure and minimize the risk of cracks.

As a result, tools with a volume of over 20,000 cm^3 can now be printed with reproducible results. The mold for Toyota was produced in less than ten days, including preparatory steps. Contour-following cooling reduces local temperature spikes, minimizes wear, and significantly extends the service life of the tools.
https://s.fhg.de/DFyE

Laser drying for battery cells: faster, more compact, more economical

A hybrid solution was also developed in another project: In the IDEEL research project (Implementation of Laser Drying Processes for Economical & Ecological Lithium Ion Battery Production), Fraunhofer ILT relied on a drying strategy combining a laser module and hot air. The researchers additionally used laser energy because electrode drying for the drive battery of electric cars in a conventional roll-to-roll process requires a great deal of energy. Here, the laser handles rapid heating and pre-drying, while the downstream oven maintains the temperature and completes the drying process. The strategy can also be retrofitted into existing systems.

The demonstrator achieved a web speed of 30 m/min during drying and reduced the drying time by more than 60 percent;

Laser Processes for large Components and new Powertrains

Mobility is changing rapidly and putting pressure on Europe both structurally and conceptually, as cars increasingly consist of large structural components and batteries, and hydrogen systems must become both more powerful and more affordable.

the required oven length is cut in half. This reduces operating costs by 20 to 30 percent and improves the carbon footprint due to reduced oven operation.

To ensure process stability, Fraunhofer ILT developed an integrated thermographic camera with industry-compatible data output that maintains the target temperature even with varying speeds and layer thicknesses. In addition, the project team developed a modular laser drying unit with an air-based design and dual-chamber wide-slot nozzles for water-based battery pastes. Tests also showed that the results of hybrid drying are on par with convection drying – in terms of adhesion, residual moisture, conductivity, and electrochemical properties.
https://s.fhg.de/AkrK

Hybrid compound bipolar plates for fuel cells in heavy-duty transport

For heavy-duty commercial vehicles, battery capacity is often insufficient because mass, charging power, and charging times limit their use. The BiFoilStack and HyCoFC projects address this by developing bipolar plates for durable, cost-effective, and high-performance fuel cells specifically designed for heavy-duty applications. After all, heavy-duty transport accounts for about 30 percent of CO_2 emissions in the mobility sector within the EU.

HyCoFC combines a metallic carrier foil with a conductive compound foil to achieve a balance of ruggedness, conductivity, and corrosion resistance. To this end, Fraunhofer ILT is developing laser processes for the fabrication and processing of these hybrid compound bipolar plates.

A particular focus is on developing processes that can be scaled up economically and enable users to produce large quantities cost-effectively. The Fraunhofer ILT team is working on selective layer ablation to increase electrical conductivity and is testing laser-beam-welded joints that are hydrogen-tight and reproducible.

Projektpartner BiFoilStack und HyCoFC

- Thyssenkrupp Steel Europe (Project Coordination)
- FEV Europe GmbH
- Fraunhofer-Institut für Lasertechnik ILT
- Fraunhofer-Institut für Umwelt-, Sicherheits- und Energietechnik UMSICHT
- Clean-Lasersysteme GmbH
- Schepers GmbH & Co. KG
- Dätwyler Sealing Solutions Germany GmbH & Co. KG
- RWTH Aachen University (VKA)
- Accelera by Cummins

https://s.fhg.de/yhgR

Large-area coating removal of a compound bipolar plate.

Automotive Technology and Mobility

- E-mobility
- Lightweight construction
- Lighting technology

Laser Technology for the Aerospace of Tomorrow

Lower weight, more efficiency, new types of propulsion, and ever shorter innovation cycles: The aerospace industry is facing technological challenges. How can modern laser processes help it master them?

The aerospace industry is developing rapidly. Electric and hybrid propulsion, lighter materials and autonomous flying systems are revolutionizing the market. At the same time, the requirements for sustainability, resource conservation and efficiency are getting stricter. New manufacturing processes are needed to produce lighter, more powerful and cost-efficient components. To meet these challenges, Fraunhofer ILT is working with leading companies on innovative processes and systems. In turbine construction, laser-based repair and manufacturing processes lengthen service life and improve efficiency significantly. Additive manufacturing with laser technology opens up completely new perspectives for lightweight construction – both in aviation and aerospace. In commercial aerospace in particular, laser technology solutions are also becoming increasingly important outside of production technology. For example, satellite-based lasers provide precise environmental and climate data and open up new possibilities in navigation and communication technology. Through close cooperation with industry and research, Fraunhofer ILT is developing pioneering technologies for a more efficient and sustainable aerospace industry.

Research Market Aerospace
at Fraunhofer ILT

- Lightweight construction
- Turbine construction
- Satellite-based measurement technology

https://s.fhg.de/aerospace-market

From Powertrains all the Way to Atmospheric Measurements in Orbit

New forms of propulsion, autonomous systems, and microsatellites are transforming the aerospace industry. Fraunhofer ILT contributes to this with three key areas of focus: additively manufactured high-performance components, rugged hybrid components, and space-qualified laser sources for satellite-based LIDAR measurement instruments.

»Thanks to additive manufacturing, we can efficiently produce lighter yet highly durable components and perform targeted repairs.«

Dr. Thomas Schopphoven

Additive manufacturing and targeted repairs

Additive manufacturing is gaining importance in the aerospace industry because components need to not only be lighter and available more quickly, but also simultaneously withstand high loads. To meet these needs, Fraunhofer ILT is focusing on two laser-based processes: laser powder bed fusion (LPBF) and laser material deposition (LMD). LPBF produces precise lightweight components with high strength, thereby enabling users to create designs that reduce weight while reliably meeting safety and quality requirements.

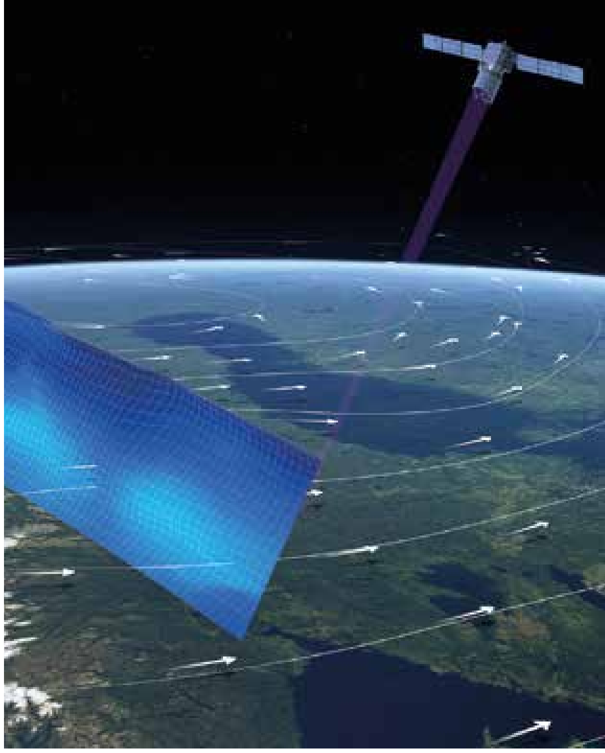
LMD demonstrates its advantages in engines and launch systems. The process builds up material locally and enables shapes and internal structures that can only be produced conventionally with great effort, such as delicate, thin-walled cooling channels in components that have to withstand high thermal loads. LPBF makes component development more flexible and significantly shortens the path from design to the finished component.

LMD also opens up additional possibilities during operation. Instead of completely replacing components, it can be used to renew worn or damaged areas, an innovation that extends service life, saves material, and reduces dependence on spare parts. This approach lowers costs and increases operational readiness, especially for components crucial to safety, where availability and delivery times play a major role.

Stably bonding metal and plastic

Lightweight construction often utilizes different materials that combine their respective strengths within a single component. To ensure that hybrid components made of metal and plastic can withstand high mechanical and thermal stresses over the long term, Fraunhofer ILT is developing laser-based processes for surface structuring of metals. The laser creates finely defined microstructures into which the plastic flows during joining and anchors itself via a form-fit.

This creates a resilient joint without additional fasteners. It also improves the weight and functional balance of the components while simultaneously increasing the reliability of the interface between the materials. This approach is particularly relevant for applications where lightweight construction and structural stability are both required, such as in structural components of aircraft and in areas that are additionally exposed to increased temperature and vibration loads.
https://s.fhg.de/y3pT



1 Helicopter with LIDAR system and a light source developed by Fraunhofer ILT, © Fluxys Belgium, David Samyn.
2 The successor to the ADM Aeolus satellite, equipped with a light source developed by Fraunhofer ILT, is designed to measure wind profiles over the Earth in detail using a powerful UV LIDAR system, © ESA/ATG medialab.

Measuring greenhouse gases from the air and orbit

Climate protection, reliable weather forecasts, and robust climate models require measurement data that is spatially dense and comparable over long periods of time. By collecting such data reliably, satellite-based LIDAR instruments make an important contribution to this: They emit defined light pulses and analyze the backscattered signal to determine trace gases and vertical profiles in the atmosphere. Fraunhofer ILT is developing space-qualified laser sources for this purpose, supplying these measurement systems with precisely defined wavelengths.

In the case of methane, the advantage over purely passive methods lies primarily in the measurement strategy. Passive methods rely on sunlight and – depending on lighting, surface conditions and cloud cover – provide data of limited use. LIDAR, on the other hand, uses two closely spaced laser wavelengths in the near-infrared: One wavelength lies in a range where methane absorbs light more strongly, the other in a reference range with significantly lower absorption. The difference between the two signals allows the methane concentration along the measurement path to be reliably determined.

Fraunhofer ILT developed the laser beam source for the helicopter-borne LIDAR system used by ADLARES. For the MERLIN mission, Fraunhofer ILT is collaborating with partners from research and industry, including Airbus Defence and Space, to develop a space-qualified laser source. This source generates the precisely tuned wavelengths that enable the system to detect methane from an orbit at an altitude of approximately 500 kilometers. Operation in space poses significant challenges: The lasers must not only withstand shock and vibration loads during launch, as well as extreme temperature fluctuations in orbit, but also operate reliably for several years.
https://s.fhg.de/NKea

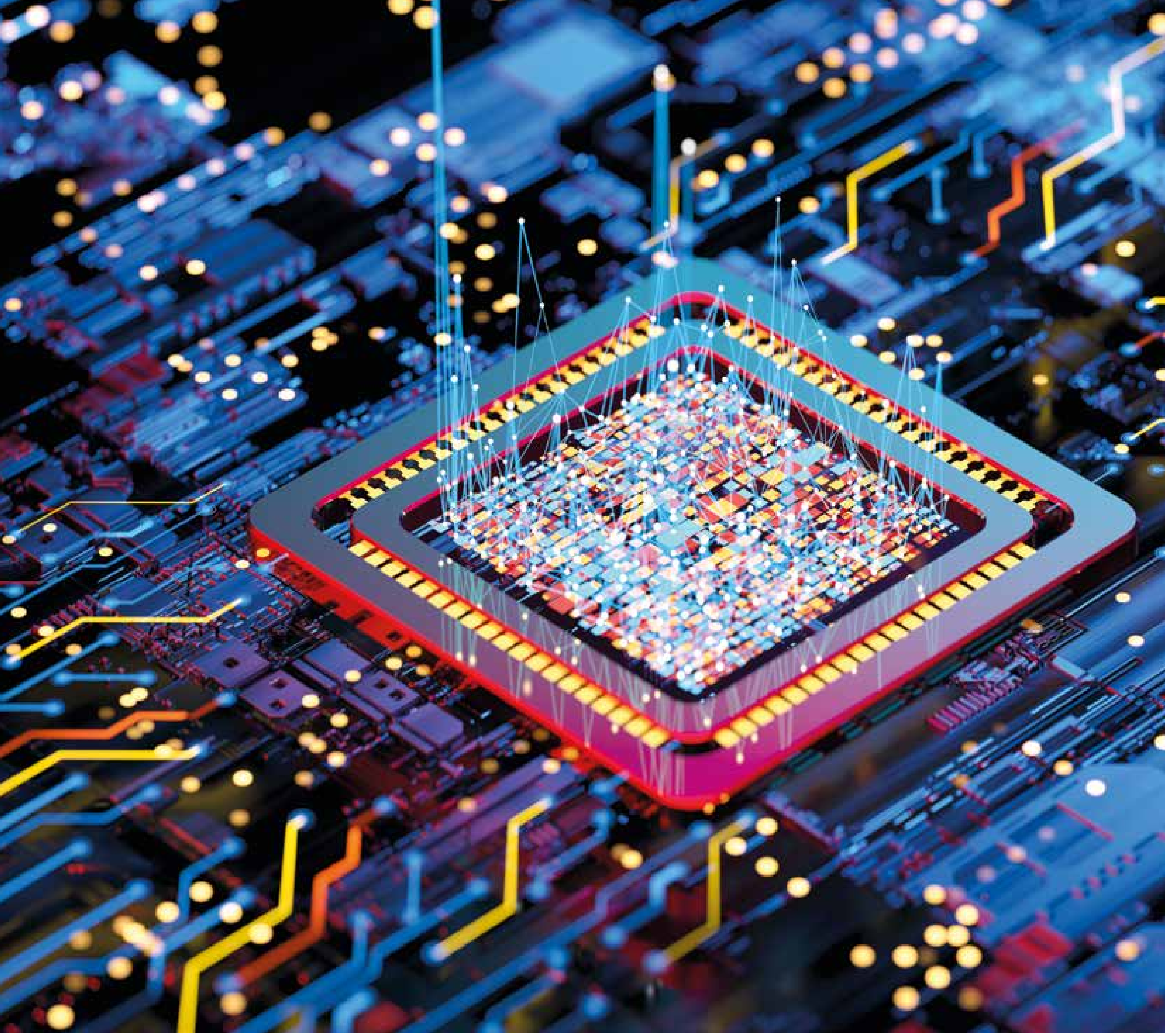
Laser source for water vapor

In the QLEO – Laser Breadboard for Future Water Vapor LIDAR project, the partners are developing a laser source designed to detect water vapor and aerosol profiles in the troposphere from a sun-synchronous orbit. A near-infrared LIDAR is planned for this purpose. The measurement principle requires four closely spaced laser wavelengths, which are emitted in rapid succession as short pulses so that water vapor can be reliably separated from reference signals.

A suitable, space-qualified high-power laser source in this spectral range is not yet available as a standard. QLEO is therefore exploring two technical approaches to generate the required wavelengths from an established infrared laser platform.
https://s.fhg.de/zQ37

Aerospace

- Lightweight construction
- Turbine construction
- Satellite-based measurement technology



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Microelectronics: High Technology in the Smallest of Spaces

Increasingly powerful, energy-efficient and compact – microelectronics is the backbone of the digital world. How do laser technologies help to push the boundaries of what is possible?

Microelectronics is reaching physical limits, while at the same time new applications such as AI, quantum computing and the Internet of Things require more powerful chips. Key to meeting these challenges are nanometer-scale structures, flexible materials, new material combinations and energy-efficient manufacturing processes. Ultra-short pulse processing makes it possible to structure sensitive materials without causing thermal damage. Selective laser etching is used to create interposers, optoelectronic components and microfluidic channels for sensors or biomedical applications. EUV lithography benefits from innovative beam sources and metrology processes. High-power lasers drive plasma sources that generate ultraviolet radiation and thus enable further miniaturization. Lasers are also used in assembly and connection technology. Glass frit bonding and laser-beam welding create stable, hermetic encapsulations for sensitive microsystems. By combining laser technology and digital manufacturing methods, the institute is creating new production processes that not only enable more powerful components, but also reduce material usage and energy consumption.

Research Market Microelectronics at Fraunhofer ILT

- Additively manufactured sensors
- Laser-based packaging
- Semiconductor technology

https://s.fhg.de/microelectronics-market

Scaling Precision, Understanding Processes, Integrating Functions

Miniaturization, 3D integration, and AI continue to drive microelectronics forward. Fraunhofer ILT is focusing on laser-based processes and measurement methods for this purpose.

Microelectronics

- Additively manufactured sensors
- Laser-based packaging
- Semiconductor technology

Interchange, system engineering, and applications for microelectronics

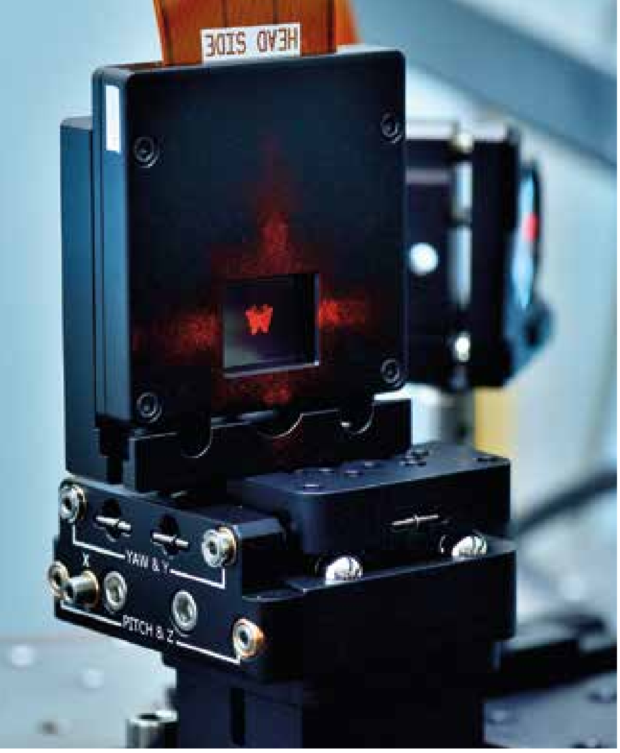
Miniaturization, 3D integration, and AI continue to drive microelectronics forward. Fraunhofer ILT is developing laser-based processes and measurement methods for this purpose. In particular, ultrashort-pulse (USP) lasers make it possible to create extremely small structures with precision, while minimizing material damage and ensuring stability. In this context, the UKP Workshop in Aachen takes on special significance. It showcases current USP laser applications from industry and research and focuses on scaling and productivity, for example, through beam shaping, fast beam deflection, high-power beam sources, and suitable system technology.

This focus is directly relevant to microelectronics. As structures become smaller and smaller, the demands on throughput, repeatability, and process stability increase. This trend not only applies to wafer processes, but also to processing thin functional layers or sensitive substrates, where thermal effects, particles, and microdefects directly influence yield. It is, therefore, crucial that processes remain reproducible over long runs, can be safely integrated into existing equipment and cleanrooms, and operate in sync with production.

These were precisely the questions at the forefront of the UKP Workshop 2025: How can USP processes be transferred from laboratory applications to robust production environments? What role do beam shaping, multi-beam concepts, and fast beam deflection play in accelerating area processes without sacrificing precision? And how can measurement and process monitoring support stable quality when material, layer thickness, or component geometry vary? Accordingly, presentations and discussions featured examples from the fields of wafer-level processes and material-friendly processing. Life insights directly from the Fraunhofer ILT laboratories revealed how high and medium power levels can be implemented in high-power setups with reliable beam guidance and suitable system technology.
https://s.fhg.de/yGiH

A fast pulse instead of scanning

With optical stamping, researchers at Fraunhofer ILT are implementing an approach that creates microstructures with a single laser pulse without time-consuming scanning of the surface with a spot. A spatial light modulator (SLM) uses software to shape the intensity profile into the desired pattern and transfers it directly to the surface. This significantly shortens process times; initial tests show savings of at least 80 percent.



1 Optical stamping allows the beam of a USP laser to be precisely shaped into the desired pattern, such as a butterfly.
2 The 8th UKP Workshop took place in Aachen from April 8–9, 2025.

For microelectronic applications, the combination of reproducibility and pattern flexibility is particularly valuable. The process allows for rapid adjustments when component requirements, follow-on processes, or layouts change. It also opens up new ways to produce functional areas on a large scale without the need for mechanical retooling of the optics.
https://s.fhg.de/KXs5

Making processes visible, ensuring quality

Laser processes in microelectronics will only become truly suitable for industrial use when they can not only be executed precisely but also controlled and monitored reliably. Various research projects have, therefore, consistently advanced the topics of data acquisition, process understanding, and process control in 2025.

Together with the German Electron Synchrotron (DESY) in Hamburg and other partners, Fraunhofer ILT is combining laser processing with high-resolution X-ray imaging to directly observe events within the process. The study has generated hundreds of experiments and large datasets. During the analysis, the researchers used data-driven methods to better understand process windows and enable steps toward adaptive process control.

In microelectronics, these methods directly contribute to yield, reproducibility, and defect prevention – particularly in areas where even the smallest defects can later limit the reliability of contacts, connections, or housings. With its outstanding brilliance and intensity, synchrotron radiation makes it possible to investigate components at resolutions in the micro- and even nanometer range, providing insights into the finest material structures and dynamic processes.
https://s.fhg.de/BSnY

EUV microlithography for the next generation of chips

EUV lithography enables users to produce semiconductor structures in the nanometer range and further drives the miniaturization of modern chips forward. At Fraunhofer ILT, laser plasma beam sources are being developed for this purpose: High-power lasers strike tin droplets and generate a plasma that emits extreme ultraviolet radiation in the required wavelength range. In addition to the stability of the beam source, the institute is focusing on efficiency and process control. It aims to further develop EUV generation so that lithography systems operate reliably, reproducibly, and with high throughput for the smallest structures, including under the conditions of industrial mass production and with varying process parameters.

»Microelectronics requires processes that can cleanly produce the smallest structures while running stably at a steady pace.«

Dr. Christian Vedder

Next-Generation Medical Technology: Precision for Health

High-precision diagnoses, minimally invasive procedures and personalized medicine – modern laser technologies are opening up new possibilities in medical technology.

Medical technology is developing rapidly: Artificial intelligence in diagnostics, automated laboratory systems and minimally invasive treatments are changing patient care. At the same time, there is an increasing need for innovative solutions to make healthcare more efficient and personalized.

Fraunhofer ILT is using high-precision photonics technologies to make new treatment methods possible. Laser systems improve the sorting of living cells and optimize diagnostic procedures with AI-supported laser scanners. In bioanalytics, lasers are used to identify cells and active substances, while in medicine, lasers are used in diagnostics and minimally invasive surgery. Fraunhofer ILT uses additive manufacturing processes to improve the production of individualized implants. By developing compact laser systems with reduced construction volumes, the institute is also helping to make innovative medical technology more accessible.

Fraunhofer ILT is working closely with clinics and industry, developing customized solutions for innovative and sustainable healthcare – from precise diagnostics to personalized medicine.

https://s.fhg.de/medicaltechnology-health

Research Market Medical Technology and Health at Fraunhofer ILT

- Biofabrication
- Bioanalytics and diagnostics
- Laser therapy

The robotically assisted, hand-guided laser surgery system developed at Fraunhofer ILT is intended to replace mechanical high-speed milling and minimize surgical risks on the open vertebral body.

Medical Technology and Health

- Biofabrication
- Bioanalytics and diagnostics
- Laser therapy

Automated high-throughput sorting of living cells with laser light and AI

Tests on living cell cultures are becoming increasingly important for personalized medicine, drug development and clinical research. A new AI-supported high-throughput method from the Fraunhofer institutes ILT and IPT makes it possible to automatically isolate specific cell types. Using the so-called LIFTOSCOPE, laboratories can locate and identify dozens of living cells per second and measure and analyze their size and focus. The researchers then transfer the cells into microtiter plates using laser-induced forward transfer (LIFT) – at survival rates of over 90 percent.

The LIFTOSCOPE integrates an AI-supported high-throughput process into a commercially available inverted microscope equipped with a high-speed camera and a flash light source. The integrated AI can be trained to recognize pluripotent stem cells as well as high-producer cells or immune cells. The Fraunhofer institutes aim to stabilize the fully automated cell recognition and the LIFT process in terms of high throughput and to limit the total process time for a complete microtiter plate to ten minutes.
https://s.fhg.de/vuEP

Laser immersion probe for inline monitoring of water and wastewater

A new type of laser-based immersion probe, which Fraunhofer ILT is testing with industrial partners and users as part of BMBF and EU-funded projects, could pave the way for continuous inline monitoring of water treatment processes in wastewater treatment plants. The 2D fluorescence measurement process generates spectroscopic data directly on site in the clarifier. In conjunction with intelligent evaluation software, these data are crucial to making water treatment energy- and resource-efficient.

The researchers implemented the complex inline measurement process, which is usually carried out offline in laboratory equipment, in the form of a handy immersion probe. A laser-ignited xenon plasma lamp serves as the beam source. A monochromator is used to filter the desired wavelength from the light and transmit it to the immersion probe via an optical fiber. There, a lens collimates the light from the source and focuses it at the measuring point using aspherical optics. The same optics couples fluorescence signals of the sought-after ingredients into another fiber and transmits them to a CCD spectrometer.
https://s.fhg.de/62X

Great Potential for Health

Demographic change is leading to particular challenges in medical care. Laser technology enables diagnoses with greater accuracy, more efficient laboratory processes, more effective drugs and therapies, gentler surgical procedures, individualized implants and highly effective personalized medicine. Laser-based inline analytics also holds great potential for environmental protection, a key pillar of preventive healthcare.

Laser osteotome – robot-assisted laser procedure for awake operations in neurosurgery

To test complex brain functions during neurosurgical procedures, surgeons operate on awake, locally anesthetized patients. However, opening the skull while the patient is awake is extremely stressful for them psychologically. A new laser procedure developed by Fraunhofer ILT – robot-assisted and precisely monitored optically – is set to enable gentle, vibration-free and virtually silent craniotomies in the future. The bone tissue of the skull is removed using short-pulse laser radiation. Since the short-pulse laser source needed for the laser craniotome – with a wavelength of 3 µm and a pulse duration of 100 ns – is not commercially available, Fraunhofer ILT is developing it with industrial partners. To ensure that the laser beam actually only ablates bone tissue and that the underlying structures such as the meninges or spinal cord remain undamaged, the laser cutting process is monitored by an OCT (optical coherence tomography) measurement system.
https://s.fhg.de/rnTf

Further development of the system for spinal surgery

For spinal surgery, the researchers now want to miniaturize the existing applicator and design it as an ergonomic hand piece so that surgeons can also perform the currently automated cutting process manually. The surgeon is to be supported by a collaborative robotic system for precise manual guidance of the applicator. The research team is also planning to use the sensors and actuators of a collaborative robot (cobot) to provide feedback during the non-contact laser cutting process.

To enable this feedback, the cobot's force-torque sensor system measures the force acting on the robot arm. Based on this data, the actuator system can provide haptic cues to the surgeons as they manually guide the laser applicator. The laser operating system will also be linked to surgical planning software and a navigation system to ensure the safety of the semi-automated operation. In such an integrated system, the laser-generated incisions could be visualized in real time in preoperatively generated image data.
https://s.fhg.de/3x2J

Random manual sampling is to be supplemented or replaced in the long term by laser-based immersion probes from Fraunhofer ILT, © Wasserverband Eifel-Rur.

Laser-Controlled Qubits for Practical Applications

Revolutionary computing power, tap-proof communication and ultra-precise measurements – quantum technologies are changing the world. What role do laser systems play in this promising technology?

Quantum technologies open up new possibilities for high-performance computers, secure data transmission and more precise measurement methods. However, highly specialized optical systems are required to manipulate individual atoms, ions or photons in a targeted manner. Lasers make it possible to monitor and control quantum systems. They are used in quantum computers to specifically excite and read out qubits. In quantum communication, they transmit entangled photons via fiber optic or satellite links. Quantum optical methods also unlock new approaches in measurement technology: For example, quantum optical coherence tomography uses entangled photons to make extremely detailed material analyses.

Fraunhofer ILT develops technologies that make these applications possible. These include laser-based micro- and nano-structuring for photonic quantum computers and selective laser etching for complex quantum components made of glass. Low-noise quantum frequency converters ensure stable signal processing over long distances. These advances form the basis for a new generation of information processing and sensor technology that far surpasses conventional systems.

Research Market Quantum Technology at Fraunhofer ILT

- Virtually noise-free quantum frequency converters
- Quantum optical coherence tomography (qOCT)
- Key components for photonic quantum computers

https://s.fhg.de/quantum-technology

Quantum Technology: Light as a Tool in the Realm of Atoms

Quantum technology is breaking into new dimensions, and often uses photonic solutions to do so. At Fraunhofer ILT, this emerging field of technology is gaining importance.

Quantum Photonics Junior Research group.

LP.PRO podcast on quantum technology with Dr. Bernd Jungbluth and Dr. Matthias Laasch

https://s.fhg.de/kXY6

Photonics enablers for controlling individual quantum systems

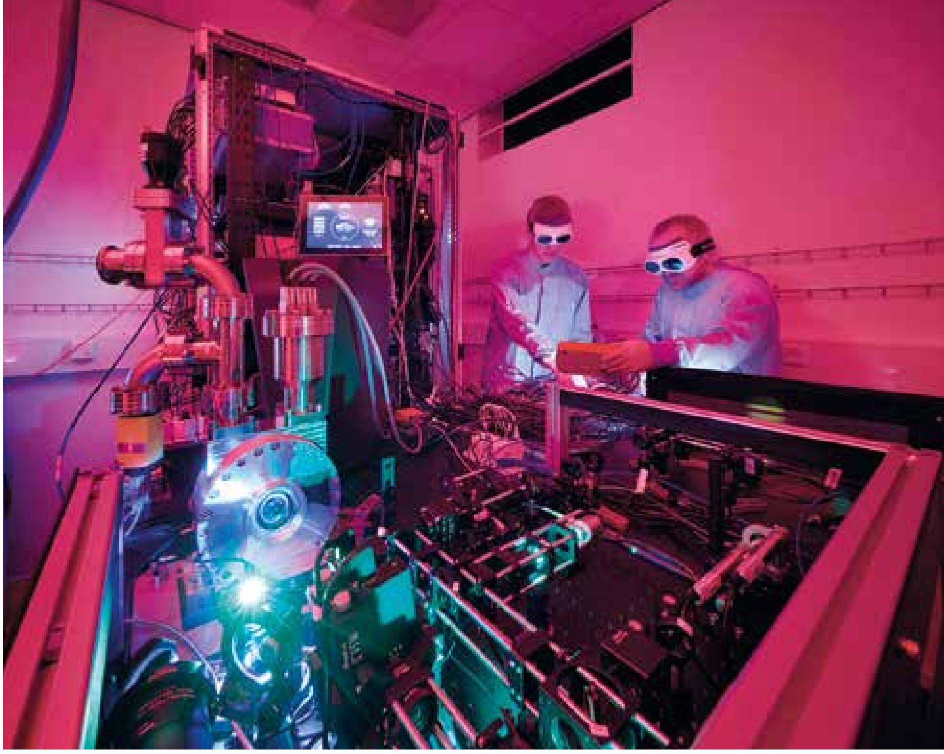
Quantum technologies are opening the next chapter in technological progress that have shaped the last 100 years. Their processes allow researchers to control and manipulate individual atoms, ions, and photons with unprecedented precision. As a result, phenomena that exist at the microscopic level – with their own often counterintuitive laws – are becoming accessible and usable at the macroscopic scale. This creates an entirely new toolbox to venture into new dimensions of computing, communication, measurement, and sensor technologies. Laser technology and photonics make these advances possible by providing the key tools that give researchers access to quantum systems and their unique properties. Fraunhofer ILT is driving the development of such Enabling Photonic Solutions across multiple fields, as the following five highlights from 2025 demonstrate.

Coordination of the QT.NRW Roadmap

In January 2025, Bernd Jungbluth, in his capacity as coordinator of the QT.NRW Roadmap, presented the position paper "On the Path to Making NRW a Quantum Technology Hub" to State Secretaries Silke Krebs (MWIKE) and Gonca Türkeli-Dehnert (MKW). From science and industry, 200 experts contributed to key points of the position paper: strengthening education and training, promoting technology transfer, and establishing application centers for practical experiments and developments.
https://s.fhg.de/ZtyV

Commissioning of the first quantum internet node in NRW

As part of the NRW-funded N-QUIK project, a team from Fraunhofer ILT oversaw the construction of a quantum network node in Delft. This node builds on the technology that previously enabled the transmission of spin-photon entanglement (NV in diamond) via a conventional fiber-optic cable between Delft and The Hague. The team dismantled this node in Delft and subsequently put it into operation in Aachen. Now, as part of the follow-up project PLUQ-IN, the Aachen engineers are connecting it to the fiber infrastructure of the Aachen campus, where it will serve as the core module of the open-access facility ALICE. This facility is intended to bring together stakeholders from research and industry along the development chain for the quantum internet of the future. The project is driven by the objectives of the Quantum Internet Strategy for Europe, which Fraunhofer ILT is helping to develop as part of the Quantum Internet Alliance (QIA). Over the coming decades, this strategy envisions the establishment of a European quantum network with up to 1,000 nodes.
https://s.fhg.de/aLiM



1 The mirror cascade is designed to direct 2,000 laser beams onto a tiny array. These serve as optical tweezers to position Rydberg atoms in a vacuum.
2 The network node for the quantum internet of the future will serve as a test bed and hub in Aachen for the first metropolitan-scale quantum networks.

BMFTR funding for EPIQS

Since 2022, Dr. Florian Elsen has been building the Quantum Photonics Junior Research group at the RWTH Chair for Laser Technology (LLT). Over the next five years, he and his team of seven will carry out the EPIQS project – Engineering Photonic Interconnects for Distributed Quantum Systems. Funded with approximately four million euros by the Federal Ministry of Research, Technology, and Space, the project aims to develop new applications involving interconnected quantum computers, sensors, and communication systems in the quantum internet of the future. To achieve this, different physical quantum systems must be coupled. Needed are efficient frequency conversion and the adjustment of photonic properties such as bandwidth and pulse duration.
https://s.fhg.de/6bbn

Delivery of tweezer array for the QRydDemo project

Rydberg quantum computers have been gaining momentum in recent years and are attracting a great deal of attention from the scientific community. As qubits, Rydberg atoms have the advantage that, as natural quantum systems, they are identical and therefore exhibit no tolerances resulting from manufacturing processes. At the same time, they enable strong, precisely controllable interactions across multiple atoms, making them ideal for complex computational operations in systems with many qubits.

A team from the University of Stuttgart is developing a Rydberg quantum computer with tweezer-array optics as part of the BMFTR-funded collaborative project QRydDemo. Acting as optical tweezers, this system can trap, sort, and prepare 2,000 individual strontium atoms in a vacuum chamber for computational processes.

Fraunhofer ILT has developed and built a complex optical system for this purpose, which was delivered in mid-2025. It positions the atoms in an array of 2,000 laser beams and can rearrange them at any time during the ongoing computational process. Each of the 20 x 100 laser foci can be individually controlled for this purpose, and the atoms dock onto them. The highly sophisticated optical setup is a key prerequisite for increasing the number of qubits and computing power. At its core, it is photonic technology that makes this type of quantum computer possible in the first place.

BMFTR Quantum Future Academy at Fraunhofer ILT

In August 2025, the Quantum Future Academy, initiated by the BMFTR, made a stop at Fraunhofer ILT with 30 STEM students from Germany and the Netherlands. Alongside Amsterdam, Delft, and Jülich, Aachen was the fourth stop, where the students participated in a workshop and a lab tour offering exclusive insights into various areas of applied quantum technologies.

Quantum Technology

- Virtually noise-free quantum frequency converters
- Quantum optical coherence tomography (qOCT)
- Key components for photonic quantum computers

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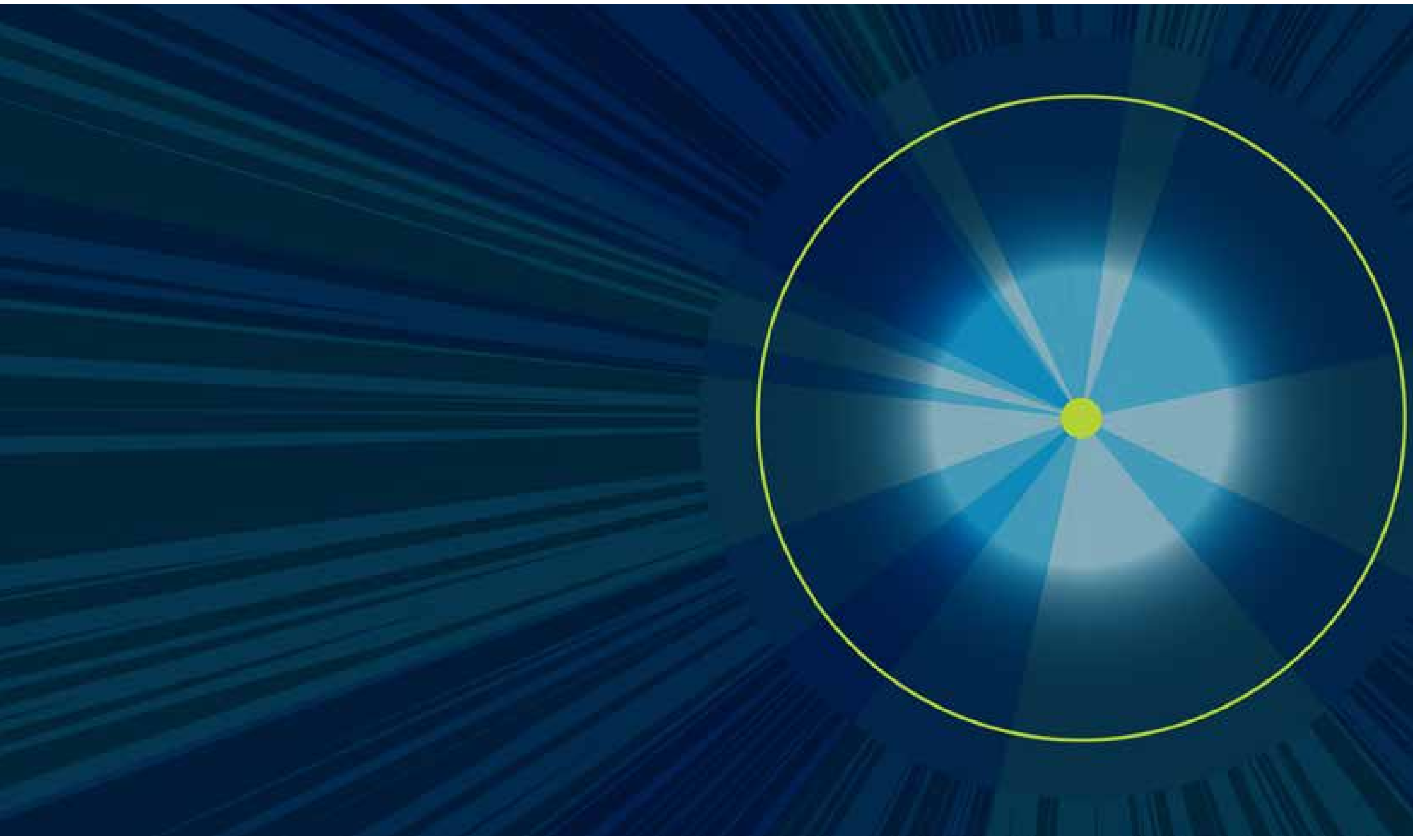
Fusion – Safe, Virtually Inexhaustible Source of Energy for the Future



More than 20 Fraunhofer institutes are researching, developing, and supplying key technologies for both laser fusion and magnetic fusion. Fraunhofer ILT advances technology development through publicly funded collaborative research projects with partners from industry and science. In addition, it participates in international cooperation projects, including collaborations with the Lawrence Livermore National Laboratory in the United States.

Fraunhofer ILT contributes its laser expertise to both fusion approaches. In laser fusion, it is using simulations to develop high-energy lasers, diode-laser pump modules, and optics capable of withstanding extreme loads. The institute is also developing manufacturing processes suitable for large-scale production of key photonic components, fuel targets, and complex reactor walls. For the production of these highly stressed reactor-wall structures and fusion targets, researchers are developing laser-based additive manufacturing processes, among other technologies. Laser-based manufacturing and processing technologies will also be indispensable for magnetic fusion. Lasers can structure surfaces, join and separate high-strength wall materials, and enable industry to additively manufacture complex power-plant components. One spill-over of high-energy laser research is the development of laser-driven secondary sources for generating X-rays, neutrons, and extreme ultraviolet radiation. In addition to serving other markets, these secondary sources are also needed for realistic materials testing in future fusion power plants.

Taskforce Fusion
at Fraunhofer ILT

- Expertise in laser fusion and magnetic fusion
- The path from research to fusion power plants

https://s.fhg.de/fusion-market

Fusion is a Relevant Growth Market for Photonics

By 2029, the German government will invest over 2 billion euros in fusion research. Fraunhofer ILT is among the first movers. In this interview, Dr. Sarah Klein, Fusion Research Coordinator, and Dr. Martin Adams, Group Leader of Computational Methods, discuss technological approaches and market potential, as well as the spillover effects of fusion research.

Fusion

- Expertise in laser fusion and magnetic fusion
- The path from research to fusion power plants

Fusion is considered a safe, climate-neutral, and nearly unlimited source of energy. How can photonics contribute to this?

Dr. Sarah Klein: *Laser-ignited inertial fusion (IFE) is the only approach to date that has demonstrated that fusion works. It now releases significantly more energy than the laser put into the process. A technology-neutral race has erupted worldwide, which is also driving considerable progress in magnetic fusion (MFE).*

Dr. Martin Adams: *IFE systems require high-energy lasers for the extreme compression and heating needed to ignite the plasma. Temperatures exceeding 100 million degrees Celsius provide the necessary kinetic energy for the hydrogen isotopes deuterium and tritium to fuse into helium. However, laser-based processes will also play a key role in manufacturing the complex components for IFE and MFE power plants.*

What is missing for commercial use?

Adams: *Laser power! In California, the successful fusion experiments use a high-energy laser pumped by flash lamps, which must cool down for hours after each shot. Power plant lasers, on the other hand, must be capable of 10 to 15 shots per second. The efficiency of converting electrical energy into optical energy must also increase by at least a factor of ten.*

Klein: *The targets, which are pinhead-sized pellets containing fusion fuel, are – just like the pump modules, amplifier slabs, and optics – orders of magnitude too expensive. The energy surplus must also increase from a factor of four to a factor of 50 to 100. Solutions are also needed for producing the fuel tritium. Neutrons from the fusion reaction are intended to convert lithium into tritium in the power plant's wall elements, in order to use it to fill new targets. The goal is to establish and expand robust supply chains through collaboration between industry and research. In this regard, industrial partners will be particularly crucial.*

What research is currently underway at Fraunhofer ILT?

Klein: *We are participating in various funded projects under the Fusion 2040 program, for which the Federal Ministry of Research, Technology, and Space (BMFTR) has increased the budget to over two billion euros by the end of the legislative period. It focuses on IFE and MFE power plants. In the PriFUSIO, DioHELIOS, IFE-Targetry-HUB, and Durable projects, we are advancing key photonic technologies: simulation and hardware development for highly efficient diode-pumped solid-state lasers, laser-based manufacturing chains for the production of optics, and additively manufactured components and targets. We are channeling our decades of accumulated expertise into fusion research. In doing so,*

we are guided by the Fraunhofer principle: We rethink technologies to transfer them from from research into concrete industrial applications.

Adams: In PriFUSIO, a broad consortium is developing and validating optical components for high-energy lasers. We are designing optics for continuous operation in 24/7 power plant environments, which requires us to significantly increase their damage thresholds and develop processes to manufacture the optical elements in the required sizes cost-effectively. To this end, we are developing process chains in which shaping, polishing, and post-processing are all conducted using laser-based methods. This involves the manufacture of lenses, optical gratings, and also amplifier slabs. The latter are intended to pump the diode laser modules developed in the DioHELIOS project. In both projects, we are developing highly complex simulation tools to virtually optimize the design of the laser diodes and high-energy lasers.

The consortium is also developing approaches for highly automated manufacturing. The cost of the pump modules per watt of output power must drop to the cent range, as a very large number of them are required for the efficient conversion of electrical energy into optical energy. A single power plant requires more high-power laser diodes than are currently produced worldwide in a single year.

Does fusion research have an impact on laser and optical development?

Klein: What makes the large-scale fusion power plant project so exciting is that it can only succeed when industry and research cooperate closely. Companies will only invest if they are convinced of the return on investment. To achieve this, innovations for fusion power plants must also gain a foothold in markets that do not yet exist. We have to create them. If we want to manufacture affordable laser diodes, we need higher production volumes. To increase production, we need to sell more. We must leverage this synergy to achieve economies of scale: bringing technology to new markets and triggering spillover effects. Findings from materials, optics, and high-energy laser development are of interest to many markets, ranging from laser-based deep-sea mining and tunnel construction to compact X-ray and neutron sources.

Adams: We're not just working on a power plant! There are exciting spill-over effects along the way. Germany has an outstanding laser and optics industry, which we are continuing to develop through fusion research and making future-proof.

Klein: We now have the opportunity to strengthen our position in global competition for decades to come and maintain production and market share in Germany.

»We now have the opportunity to strengthen our position in global competition for decades to come.«

Dr. Sarah Klein

Fraunhofer Locations in Germany

Fraunhofer Networks

The Fraunhofer ILT together with other Fraunhofer Institutes bundles its competencies in clusters and lighthouse projects and develops applications for industry and research.

The Fraunhofer-Gesellschaft

The Fraunhofer-Gesellschaft, based in Germany, is one of the world's leading applied research organizations. It plays a crucial role in the innovation process by prioritizing research in key future technologies and transferring its research findings to industry in order to strengthen Germany as an economic hub as well as for the benefit of society. Fraunhofer experts support industry partners from ideation to market launch. Fraunhofer is one of the most active patent applicants in Germany and Europe. The organization is developing an extensive, international patent portfolio in various technology sectors, primarily as a basis for transferring technology through research projects, spin-offs and licensing.

Founded in 1949, the Fraunhofer-Gesellschaft currently operates 74 institutes and research units with more than 30,000 employees, predominantly scientists and engineers. The high proportion of industrial revenue is Fraunhofer's unique selling point in the German research landscape. Highly motivated employees are the most important factor in Fraunhofer's success. The Fraunhofer-Gesellschaft is a recognized nonprofit named after the Munich scholar Joseph von Fraunhofer (1787–1826), who enjoyed equal success as a scientist, inventor and entrepreneur.
www.fraunhofer.de/en.html

Fraunhofer groups, clusters and lighthouse projects

Technically related Fraunhofer institutes are organized in various groups, clusters and lighthouse projects and operate together on the market.
www.ilt.fraunhofer.de/en/clusters.html

The Fraunhofer Cluster of Excellence Advanced Photon Sources CAPS aims a.o. to become the international technology leader in laser systems that achieve maximum power with ultrashort pulses (UKP). Furthermore, it intends to explore their application potential in cooperation with 13 Fraunhofer institutes. CAPS is coordinated by Fraunhofer ILT in Aachen and Fraunhofer IOF in Jena, both of which provide interested users from industry and science with two application laboratories with multi-kW UKP laser sources and the necessary system technology at their respective locations.
www.caps.fraunhofer.de

The Fraunhofer Group for Light & Surfaces combines the scientific and technical expertise of the Fraunhofer-Gesellschaft in the fields of optics, photonics, laser and surface technology. Fraunhofer ILT is one of the eight member institutes in the group. In these institutes, more than 1,900 scientists conduct research to solve complex technological questions from industry and business, and to develop concrete applications for them.
www.light-and-surfaces.fraunhofer.de/en.html

At a glance

- 74 institutes
- 30,000 employees
- Business volume of 3.6 billion euros
- 3.2 billion euros of which designated as contract research

Figures as of April 2026

Networking Industry and Science in Aachen

In Aachen, Fraunhofer ILT has been operating innovation clusters for many years, associations that ensure close links between industry and science in the field of photonics. Innovation clusters are a source of transferring know-how, promoting young talent and creating spin-offs. Our strategic location facilitates the efficient networking of both personnel and infrastructure.

RWTH Aachen University in Figures (as of 2025)

- 44,382 students
- of which 15,811 are international
- A total budget of € 1,264 million
- University of Excellence
- 3 Clusters of Excellence
- 175 study programs

Thanks to its constantly updated infrastructure, Fraunhofer ILT has one of the largest laser system parks in Europe. Its proximity to RWTH Aachen University, in turn, guarantees an influx of highly trained engineers and scientists. In particular, the university, Fraunhofer ILT and industry cooperate systematically and for the long-term on the Digital Photonic Production (DPP) Campus.
www.rwth-campus.com

International Center for Turbomachinery Manufacturing – ICTM

Fraunhofer Institutes IPT and ILT as well as several chairs at RWTH Aachen University operate the "International Center for Turbomachinery Manufacturing – ICTM" together with 19 industrial partners, investigating turbine construction in energy technology and aviation.
www.ictm-aachen.com

Laser technology and optics at RWTH Aachen University

In the field of optical technologies, RWTH Aachen University has an outstanding competence cluster: the Chairs for Laser Technology LLT and for Technology of Optical Systems TOS. The close cooperation with Fraunhofer ILT facilitates industrial contract research underpinned by solid fundamental knowledge.
www.llt.rwth-aachen.de
www.tos.rwth-aachen.de

Location initiatives – Battery Lab and Hydrogen Lab

In its Battery Lab, Fraunhofer ILT has state-of-the-art technology for laser-based battery production. Electrical and mechanical test benches allow users to directly evaluate the laser processes, both for today's conventional lithium-ion batteries with liquid electrolytes and for future solid-state batteries. The Hydrogen Lab focuses on optimizing fuel cells.
https://s.fhg.de/BiHp

Regional networks

At a local level, Fraunhofer ILT cooperates with RWTH Aachen University, the FH Aachen – University of Applied Sciences and Forschungszentrum Jülich on many fundamental issues. At the Aachen Center for 3D Printing, a cooperation between FH Aachen – University of Applied Sciences and Fraunhofer ILT, medium-sized companies, in particular, receive support in all aspects of additive manufacturing.

Main building and "Super-C" of RWTH Aachen University, © RWTH Aachen University / Peter Winandy.

Fraunhofer ILT and the LLT and TOS chairs are active partners in the WIR! alliance LASER. region.Aachen, which is funded by the Federal Ministry of Research, Technology and Space. This is a regional network of now over 60 companies, research institutions and other partners focused on laser and photonics technologies in the Aachen region. The aim of the alliance is to strengthen the region as a leading location for laser technology, promote innovation and technology transfer, and secure qualified professionals. Key activities include networking among stakeholders, joint R&D projects, trade fair and marketing appearances, as well as information, qualification, and junior staff development.
www.laserregionaachen.de

The trade association IVAM e.V. gives Fraunhofer ILT access to numerous experts in microtechnology. In the state cluster NMWP.NRW, the institute is involved in nanotechnology, photonics, microsystems technology, aerospace and quantum technology.

National cooperation

Fraunhofer ILT is actively involved in numerous industry associations such as DVS, SPECTARIS, VDE and VDMA as well as in national standards committees such as DIN NWT. The laser experts also support initiatives such as the BMBF research campus or the BMWK's "go-cluster"program. In all committees, they provide impetus to further develop both the specialist field of laser technology and forms of cooperation between science and industry for the benefit of society.

Internationally networked

Fraunhofer ILT carries out both bilateral and joint projects with foreign companies and branches of German companies abroad. In addition, the institute participates in major international projects such as the Franco-German space mission MERLIN in climate research or in the design of research programs such as the European Commission's Photonics21 technology platform.

In nuclear fusion research, Fraunhofer ILT collaborates with the Lawrence Livermore National Laboratory (LLNL) in a strategic partnership. The institute's employees support international developments through their involvement in selected associations and networks such as the European Photonic Industry Consortium EPIC at European level or OPTICA and the Laser Institute of America (LIA) at transatlantic level.

»Innovation clusters as a source of know-how transfer, promotion of young talent and spin-offs.«

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RWTH Aachen Campus

Right in the heart of Aachen, the RWTH Aachen Campus is expanding across 2.5 km² into one of Europe's leading ecosystems for applied research. Part of it is the Photonics Cluster with the Research Center Digital Photonic Production (DPP) and the Industry Building DPP.

The RWTH Aachen Campus acts as a catalyst for successful start-ups.

Research Center DPP

To shorten innovation cycles, different research areas need to network in an inter- and transdisciplinary manner. Scientists from different institutes and chairs at RWTH Aachen University conduct research together on different topics with common goals over a relatively long period of time. The Research Center Digital Photonic Production, which opened in 2019 and was fully operational in 2020, offers researchers space for fundamental research in the field of photonics on approximately 4,300 square meters of floor space – including 2,800 square meters of laboratories, clean rooms and halls. The institutes and chairs currently involved come from six faculties at RWTH Aachen University: Mechanical Engineering, Mathematics, Computer and Natural Sciences, Electrical Engineering and Information Technology, Georesources and Materials Engineering, Medicine and Economics.

Industry Building DPP

Companies can set up shop in the Industry Building Digital Photonic Production – which is in the immediate vicinity of the Fraunhofer Institute for Laser Technology ILT – to develop new components, systems, processes, process chains or business models in the field of optical technologies, especially for production technology. The Industry Building DPP thus offers the necessary infrastructure for long-term, strategic cooperation. Premises such as laboratories and offices can be rented as needed through the private operator. Mixed teams from industry and science can interact and inspire each other in open space structures and jointly occupied laboratories. The close exchange on site creates direct access to young scientists from RWTH Aachen University and FH Aachen – University of Applied Sciences. This allows young talents to be involved in practical projects at an early stage. Education and training as well as access to scientific events on site are also very efficient and future-oriented since companies "enroll" at RWTH Aachen University.

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Spin-Offs

Together with the RWTH Aachen Campus, Fraunhofer ILT offers an ideal environment to found a company in the field of photonic production.

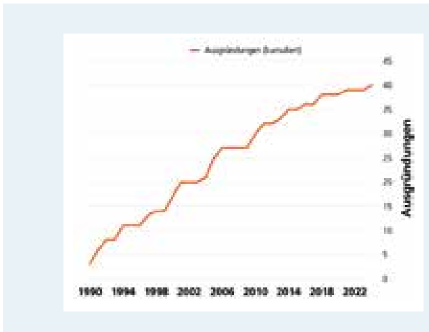
Intensive spin-off culture at Fraunhofer ILT

The Fraunhofer Institute for Laser Technology ILT has cultivated an intensive spin-off culture since the early 1990s, which has led to more than 40 new companies in the last 40 years. In this context, Fraunhofer ILT acts as a know-how partner that is more or less involved in the development of new technologies, depending on the cooperation agreement. Through corresponding license agreements, the spin-offs also have access to those patents that the founders obtained while at Fraunhofer ILT. Innovative founders are both impulse generators in the industry for new technological solutions and perspectives as well as classic entrepreneurs who keep an eye on sustainable business development and secure jobs.

Spin-offs generate added value for the laser industry

The about 40 spin-offs of Fraunhofer ILT not only generate new revenue, but also expand the market potential of the laser industry. They are also attractive employers in an industry that has been showing outstanding growth rates for years.

The spin-offs' product spectrum ranges from innovative cleaning processes, customized additively manufactured implants and new high-power diode lasers all the way to powerful ultrashort pulse lasers.



Headquarter of the spin-off Lang Laser-System GmbH in Ummendorf, © Lang Laser-System GmbH.

Awards and Prizes

Fraunhofer ILT researchers once again received several awards and prizes in 2025. Dr. Wilhelm Meiners was inducted into the TCT Hall of Fame, while Dr. Sarah Klein received third place in the Hugo Geiger Prize competition.

Hugo Geiger Prize

The Hugo Geiger Prize for young scientists is awarded annually by the Bavarian Ministry of Economic Affairs and the Fraunhofer-Gesellschaft to three young researchers. It recognizes outstanding, application-oriented doctoral dissertations that were completed in close cooperation with a Fraunhofer Institute.

Hugo Geiger Prize
Third place for Dr. Sarah Klein

Whether in medical technology, telecommunications or aerospace, the demand for high-power lasers continues to grow across many industries. For users, system stability and cost-effectiveness are critical.

Fraunhofer ILT has made significant progress in the development of efficient and stable high-power diode lasers. As early as 2019, Dr. Sarah Klein, a researcher at Fraunhofer ILT, contributed to the BMFTR-funded EKOLAS project, where she helped develop a method for embedding fiber Bragg gratings (FBGs) inside optical multimode fibers. Integrating FBGs can dramatically reduce the complexity of fiber-laser systems. When the optical gratings are written directly into the fiber, they can replace external resonator mirrors, eliminating the need for complex mirror alignment.

As part of her doctoral research, Dr. Klein transferred this method to fiber-coupled diode lasers in a Fraunhofer internal research project. On February 19, 2025, she was awarded third place in the prestigious Hugo Geiger Prize competition for her work entitled "Fiber Bragg gratings for the frequency stabilization of multimode high-power diode and fiber lasers."

Unlike their role in fiber lasers, FBGs in diode lasers primarily improve spectral properties. For this reason, Dr. Klein developed this concept to reduce bandwidth in a targeted manner and stabilize the wavelength of the laser radiation. Once again, the key element is a directly written FBG. It ensures that the high-power diode lasers emit only the desired wavelength. The resulting increase in brilliance makes energy input during the pumping of solid-state lasers far more efficient and, thus, more cost-effective. This represents a major advantage for industrial applications, where cost-effectiveness and energy efficiency are becoming increasingly important – including laser-based inertial fusion.

Dr. Sarah Klein (center) with Hubert Aiwanger (left), Deputy Minister-President of Bavaria, and Prof. Holger Hanselka (right), President of the Fraunhofer-Gesellschaft, at the award ceremony for the Hugo Geiger Prize in Munich, © Markus Jürgens, Fraunhofer.

TCT Hall of Fame 2025: Dr. Wilhelm Meiners honored for lifetime achievements in 3D printing

Dr. Wilhelm Meiners has been inducted into the TCT Hall of Fame 2025. With this distinction, the international additive manufacturing community recognizes his outstanding contributions to the development of metal 3D printing. As a doctoral researcher at Fraunhofer ILT, Wilhelm Meiners laid the foundation for a technology that is now used worldwide when he invented and patented the laser powder bed fusion (LPBF) process in 1996. Today, LPBF is employed in applications ranging from medical technology to aerospace.

This year's award recipients were announced on June 4, 2025, during the TCT 3Sixty exhibition in Birmingham, UK. The jury high-lighted the lasting impact of the LPBF process on industrial manufacturing, the innovative strength of the original patent, and the continuous technological advances achieved at Fraunhofer ILT. Wilhelm Meiners is only the second German ever to receive this honor, underscoring the international reputation of Fraunhofer ILT in the field of metal additive manufacturing.

Kim Kallies: Ambassador for 3D printing

Kim Kallies, research associate and project manager at Fraunhofer ILT, has been appointed Women in 3D Printing Ambassador for Aachen. She develops innovative additive manufacturing solutions based on laser metal deposition (LMD) and extreme high-speed laser material deposition (EHLA). Kallies studied mechanical engineering in Frankfurt, specializing in product development, production engineering, and automotive technology, and contributes her experience spanning the entire additive manufacturing process chain. Through her work with the international Women in 3D Printing (Wi3DP) network, she is committed to increasing the visibility of women in the 3D-printing industry and strengthening professional networking opportunities.

First place in the Student Paper Award for Viktor Glushych

Viktor Glushych, Head of the LMD Coating and Heat Treatment Group at Fraunhofer ILT, received first place in the Student Paper Award competition during the International Congress on Applications of Lasers & Electro-Optics (ICALEO) 2025 in Orlando, Florida. He received the award for his presentation entitled: "Advanced powder flow regulation in DED-LB/P and EHLA3D via a novel nozzle-integrated fluidic powder switching mechanism."

»Induction into the TCT Hall of Fameis considered one of the highest honors in the world of additive manufacturing.«

Dr. Wilhelm Meiners (center) was inducted into the TCT Hall of Fame 2025, © TCT Group.

Training the Next Generation

Innovation and excellent research are driven by people. We are already investing in the talents of tomorrow, creating sustainable opportunities for the future.

1 Fraunhofer staff at Kimiko Campus Festival.
2 Networking Brunch of RWTH International Academy,
© RWTH International Academy.

Career Day for women of the RWTH Aachen University
January 21, 2025

The aim of the Career Day is to promote women in the STEM fields – also a key topic at Fraunhofer ILT.

Girls' Day
April 3, 2025

Fraunhofer ILT, IPT and IME once again invited girls from the 5th to 8th grades to participate in laboratory tours and experiments in their institutes.

meet@fh-aachen
April 23, 2025

Fraunhofer ILT provided information about the different career opportunities at Fraunhofer ILT at the FH Aachen company contact fair.

Vocatium Aachen
May 8 and 9, 2025

Fraunhofer ILT used the student exhibition to promote young talent.

bonding Institute Market
May 14, 2025

Fraunhofer ILT and IPT were also present on site among the many institutes of RWTH Aachen University.

Networking Brunch of the RWTH International Academy
June 15, 2025

Fraunhofer ILT networked with top international talents from RWTH Aachen University.

Mechanical Engineering Day of RWTH Aachen University
May 24, 2025

Fraunhofer ILT and the RWTH Aachen University chairs LLT and TOS provided active on-site support to make mechanical engineering accessible to school students.

Guided tour for the German National Student Spaceflight Society (BVSR)
May 30, 2025

In the course of the conference from May 29 to June 1, 2025 in Aachen, some members learned about aerospace projects at Fraunhofer ILT.

Kimiko Campus Festival
June 14, 2025

The Fraunhofer Institutes ILT, IPT and IEG took advantage of the festival on Campus Melaten to increase awareness of Fraunhofer.

1 Participants of the Aachen Girls'Day 2025 in front of Fraunhofer ILT, © Fraunhofer IPT.
2 Fraunhofer ILT at the Carrer Day for women at RWTH Aachen University, © Heike Lachmann.

Student University of Mechanical Engineering
July 18, 2025
Students from the 10th grade onwards got a first-hand look at university life – Fraunhofer ILT and the LLT and TOS chairs of RWTH Aachen University provided insights into their work.

Hackathon #hackingforfuture
July 30 and 31, 2025
The hackathon organized by Fraunhofer ILT and IPT for students once again provided plenty of room for creative solutions.

Guided tour for the Young German Physical Society (jDPG)
August 25, 2025
JDPG Members were given a behind-the-scenes look at Fraunhofer ILT.

Quantum Future Academy
August 27 and 28, 2025
German and Dutch students visited, among other places, Fraunhofer ILT to learn about the current state of research and possible perspectives.

Fraunhofer Photonica Summer School
September 26 and 27, 2025
A select group of top students from around the world visited three Fraunhofer Institutes, including Fraunhofer ILT.

RWTH First Semester Week Guided Tour of Fraunhofer ILT
October 7, 2025
Institute tour for the first-year students of the Materials Science and Engineering Student Council at Fraunhofer ILT.

Open workshop day of the Association Ecurie Aix
October 23, 2025
The Formula Student Team opened its doors again and Fraunhofer ILT was right there with them.

bonding Student Fair
November 5, 2025
The highlight of the year: In 2025, Fraunhofer ILT and IPT once again presented themselves to students and graduates.

RWTH Science Night "5 to 12"
November 14, 2025
Once again, the LLT and TOS chairs at RWTH Aachen University inspired young and old with science and research at an unusual time.

Change starts with us!

You want to contribute your ideas where top-level research happens? At Fraunhofer ILT, you work on innovations with a real impact on the economy and society.

Look here at our career website:

Fusion, the Energy of the Future, Comes to the Classroom

A team from Fraunhofer ILT, working together with the digital-learning startup tinkerbrain as part of a funded Science Year 2025 project, has developed a multimedia, multidisciplinary learning platform dedicated to fusion energy. Three schools in Aachen have already incorporated the material into their teaching programs.

»The energy of the future needs young people to shape the future«

Further information

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www.fusionslab.de
www.wissenschaftsjahr.de/2025

As part of Science Year 2025, the BMFTR sought to support accessible and participatory science-communication projects focused on future energy technologies. The Fraunhofer ILT communications group's project, Future Energy Fusion (ProZeF), was selected as one of fifteen funded initiatives.

Since July 2025, students and teachers at three schools in Aachen have explored the topic of fusion energy using web-based teaching and learning materials developed jointly by Fraunhofer ILT and the start-up tinkerbrain. Lectures, videos, experiments, and interactive learning modules introduce participants to this complex subject. Through fusionsLAB.de, students from the eighth grade onward first learn how economic development, prosperity, and energy supply are interconnected. They also discover how the fusion processes that have powered the sun for 4.6 billion years form the basis of life on earth and ultimately underpin every form of energy we use. The educational materials also address questions of global energy and climate justice and illustrate the close relationship between primary energy consumption and gross domestic product. Students independently research key units of measurement, essential terminology, and the physical principles behind both laser-based inertial fusion and magnetic fusion. To reinforce what they have learned, they present their findings to one another through videos, podcasts, and posters.

Inspiring enthusiasm for fusion

At the heart of fusionsLAB is a module that combines our technological fascination for fusion energy with the underlying physics, ranging from atomic-scale processes to laser technology. Depending on their interests, students can explore six subject areas in-depth: at the physical or technical level, or they focus on modern energy systems, global justice, social acceptance, or economic issues. The program concludes with a role-playing exercise in which students debate fusion energy from the perspectives of concerned citizens, power-plant planners, scientists, financial experts, and media professionals.

Following a pilot project week at the Städtische Gesamtschule Aachen Brand (Comprehensive School Aachen-Brand), the project partners refined the interdisciplinary teaching materials in collaboration with physics teachers and STEM coordinators from two local high schools, the Couven Gymnasium and Kaiser-Karl-Gymnasium. Both schools now use the materials in their regular curricula. The Bildungsbüro (Education Office) of the Aachen Municipal Region facilitated the collaboration. The fusionsLAB platform is now available to all interested schools and extracurricular learning centers.

Customer References

Customer references

The companies listed here are a representative cross-section of Fraunhofer ILT's extensive customer list.

Status December 2025.
Printed with the kind permission of our partners.

Fraunhofer ILT at Laser World of Photonics 2025 in Munich with around 1,400 exhibitors from 41 countries and 44,000 trade visitors.

Projects from the four research markets: energy industry, automotive technology and mobility, aerospace and microelectronics were presented by Fraunhofer ILT in hall A3.

Laser World of Photonics, World of Quantum and automatica 2025

Our researchers presented Fraunhofer ILT as an innovative and highly capable partner for digitally integrated, future-oriented photonics solutions.

Across seven exhibition stands, the institute showcased its latest R&D results. Key topics included AI in photonics, high-energy lasers for fusion, integrated sensor technology, lasers for climate research, laser-based optics manufacturing, quantum communication, and medical technology.

AI drives the manufacturing of the future

At the special exhibition "Photonics Meets Robotics: AI Success Stories," Fraunhofer ILT demonstrated how artificial intelligence can automate laser-based manufacturing processes. The institute focused on data-driven process models that use sensor data to monitor processes, detect defects, and ultimately enable autonomous process control, in order to achieve first-time-right production. Highlights included an autonomous mobile repair robot for laser metal deposition and an articulated-arm robot for VR-assisted laser welding. Both exhibits illustrated the close integration of metrology, data analysis, and AI-supported decision-making.

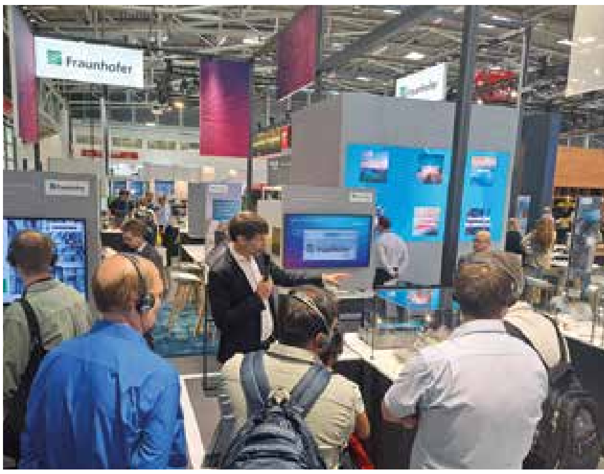
Laser-based manufacturing of optical components

Another focal point was the fully laser-based production of optical components. By shaping components in a single setup, manufacturers can prevent centering errors and reduce scrap. Final surface finishing is carried out using CO_2-laser polishing and form correction. The process is independent of component geometry, which also makes it therefore suitable for aspheres and freeform optics as well. It is particularly attractive for the flexible production of small batch sizes and even one-off components.

High-energy lasers for fusion and secondary radiation sources

A third pillar of the exhibition focused on the development of high-energy lasers for fusion research and secondary radiation sources. Working together with industrial and research partners, Fraunhofer ILT is helping establish the corresponding supply chains. One example is the DIOHELIOS project, which is developing robust, scalable quasi-continuous-wave (QCW) diode-laser modules capable of producing highly uniform beam distributions over large areas. The institute also presented designs for compact EUV and neutron sources for applications such as non-destructive testing.

https://s.fhg.de/KdV7



Well attended: Fraunhofer ILT at the Fraunhofer-Gesellschaft joint exhibition stand in Munich.

Special exhibit of Fraunhofer ILT at Laser 2025: "Team Sonnenwagen" solar racing car of RWTH Aachen University and FH Aachen, © Messe München.

Trade Fairs 2025

Fraunhofer ILT is regularly represented with current research topics at trade fairs in Germany and abroad.

- **SPIE Photonics West**
  25.1.–30.1.2025 | San Francisco
- **Hannover Messe**
  31.3.–4.4.2025 | Hanover
- **The Battery Show Europe**
  3.6.–5.6.2025 | Stuttgart
- **Laser World of Photonics, World of Quantum, automatica**
  24.6.–27.6.2025 | Munich
- **Hydrogen Technology Expo Europe**
  21.10.–23.10.2025 | Hamburg
- **Compamed**
  17.11.–20.11.2025 | Düsseldorf
- **Medica**
  17.11.–20.11.2025 | Düsseldorf
- **Formnext**
  18.11.–21.11.2025 | Frankfurt / Main

Further information to our conferences and trade fairs

https://s.fhg.de/h6t

1 Conference "AI in Photonics" in Berlin, © SPECTARIS.
2 Dr. Alexander Olowinsky at LSE'25 in Aachen.

Conferences 2025

In 2025, Fraunhofer ILT once again organized a lot of international conferences with speakers from industry and research on current topics. The institute focuses on the exchange between technology suppliers and customers as well as the interface between research and industrial practice.

- **LSE'25 – Laser Symposium Electromobility**
  28.1.–29.1.2025 | Fraunhofer ILT, Aachen
  https://s.fhg.de/87L

- **7. ICTM Conference**
  12.3.–13.3.2025 | Eurogress, Aachen
  Organization: Fraunhofer ILT and IPT
  https://www.ictm-aachen.com/en/Conference.html

- **8. UKP Workshop Ultrafast Laser Technology**
  8.4.–9.4.2025 | DAS LIEBIG, Aachen
  https://www.ultrakurzpulslaser.de/en/ukp-workshop.html

- **KI in der Photonik – Mehr Wertschöpfung in Laserfertigungstechnik & Optikdesign**
  1.10.–2.10.2025 | Karl-Storz-Schulungszentrum, Berlin
  Organization: Spectaris in cooperation with Fraunhofer ILT and Bundesverband IT-Mittelstand e.V.
  https://s.fhg.de/M8xU

45
Bachelor theses

43
Master theses

20
Patents worldwide

6
Patent applications

112
Scientific publications

6
Dissertations

Patents 2025

Patents Germany

- **102022134350**
  Herstellung von Quarzglasbauteilen mit optimierter Oberflächentopografie
- **102015122300**
  Spiegel zur Reflexion von EUV-Strahlung in Strahlung im Spektralbereich zwischen 6 nm und 10 nm und optische Anordnung mit dem Spiegel
- **102023116881**
  Stereotaktische Vorrichtung zum Schneiden von Hartgewebe am Schädelknochen mit energetischer Strahlung
- **102024125476**
  Verfahren und Anlage zur Herstellung funktionell hochwertiger elektrisch leitfähiger Schichten
- **102024110083**
  Verfahren und Vorrichtung zur Formkorrektur eines optischen Bauelements mittels Laserstrahlung
- **102015010369**
  Verfahren zum Abtragen von sprödhartem Material
- **102023116866**
  Verfahren zur Frequenzstabilisierung eines gütegeschalteten schmalbandigen Lasers

Patents Europe

- **EP4383002**
  Optische Baugruppe für ein dynamisches 2D optisches Tweezer-Array mit mikrosekunden-zeitaufgelöster Positions- und Amplitudenkontrolle

Dissertations 2025

- **25.3.2025 – Christian Knaak (Dr.-Ing.)**
  Echtzeitüberwachung und -optimierung der Nahtqualität beim Laserstrahlschweißen mittels bildgebender Sensorik und künstlicher Intelligenz
- **5.5.2025 – Jörg Hofmann (Dr.-Ing.)**
  Kompensation thermischer Linseneffekte in optischen Systemen für die Lasermaterialbearbeitung
- **14.5.2025 – Thilo Alexander Barthels (Dr.-Ing.)**
  Prozessführung bei stark parallelisierten UKP-Bearbeitungsprozessen für Metallfolien
- **28.5.2025 – Manuel Jung (Dr.-Ing.)**
  Einfluss des Temperatur-Zeit-Verlaufs auf Formtreue und Welligkeit bei der Laserpolitur von Glas
- **8.10.2025 – Woo-Sik Chung (Dr.-Ing.)**
  Increase of Joint Area by Gap-bridging Laser Beam Welding on Metalized Substrates
- **8.10.2025 – Max Fabian Steiner (Dr.-Ing.)**
  Entwicklung und experimentelle Untersuchungen des koaxialen Laser-Lichtbogen-Hybridschweißens als additives Verfahren

Scientific publications and lectures

You will find a list of Fraunhofer ILT’s scientific publications and lectures in our media center on our website:

www.ilt.fraunhofer.de/en/media-center.html

Funding Bodies

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Ministerium für Wirtschaft, Industrie, Klimaschutz und Energie des Landes Nordrhein-Westfalen

Ministerium für Kultur und Wissenschaft des Landes Nordrhein-Westfalen

DFG Deutsche Forschungsgemeinschaft

esa European Space Agency

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