

Thursday April 23, 2026 | 4:30 p.m. to 7:30 p.m.

Laser Technology Live Presentations at:

- Fraunhofer ILT
- Industry Building DPP
- Research Center DPP

Live

Welcome to Laser Technology Live!

Join us on Thursday, April 23, 2026 at Campus Melaten in Aachen for an exciting journey to the latest in Laser Technology! Visit Laser Technology Live from 4:30 p.m. to 7:30 p.m.. Our scientists are looking forward to presenting their latest research and development results during over 50 live demonstrations in our application labs as part of the AKL'26 – International Laser Technology Congress.

Prepare to immerse yourself in a variety of topics. From Additive Manufacturing to Laser Beam Sources, Quantum Technology, Laser Technology for Fusion, Digitalization and AI, Surface Technology, Medical Technology, EUV and Plasma Technology, Joining, Cutting, and much more.

Don't miss the opportunity to visit the Application Center with the Battery and Hydrogen Lab. Meet our experts and discover the future of Laser Technology firsthand!

Shuttle Transfer on April 23, 2026

Eurogress – Fraunhofer ILT

4:05 p.m., 4:10 p.m., 4:15 p.m., 4:55 p.m.,
5:00 p.m., 5:05 p.m.

Fraunhofer ILT – Eurogress

5:30 p.m., 6:20 p.m., 6:25 p.m., 7:20 p.m., 7:25 p.m.,
7:35 p.m., 8:10 p.m., 8:20 p.m., 8:25 p.m.

Fraunhofer ILT – Research Center DPP

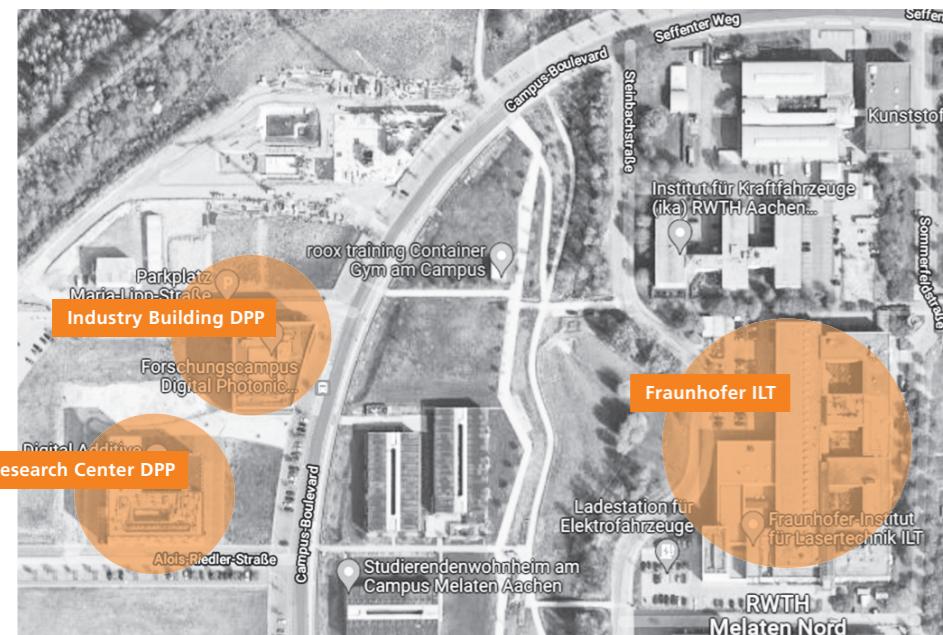
Between 5:20 p.m. to 7:20 p.m. (frequently)

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Presentations – Laser Technology Live



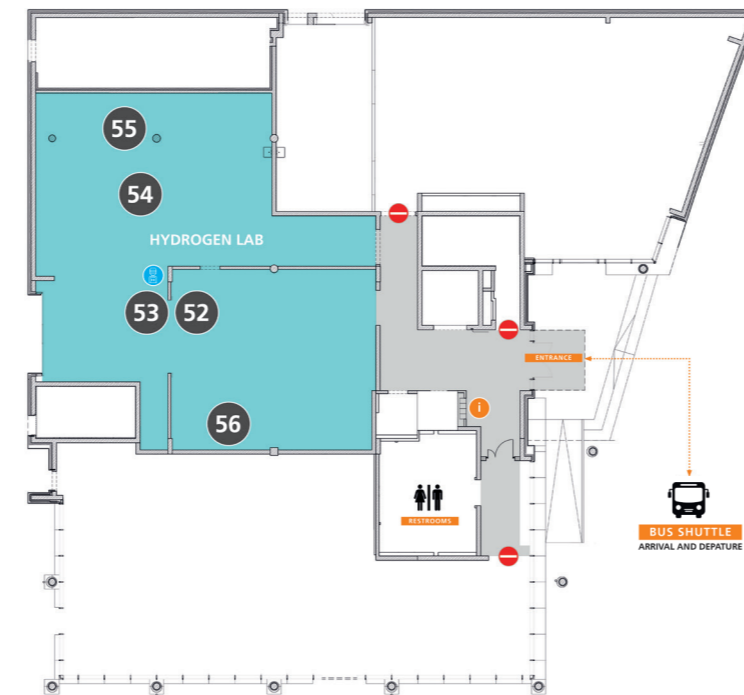
BOOTHS BY TOPICS

Central Information	Surface Technology	Cutting	Digitalization and AI
Special Exhibits	Additive Manufacturing	Joining	Quantum Technology
Point of Information	Medical Technology	Lasers	Battery Lab
Water Dispenser	EUV Technology	Optical Systems	Hydrogen Lab
		Laser Technology for Fusion	

BOOTH PLAN

Industry Building DPP

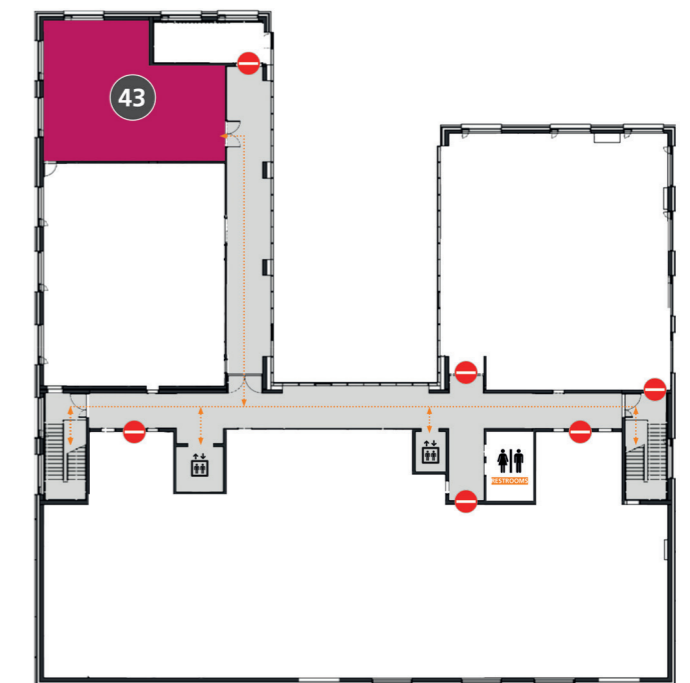
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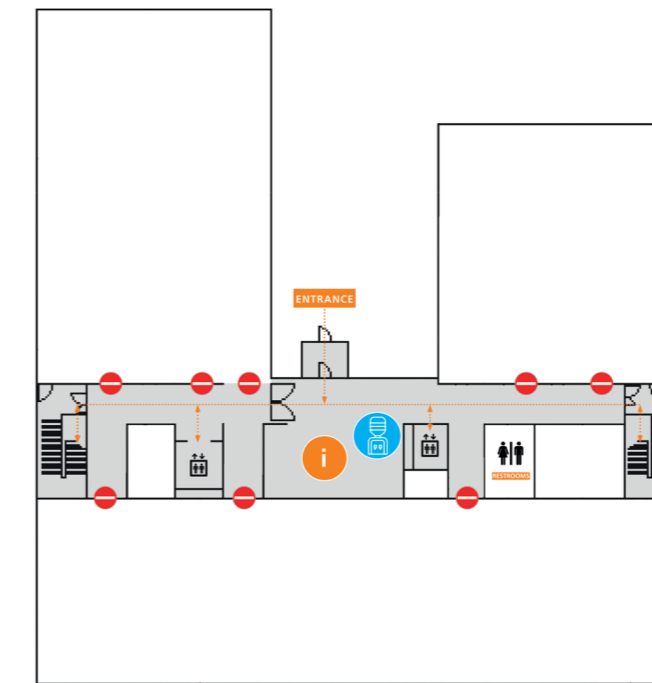
BOOTH PLAN

Research Center DPP

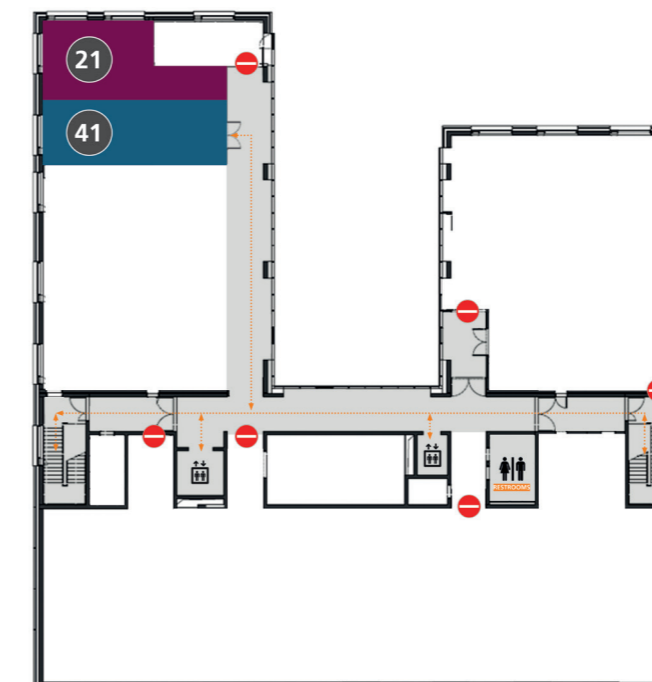
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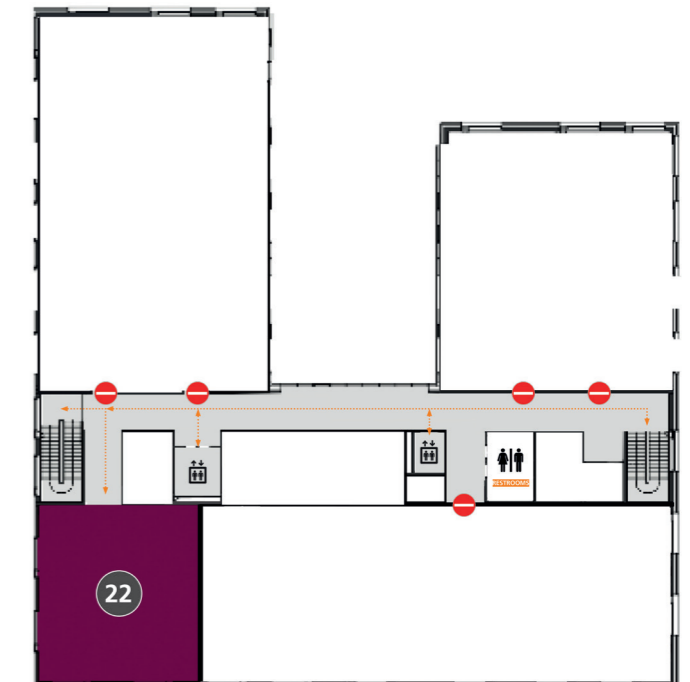
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2ND FLOOR



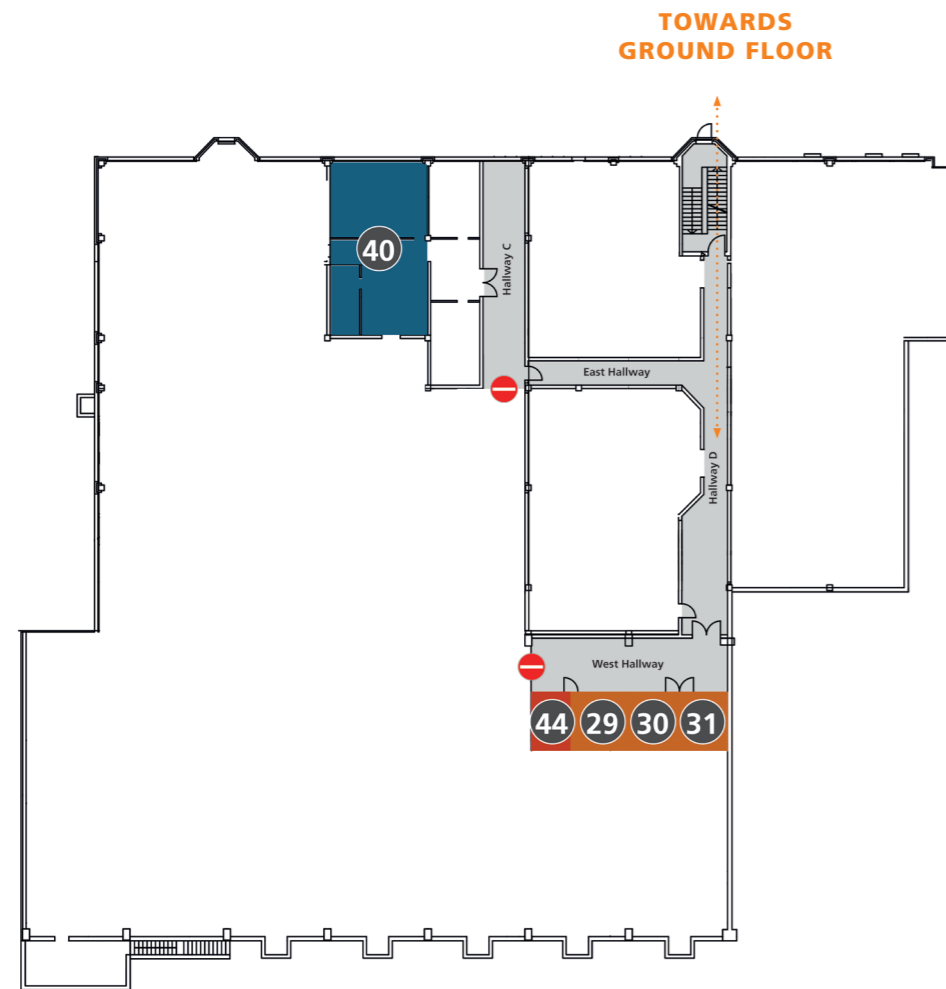
3RD FLOOR



BOOTH PLAN

Fraunhofer ILT

BASEMENT



GROUND FLOOR



BOOTHS BY TOPICS

- | | | | |
|---|---|--|--|
| ■ Central Information | ■ Surface Technology | ■ Cutting | ■ Digitalization and AI |
| ■ Special Exhibits | ■ Additive Manufacturing | ■ Joining | ■ Quantum Technology |
| ■ Point of Information | ■ Medical Technology | ■ Lasers | ■ Battery Lab |
| ■ Water Dispenser | ■ EUV Technology | ■ Optical Systems | ■ Hydrogen Lab |
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Entrance

Fraunhofer Institute for Laser Technology ILT

With approximately 490 employees, more than 19,500 m² net floor space and more than 40 spin-offs, the Fraunhofer Institute for Laser Technology ILT is one of the world's most important contract research and development institutes in the fields of laser development and laser applications for over 40 years. Our core competencies include the development of new laser beam sources and components, laser measurement and testing technology, and laser manufacturing technology. This includes cutting, ablation, drilling, welding and soldering as well as surface finishing, micro manufacturing and additive manufacturing, among others. The areas of application for laser beam sources and processes include production and metrology, energy and mobility, medical and environmental technology, quantum and fusion technology. Together with excellent partners from German and international research and industry, we develop, for example, satellite-based measurement systems for climate research or frequency converters for a fiber-based quantum internet. Cross-sectionally, Fraunhofer ILT addresses issues of digitalization in photonics and production technology, process monitoring and control, simulation and modeling, AI in laser technology, and the entire field of system technology.

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Entrance

Arbeitskreis Lasertechnik e.V.

Arbeitskreis Lasertechnik e.V. is a registered non-profit association formed in 1990 by a group of companies and private individuals aiming to pool their experience and conduct joint public-relations activities to spread the use of laser technology in industry and promote the sharing of scientific ideas. The "Innovation Award Laser Technology" aims to reward excellent achievements in applied research and outstanding innovation in the field of laser technology and to shine a spotlight on their authors. In 2026, about 200 laser experts and enthusiasts were signed up as active members of the AKL network. The association's activities include disseminating information on innovations in laser technology, organizing conferences and seminars, compiling educational material dealing with laser technology, stimulating the interest of future young scientists, and providing advice to industry and research scientists on questions relating to laser technology.

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Entrance

Women in 3D Printing Aachen Chapter

Women in 3D Printing Aachen Chapter is part of the global Women in 3D Printing network, connecting professionals, researchers, students, and enthusiasts in Additive Manufacturing. With strong ties to Aachen, we create a platform for exchange, visibility, and collaboration across industry, research, and academia. Our chapter organizes networking events, company visits, and community meetups to strengthen diversity and innovation in additive manufacturing. We welcome people of all genders, ethnicities, and backgrounds who are interested in advancing AM together.

Join us to connect, collaborate, and shape the future of Additive Manufacturing.

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Entrance

Planar galvanometer scanner for fast, precise, parallel laser processing with a minimal footprint

With the planar galvanometer scanner (PGS), new performance benchmarks for laser material processing are within reach. The 2D beam-steering system is faster and significantly more compact than today's galvanometer scanners. Depending on the design target, PGS either requires about 90 percent less installation space while weighing only one tenth of current galvanometer scanners with the same aperture size, or it fits into the same volume as a conventional 2D scanner while offering almost three times larger aperture, resulting in improved power handling and reduced spot size. In addition, the PGS achieves at least 50 percent higher acceleration than standard galvanometer scanners, helping to reduce processing times. Its compact, lightweight and highly dynamic design makes the PGS particularly suited for parallelized material processing with high-power lasers and multiple scan heads in very compact systems.

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Entrance

Scalable LPBF machine concept for Additive Manufacturing of large components

Laser Powder Bed Fusion (LPBF) is becoming increasingly important in industrial production. One of the decisive factors is the scalability of the build volume. For large build areas, established shielding gas flow concepts are no longer effective. Therefore, current research focuses on machine concepts with movable processing heads with a local shielding system, which ensures a constant stream of inert gas at every processing position for build volumes of any size. Following this approach, it is easier than before to adapt the build volume to the respective application since there is no need to adjust the shielding gas system or the optical system. Based on this concept, a new LPBF laboratory system with an effective utilizable build volume of 1,000 mm x 800 mm x 350 mm was built. In order to increase the machine's productivity, the processing head is equipped with five laser-scanner-modules. This system was investigated within the Fraunhofer lighthouse project "FutureAM." Recent technological advancements and current developments are showcased at Booth 9 (E100.C13).

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E100.A11.2

EHLA3D – Extreme High-Speed Laser Material Deposition for Additive Manufacturing

The use of Extreme High-Speed Laser Material Deposition (EHLA 3D) for Additive Manufacturing offers numerous advantages over conventional laser deposition processes, such as significantly higher precision and resolution of manufactured structures and shapes while maintaining high deposition rates. By tailoring the process, the heat input into the base material and filler metal, as well as the cooling rates, can be precisely controlled. As a result, alloys that are considered impossible or difficult to weld with conventional LMD processes can be processed without defects. These include nickel-based superalloys as well as aluminum- and iron-based materials. The highly dynamic tripod system specially designed for EHLA3D processes was developed by ponticon GmbH in close collaboration with Fraunhofer ILT. The machine concept allows EHLA feed rates of up to 200 m/min which can be used to adjust the cooling rates for improved material processability.

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E100.A12

Coaxial wire-based Laser Material Deposition (LMD)

For certain applications, using wire feed instead of powder as the additive material in Laser Material Deposition (LMD) offers significant advantages. Key challenges associated with powder-based processes can be avoided, including contamination of the process chamber with metal powder, considerable material losses during processing, and build-defects caused by insufficient powder quality. A defining feature of the showcased LMD head is its continuous annular laser beam. The laser beam and the wire are arranged coaxially, allowing the welding process to operate independently of the feed direction. Combined with a very high level of material utilization, this enables the efficient and precise buildup of complex geometries. Additional integrated sensors can also be used for process monitoring and control.

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E.100.C12.2

Laser Powder Bed Fusion (LPBF) of tungsten-copper multi-material components

Additive Manufacturing enables freedom in design for function-driven components. Copper offers high thermal conductivity, while tungsten presents an exceptionally high melting point, making them valuable functional engineering materials. The combination of both unlocks unused potential to manage high process heat in applications such as rocket combustion chambers and fusion reactors, and to improve heat transfer interfaces. The challenge lies in developing robust LPBF process conditions to achieve the right properties – electrical/thermal conductivity, mechanical strength and material thickness.

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E.100.C12.2

Laser Powder Bed Fusion (LPBF) of functionally-graded porous structures

Laser Powder Bed Fusion (LPBF) is a highly complex process and is well known for unwanted pore formation inside the printed part caused by the process itself. While the traditional focus has been on achieving maximum density, we deliberately introduce local porosity as a functional feature. By adjusting process parameters, zones with different densities can be created within a single part, either sharply separated or gradually graded. This enables fully metallic components that are locally permeable to gases or liquids while maintaining mechanical integrity. A key application area is hydrogen technology, particularly electrolyzers with complex cell stacks and multiple functional layers. At Fraunhofer ILT, we are investigating whether these layers can be additively manufactured directly, including defined permeable regions.

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Laser-based Additive Manufacturing of polymers

At this station, current research activities and results in laser-based Additive Manufacturing of polymers are presented. The focus is on Selective Laser Sintering (SLS) of novel and smart materials. It is demonstrated how part properties, such as hardness, can be adjusted and varied locally via process- and laser parameter variation. In addition, 4D printing is presented using a thermoresponsive material, in which a defined shape change can be triggered by heat. Complementary work on multi-photon polymerization (MPP) is also being conducted at Fraunhofer ILT. With this micro Additive Manufacturing approach, targets for inertial fusion energy with features in the sub- μm range are intended to be realized.

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Approaches for high-productive, high-power Laser Powder Bed Fusion (LPBF) – Beam shaping and fastlight

A significant challenge for Laser Powder Bed Fusion (LPBF) of metals lies in transferring laser power into build rate efficiently. The current state of the art of the process relies heavily on focused, rarely defocused Gaussian beams, which limit the use of laser power due to their tendency to overheat locally. Higher build rates are therefore achieved by costly parallelizing the low-power process. However, by adjusting the intensity distribution of the laser beam, the geometry and dynamics of the melt pool can be effectively adapted to achieve higher process efficiency and build rates per individual laser beam. Another effective approach to control melt pool dynamics is the usage of pulsed laser power, which reduces productivity due to pulse pauses. In present work, this is overcome by rapid deflection of a continuous power beam to obtain a continuous power pulsed process.

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Laser Powder Bed Fusion (LPBF) of large, conformally-cooled HPDC tool inserts for mega-/giga-casting

Fraunhofer ILT's gantry-based multi-scanner Laser Powder Bed Fusion (LPBF) machine will be shown. The machine is developed to manufacture components of very large cross-sections up to 1 m² and is further scalable in build volume. Recently, the system demonstrated the feasibility of manufacturing large, high-volume tool inserts (> 20,000 cm³) for aluminum high-pressure die casting (HPDC) from tool steel. The inserts benefit from conformal cooling with complex, contour-following channels that can only be realized by Additive Manufacturing. During the Laser Technology Live presentation, the machine and a demonstrator of the HPDC tool insert can be viewed. The approach to realize the high-volume component will be demonstrated to the visitor.

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Additive Manufacturing of a rocket nozzle on a robot with Laser Material Deposition (LMD)

Laser Material Deposition (LMD) is an Additive Manufacturing process in which powder feedstock is delivered through a nozzle and melted by a laser to create a controlled melt pool. The material solidifies to form free-form coatings or 3D components. LMD offers high material utilization (60–90 %), deposition rates of several kilograms per hour, strong design flexibility, and fewer manufacturing steps for near-net-shape large components. It is well suited for rocket nozzle production, reducing cost and lead time while ensuring structural integrity under extreme thermal and mechanical loads. A 1.4 m diameter, 0.8 m high lower-cone nozzle demonstrator can be completed in about 15 days at ~2 kg/h, with real-time optical coherence tomography for process monitoring.

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E100.B05

Advanced high-speed laser cutting: Tailored solutions for challenging industrial applications

As conventional cutting methods often reach their limits regarding speed, quality or flexibility, laser solutions are becoming increasingly important in large-scale manufacturing. The exhibit features a versatile R&D platform for developing highly productive and robust high-speed cutting processes. Applications range from notching of battery foils and cutting hydrogen components, such as BPPs and PTLs, to laser blanking in high quality – burr free and with clean surfaces. Key features include highly dynamic actuators (5 m/s, 5 g), an integrated auxiliary axis for simulating on-the-fly processes, and a sophisticated multispectral process monitoring system. This advanced monitoring, coupled with integrated ML functionality, ensures unparalleled process stability, pushing the boundaries of high-speed laser processing and highlighting its advantages over mechanical processing.

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E100.C02

50 kW ultra-high power laser cutting

Ultra-high power fiber lasers enable very fast, high-quality cutting and significantly extend the cutting thickness range. High cutting speeds reduce assist-gas consumption, heat-conduction losses, and piercing time – thus lowering cost per part. On display is a new 50 kW fiber laser installation for process development on metals and non-metallic materials such as concrete and ceramics, with a planned expansion beyond 100 kW. High-power-optimized process parameters and nozzle design help to control plasma formation, melt flow, and melt ejection for stable cutting. The setup supports scaling studies as power levels move from 50 kW toward the > 100 kW range. Key topics include plasma-resilient assist-gas flow, beam shaping, employing modulated power and piercing strategies.

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E100.A06

Hybrid joining of polymer and metal

Lightweight components are made from different materials for cost and stability reasons, utilizing each material's load-bearing properties. To join these materials, a technology is required that connects dissimilar materials securely in short process times. First, high speed laser microstructuring creates undercuts on the metal surface that facilitate joining. In the subsequent laser-based joining process, the polymer is selectively melted at the joint, allowing it to clamp onto the pre-structured metal. Thanks to a load-optimized dimension of the direction, form and number of structures, a large bandwidth of possible hybrid connecting structures for a multitude of material combinations results. In combination with mechanical separation, laser processing enables recycling options for a sustainable use of materials and a complete separation by type.

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E100.A07

Laser-based joining of glass and glass metal systems

Laser-based low-temperature glass frit bonding is used for durable encapsulation in industrial applications. Conventional frit bonding is carried out in a furnace at peak temperatures of up to 500 °C, which is often unsuitable for temperature-sensitive components. With laser-based glass frit bonding, the energy is spatially limited to the bonding area, as the glass frit is melted by absorption of the laser radiation in the frit itself. This keeps the thermal load on the surrounding area low. The process is particularly suitable for hermetic feedthroughs and housings in electrical engineering and electronics. Alternatively, ultra-short pulse lasers can also be used for joining, but this places significantly higher demands on surface quality, making this process suitable for encapsulation at the wafer level.

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E100.C02

50 kW ultra-high power laser welding for thick materials

Fraunhofer ILT pushes the boundaries of material processing through the use of our new ultra-high-power laser system. The power density achieved with 50 kW of continuous-wave laser power and a 100 µm fiber-core diameter enables welding of significantly thicker materials than before, supporting applications, e.g. in offshore wind energy or heavy-duty construction machinery. The new setup also enables research on ultra-fast welding for reduced heat-affected zones and higher productivity. Our portal robot system allows big parts to be processed in 3D with consistent precision.

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E100.B07

Digitalization and AI in Photonic Production

In this smart laser welding cell, AI-based quality assurance, multimodal process sensing, digital twins and augmented reality assistance are combined. Inline cameras, 3D sensors and HDR imaging continuously capture the weld pool and filler wire and stream synchronized data to a scalable data infrastructure. Deep-learning models based on Vision Transformers segment wire position, weld pool and seam geometry, then fuse the sensor data, detect pores and geometric defects with up to 99 percent accuracy, all in real time. Intelligent data reduction automatically extracts relevant sequences into compact error cases and links them with process parameters. These are shared with remote experts via AR-enabled devices, enabling rapid root-cause analysis, guided parameter optimization and easy transfer to other laser and joining processes.

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E310

Make the invisible visible: Synchrotron insights into dynamically modulated laser processing

The use of Synchrotron radiation enables in situ investigation of laser beam processes with high temporal and spatial resolution, providing insights into fundamental phenomena. A mobile setup allows the modular change between laser beam sources of different type and wavelength and optical systems to carry out laser beam welding, cutting, or drilling experiments at the German Electron Synchrotron in Hamburg. Synchronized process control with optical and acoustic sensors is used to develop algorithms for process evaluation. For efficient execution of the experiments, sample handling and data acquisition is fully automated. Since 2026 a high-power flexible laser with 14 kW and coherent beam combining has been part of the portfolio. Temporal and spatial shaping of the beam offer new possibilities in welding applications and tailoring material properties.

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E100.C10

Automated parameter development for coating, repair and AM with Laser Material Deposition (LMD)

Laser Material Deposition (LMD) is an advanced manufacturing technology that enables the deposition of metallic coatings at high productivity and high precision. Compared to conventional methods, LMD offers significant advantages in terms of efficiency, coating quality, and material savings. However, realizing these benefits requires meticulous control and optimization of numerous interdependent process parameters, many of which are nonlinearly coupled. The lack of a reliable, predictive process model further complicates model-based optimization approaches. To address these challenges, Bayesian Optimization (BO) is applied to systematically tune LMD process parameters. BO leverages probabilistic models, trained on experimental data, to efficiently explore the parameter space and predict optimal settings based on past outcomes. To improve efficiency and reduce the number of required experiments, physical simulations are used in advance to narrow down the feasible parameter space, thereby guiding the optimization process toward promising regions.

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Diffraction Neural Networks (DNNs) for beam shaping

Diffraction Neural Networks (DNNs) are a method for treating a system of Cascaded Diffraction Optical Elements (DOEs) or Spatial Light Modulators (SLMs) as artificial neural networks. Here, light acts as information and phase masks emulate layers. These networks can be trained in a computer for fulfilling complex beam shaping tasks like three-dimensional intensity distributions or simultaneous optimization of amplitude and phase. Additionally, by training DNNs with random variations in alignment, these systems gain increased robustness against misalignment and/or variations in the input beam. We showcase here our DNN test bench with live presentations of the beam shaping capabilities of cascaded SLMs and other novel advances of this method.

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LABRADOR – Intelligent and environmentally friendly weeding

In the LABRADOR project, we are developing an environmentally friendly, AI-driven weed control robot based on laser diodes. The robot utilizes a camera-based model for precise plant identification and targets unwanted weeds selectively with its laser system. By employing an array of laser diodes, the system focuses energy exactly on detected weed positions, enabling efficient and sustainable elimination of invasive plants without the use of chemicals, thus preserving both crops and the environment.

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Cloud-based microservices and Bayesian optimization for autonomous machining

This software solution connects cloud based microservices with an industrial USP laser ablation system and integrates machine learning, databases, and adaptive feedback directly into the machining process. The distributed architecture runs across multiple computing nodes inside an HPC to ensure scalable and efficient resource allocation. A closed loop Bayesian optimization routine autonomously determines optimal process parameters. Surface roughness and ablation efficiency are measured inside the machine and continuously fed back into the optimization loop. In addition, an on-demand beam shaping module based on diffraction neural networks computes the required SLM phase mask during operation, enabling dynamic beam profile adaptation and flexible generation of arbitrary beam shapes within the same control framework.

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Digital Photonics for next generation laser material processing

Laser technology has evolved from a specialized tool to a widely used resource, driven by the decreasing cost and increasing availability of laser beam sources. This development requires new, cost-efficient and scalable system technologies tailored specifically to laser applications. Digital Photonics addresses this need through an integrated development approach focused on affordable, highly productive, modular, and scalable system solutions. Innovations include mobile and low-cost robotics for flexible scalability, advanced optical systems such as cascaded beam concepts, and speckle-based sensors to enhance accuracy. In addition, the software architecture of laser systems must be redesigned for greater flexibility, using microservices and publisher-subscriber structures. This enables data-driven applications, including AI-based and Bayesian optimization of process parameters.

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E316

MERLIN – Robust and reliable laser source for spaceborne methane sensing

In the frame of the Franco-German climate mission MERLIN, which is dedicated to measuring the space-resolved methane concentration in the earth's atmosphere from a satellite, Fraunhofer ILT is building the laser source for the instrument. The laser itself consists of a frequency-stabilized oscillator, a highly efficient Innoslab amplifier, and a subsequent frequency-stabilized optical parametrical oscillator (OPO). The output is a narrow-bandwidth pulse at one of methane's absorption lines, allowing for an optical measurement of the methane concentration. A major challenge is the necessary robustness of the laser source with respect to environmental conditions in space. These comprise a non-operational temperature range of -25 to +50 °C, vibrational and shock loads. To fulfill these requirements, Fraunhofer ILT has developed a soldering technique for the mounting of optics. That allows for a "set and forget" approach, resulting in an unmatched stability of optical mounts with respect to their initial alignment.

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Compact and efficient alexandrite laser in the UV for an autonomous atmospheric LiDAR network

Due to the increasing impact of anthropogenic emissions on the climate, the importance of understanding and monitoring atmospheric processes is growing. Mobile resonance LiDAR systems measure wind and temperature profiles up to 120 km altitude. Several systems with overlapping observation areas form a network with unrivaled spatial resolution and coverage. The systems must be robust, compact, transportable, autonomous and low-maintenance. Continuous development over more than ten years, starting with a feasibility study, led to six alexandrite-laser prototypes successfully demonstrated in field campaigns. The use of adapted UV wavelengths drastically reduces solar background and enables daylight measurements without loss of resolution. An optimized frequency-doubling design ensures high efficiency (2 percent el-opt) and narrow linewidth. The systems are currently deployed across Europe in polar, alpine, Mediterranean and near-equatorial environments from sea to mountain level.

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Laser technology for future spaceborne earth-observation LiDAR missions

Future spaceborne LiDAR missions require high-energy, highly reliable laser transmitters at dedicated wavelengths to improve wind measurements, weather forecasts, and greenhouse-gas detection. For ESA's QLEO mission, a differential-absorption LiDAR with four distinct wavelengths near 935 nm is used for precise H₂O profiling. The emission wavelength is tuned shot to shot, each with 70 mJ pulse energy. As a technology demonstrator, a frequency converter bread board is pumped by an INNOSLAB based high-energy laser, which was developed within the framework of the Aeolus-2 program. To dissipate the residual heat, the laser is equipped with a lightweight and scalable thermal control system based on CuH₂O heat pipes. This engineering model enables > 400 mJ pulse energy at 1064 nm with repetition rates > 100 Hz. With a subsequent SHG and OPO/OPA frequency conversion unit, the target wavelengths are generated.

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E103.1

Narrow linewidth, linearly polarized lasers for ultra-high precision metrology

Lasers with narrow linewidth and high power-stability are a key technology for many applications in the fields of ultra-high precision metrology or quantum technology. In particular, next-generation gravitational wave detectors such as the Einstein Telescope or the Laser Interferometer Space Antenna (LISA) impose highest demands on the laser beam source. To meet such requirements, Fraunhofer ILT develops both fiber-based and solid-state laser systems. For example, the following lasers are being developed:

- Holmium- and thulium-doped fiber amplifiers with narrow linewidth and linear polarization with > 25 W (2090 nm) and > 100 W (1950 nm) output power
- Ho:YAG NPROs at 2090 nm and 2122 nm wavelength with narrow linewidth
- Neodymium-doped fiber amplifiers for wavelengths around 922 nm
- Ytterbium-doped fiber amplifiers with narrow linewidth, linear polarization and highest power stability

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Optical system for Laser Diode Floating Zone (LDFZ) crystal growth of high-purity optical isolators

The LDFZ method is a crucible-free technique for growing monocrystalline materials of high purity. In this process, a ceramic feed rod is irradiated and remelted by diode laser radiation within a defined area, the floating zone. From the molten phase, a single crystal is grown. Fraunhofer ILT develops optical systems to precisely shape multi-kW diode laser radiation such that an intensity profile is created which is ideally suited to the process. This enables defined heating and melting of the feed rod, allowing for the growth of high-purity single crystals. In the BMFTR-funded project HiPEQ, a system capable of 12 kW laser power was designed and set up to grow optical crystals based on terbium oxide, a material that is considered a promising candidate for the next generation of Faraday isolators. Last year, the first isolator crystals were successfully grown using the new LDFZ system.

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Rugged and reliable optomechanical systems for space applications and comparable extreme environments

Many laser applications require reliable long-term operation of the laser source under harsh environmental conditions. This means that the laser system must be able to withstand temperature cycles and mechanical loads. This applies in particular to space applications, but similar requirements also exist in industry. A space-qualified LiDAR instrument must operate maintenance-free for several years. To achieve this, it is essential to avoid using organic materials such as adhesives or plastics. In addition to the aforementioned mechanical stability and freedom from outgassing, soldering technology offers the possibility of readjusting components by remelting the solder joint. Soldered solutions have been developed for mirrors, lenses, laser crystals and crystals for Faraday isolators, Pockels cells as well as frequency converters. All components have been qualified by various testing procedures.

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Laser-based optics manufacturing – SLE, polishing and precision form correction

Manufacturing of optics made from glass requires multi-step process chains consisting of form generation, polishing and, depending on the application and requirements, a precision form correction. All these process steps can be performed laser-based. Selective laser-induced etching SLE, precision glass ablation, laser polishing and laser beam figuring (LBF) will be shown. Laser-based optics manufacturing can lead to improved processing speeds and reduced costs, especially for aspherical and freeform optics. For example, laser-based form generation by SLE can process all lens surfaces (front, back, and edge cylinder) without reclamping, allowing for near perfect alignment of the optical axes. The processes are being developed for micro-optics, micro-lens arrays, and macro-optics, all with spherical as well as aspherical shape.

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Inverse Laser Drilling (ILD) for hollow structure fiber preform manufacturing

Inverse Laser Drilling (ILD) is a laser microstructuring technique to drill geometrical forms of high aspect ratio into dielectric materials like glass. The sample is placed on a vertically movable translation table with a polished surface facing upwards. The laser beam is focused through the top surface onto the bottom surface of the bulk. The beam is deflected by scanning mirrors in the horizontal plane; this way the desired form's first layer is ablated. By moving the translation table and ablating layers step by step the entire geometrical form can be ablated or "drilled." ILD is ideal for the automated production of hollow-structure fiber preforms. Due to its geometric freedom, ILD enables the production of fibers with special designs that cannot be manufactured by conventional methods. Several ILD manufactured preform prototypes have been drawn and the fibers characterized.

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U102

Examples of semi-automated optical design for rapid manufacturing using laser-based optics manufacturing

Traditional production of customized optics takes weeks to months, creating bottlenecks for R&D projects. The Fraunhofer OPTICS48 consortium is developing a digitalized, laser-based process chain producing customized optics within 48 hours from design to finished component (booth 28). A key challenge is the optical design process, characterized by high-dimensional parameter spaces, complex trade-offs between performance and manufacturability, and computationally intensive modeling, especially for freeform optics. Optical design has thus become a specialist domain with manual, time-consuming workflows. To achieve the 48-hour target, OPTICS48 employs semi-automated design environments integrating optimization algorithms and machine learning. These tools significantly accelerate the design phase and enable rapid iterations.

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E100.A14.1

Sensor integration into additive parts with Thz-based quality control

The Fraunhofer ILT's SMARTPART machine combines Additive Manufacturing with printed electronics. A Laser Powder Bed Fusion (LPBF) process builds metal parts and pauses to print sensors inside the part. The printed electronics process runs in the same machine without moving the part. A dispenser deposits an insulating layer, and an aerosol jet prints conductive elements which are then laser sintered. The sensor is encapsulated and contacted, and LPBF resumes finishing the part. Internal sensors enable better stress, temperature, and vibration modeling. We also present inline quality control and error correction for printed electronics using THz mapping for conductivity homogenization via laser re-sintering. An inline THz-scanner with real-time data at 10 kHz and 250 mm/s was developed. Reduction of THz-amplitude nonuniformity on silver layers from 10 to 2 percent has been shown in fast re-sintering.

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SCaRB – Simultaneous Coating and Roller Burnishing

The Simultaneous Coating and Roller Burnishing (SCaRB) process combines Extreme High-Speed Laser Material Deposition (EHLA) with roller burnishing to enhance surface and subsurface properties. As a hybrid approach, SCaRB increases productivity by integrating additive deposition and mechanical treatment in a single step. Residual heat from EHLA promotes plastic deformation, reducing roughness, increasing hardness, modifying microstructure, and transforming tensile stresses into beneficial compressive stresses. SCaRB enables efficient repair of high-strength components, such as aircraft landing gear, improving fatigue performance and restoring mechanical integrity.

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E100.C10

Novel Fluidic Powder Switch for resource efficient Laser Material Deposition (LMD) processes

The novel Fluidic Powder Switch developed by Fraunhofer ILT is an advanced solution for precise powder-flow control in demanding Laser Material Deposition (LMD) and Extreme High-speed Laser Material Deposition (EHLA) processes. It enables three key functions: rapid diversion of powder between the nozzle and a collection container, instant switching between two or more materials for multi-material deposition within a single track, and immediate adjustment between discrete powder mass-flows. Its novel functioning principle allows integration directly before or inside the nozzle, reducing latency linked to system inertia and enabling very fast response times. Because no mechanical components come into contact with powder material, the system offers high reliability and long-term durability. It eliminates powder waste in automated serial manufacturing, such as Euro7 brake disc coatings, and improves efficiency in complex repair and additive manufacturing applications.

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E100.C10

Hybrid EHLA-PEEK process for PFAS-free functional coatings replacing "forever chemicals"

Fraunhofer ILT is developing a laser-based hybrid process for producing PFAS-free functional coating on metallic components is being developed. The approach combines Extreme High-Speed Laser Material Deposition (EHLA) with a subsequent polymer coating using polyetheretherketone (PEEK). In the first step, a metallic functional layer is deposited by EHLA. Subsequently, PEEK powder is applied onto the hot surface and directly melted. By utilizing the residual process heat, a strongly adhering hybrid coating can be generated without the need for an additional furnace process. The resulting surface structure enables mechanical interlocking between the metallic and polymer layers and supports high adhesion strength. The process addresses applications requiring wear protection, friction reduction, or corrosion resistance and represents a scalable technology option for substituting PFAS-based coating systems.

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E034

Flexible laser-induced transfer of μ LEDs on wafer-scale

Although LCD and OLED technologies dominate the display market, they have limitations: LCDs need backlighting, while OLEDs suffer from image burn-in. These drawbacks have led to a shift towards μ LED displays, which can deliver high resolution and brightness, which are essential for applications such as AR/VR displays, next-generation automotive lighting or short-distance data transfer in AI data centers. The main manufacturing challenge for this technology is reliable mass transfer of μ LEDs from sapphire growth substrates to backplanes. Our solution uses backside UV-laser illumination and a MEMS-based spatial light modulator (SLM) for flexible multi-beam processing and individual beamlet deactivation at rates over 10 kHz. To ensure sub- μ m placement accuracy, the system uses multi-axis stages and sensors with resolutions up to 10 nm to enable precise alignment, rotation, and tip-tilt correction.

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Laser Induced Forward Transfer (LIFT) of functional films

Laser-Induced Forward Transfer (LIFT) is a digital, contactless printing process for structuring functional thin films with high spatial accuracy. A short laser pulse propels material from a donor layer onto a receiving substrate, enabling direct patterning without physical contact. For strain gauge sensors, LIFT allows controlled deposition of conductive and sensing films on rigid, flexible, or curved surfaces. The process prevents thermal and mechanical damage, supports fine feature sizes, and is compatible with sensitive materials. LIFT offers a scalable route to high-performance, customized sensor patterns for next-generation printed electronics.

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E110

Flexible multi beams with Spatial Light Modulator for SLE

SLE is a manufacturing process enabling the fabrication of 3D parts from transparent materials with unique geometrical freedom and high precision. The outer contour of the part is inscribed into the material using focused ultrashort pulsed (USP) laser radiation. The modified design is then exposed from the bulk material by wet chemical etching. In our laser micro-machining system, a Spatial Light Modulator (SLM) for flexible diffractive phase modulation is utilized. In this way, the beam shape in the focus is adjusted to increase productivity and/or enhance precision by correcting aberrations. The beam shape can be calculated by an Inverse Fourier Transform Algorithm with camera feedback, or with Diffractive Neural Networks (DNNs). We demonstrate a 2D multibeam approach for drilling through wafer holes to deliver higher average laser power, resulting in increased productivity.

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USP laser processing with 1 kW average power and up to 10 mJ pulse energy

USP laser processing is established in many industries for its capability to process almost every material with micrometer precision. But its high processing times compared with other technologies hinders USP laser processing from being utilized for more industrial processes. With the latest advances in available average power and pulse energy, Fraunhofer ILT explores strategies to scale up USP laser processes and reach production-capable productivity values. This is demonstrated in two setups:

- A polygon scanner with deflection speeds of up to 1,000 m/s. The available average power is temporally distributed with low pulse energies but with high repetition rates.
- The pulse energy of up to 10 mJ is spatially distributed with either up to 1000 beamlets which facilitate parallel processing or by spatially shaping the intensity distribution. The result is an "optical stamp."

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U120

Laser polishing of metals and scanner-based 3D processing

Machine tool, process and CAM-NC data chain for laser polishing of complexly shaped 3D parts are shown. Laser polishing of 3D parts is done with 5+3 axis machines, 5 mechanical axes for positioning the workpieces and having access to all sides of the parts, and a 3 axis laser scanner for highly dynamic and fast movement of the laser beam. A CAM-NC data chain allows easy programming of the machine in workpiece coordinates. Laser polishing can be used, e.g. for many different steels as well as titanium and nickel alloys. Fields of application are tool and mold making, medical engineering, tribology, and also special applications like deburring of sheet metal parts.

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CD2-206 | RCDPP

Optical stamping with flexible beam shaping for increased productivity of USP laser processing

Optical stamping has become a viable approach for scaling laser micromachining processes with the advent of high power ultrashort pulsed lasers and capable spatial light modulators (SLM). The intensity profile of an ultrashort pulsed laser is shaped into an "optical stamp" that matches the desired structure. Instead of scanning many single spots, the complete target geometry is ablated directly – in some applications even a single pulse is sufficient to ablate macroscopic geometries. This concept can boost productivity by a factor of up to 30. Using two SLMs enables 3D beam shaping: the intensity pattern can be engineered to vary along the propagation axis, allowing for ablation of, as instance, vertical – or even negatively tapered – side walls.

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E118

Integrated photonic devices for Quantum Technology

Quantum networks are a key technology and promise groundbreaking applications in fields like secure communication, distributed quantum computing, and future quantum sensing. To enable global implementation of such networks, long-range transmission of photonic qubits is a prerequisite. With qubit wavelengths in the visible or near-infrared, an optical interface for efficient quantum frequency conversion (QFC) is essential to utilize existing low-loss fiber infrastructure. Here we present a prototype of a new QFC approach, which demonstrates very high efficiency and ultra-low noise, achieving a significant SNR improvement over current state-of-the-art solutions. For the first time, this performance is realized in a compact, modular and highly integrated manner designed for scalability and cost-efficient manufacturing, which carries potential for future commercialization.

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Photonic Technologies for Quantum Networks

The invention of computers and the internet has fundamentally transformed our society and economy. Today, advances in quantum technologies – particularly quantum computing – promise a new paradigm shift beyond the limits of classical information processing. To fully exploit this potential, quantum systems must be interconnected in scalable quantum networks, enabling distributed quantum computing and secure communication. At Fraunhofer ILT and the Chair for Laser Technology LLT, RWTH Aachen University, we develop photonic technologies that form the backbone of such quantum networks. During the lab tour, we present key building blocks including low-noise quantum frequency conversion (QFC), an NV center-based quantum internet node as a spin-photon interface, and quantum photonic interconnects for linking quantum computers to optical channels as well as for precise photon manipulation.

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Prifusio – Optics for Inertial Fusion

The construction of IFE power plants is expected to require tens of thousands of large optical elements per plant. An optical element with a diameter of 300 mm, manufactured using state-of-the-art technology, costs several tens of thousands of euros. Therefore, disruptive solutions for the cost-efficient, large-scale production of precision optics are a prerequisite for the construction and economical operation of IFE power plants. In recent years, significant advances have been made in production speed and achievable dimensional accuracy of laser processes for optics manufacturing. These processes promise shorter production times (days instead of weeks or months), reduced costs, and higher damage thresholds (LIDT). Concurrently, there is potential for the first time to fully automate the production of medium and large precision optics made of glass.

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Additive Manufacturing of plasma-facing components for fusion reactors

In accordance with the pathway outlined by the BMBF toward a German fusion power plant by 2040, additive manufacturing is being further developed as a key enabling technology for nuclear fusion through the collaboration of leading research institutions, industrial enterprises, and small and medium-sized companies. Within the DURABLE consortium, the foundations for the future additive manufacturing of plasma-facing components for fusion reactors are being established, while the timely industrial implementation of the developed solutions is being actively advanced. In this way, new design possibilities for plasma-facing components involving previously challenging material combinations will become feasible, thereby providing engineers and designers with an entirely new solution space for addressing the principal failure mechanisms of such components. At the same time, the solutions developed within this collaborative project are particularly well suited for exploitation in other sectors, such as aerospace and medical technology.

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Prifusio – Modeling of high-energy high-average-power laser systems

Within the PRIFUSIO project, we are building a flexible simulation tool that couples together multiple physical models to accurately predict the laser performance of high-energy, high average power lasers. Developing these kinds of lasers with high efficiency and good beam quality is challenging due to heat management and amplified spontaneous emission (ASE) mitigation. In applications such as a laser-based fusion powerplant, a high precision simulator (or "digital twin") can monitor the laser in operation and enables proactive maintenance. It also reduces the high costs and risks associated with building large-scale lasers. Other applications of these lasers include secondary sources (generation of X-rays, EUV), materials processing and laser particle acceleration. As such simulation tools are not publicly available, we must build one with all the desired physical effects at all the dimensional resolutions (time, space, spectrum). It also needs the versatility to allow any geometric complexities and explore different laser configurations, including, but not limited to, Innoslabs and multi-slab amplifiers.

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Next generation pump sources for high-energy lasers

Highly efficient and cost-effective diode laser pump modules are an indispensable part of high-energy solid-state lasers for fusion power plants. Commercially available pump sources do not meet the required parameters in terms of performance, cost and production volume. Within the two projects DioHELIOS and PumpHEL, Fraunhofer ILT is addressing these key issues at different parts of the value chain. This includes the design of next generation laser diode bars using sophisticated in-house simulation software (SEMSIS). Tailored optical components and systems are developed for beam collimation and homogenization. The temporal, spatial and spectral performance of single stacks and the whole pump module will be characterized in proprietary setups. Finally, a configuration tool is being developed to adapt the design of a pump module based on the requirements of a certain laser architecture.

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Robot-guided laser surgery system for cutting bone

In certain neurosurgical procedures, patients benefit significantly from awake neurosurgery – particularly in the implantation of electrodes for deep brain stimulation or the resection of brain tumors in eloquent areas. Although these patients receive local anesthesia, they suffer from discomfort, especially psychological stress during the opening of the cranium with mechanical drills and milling cutters. To reduce this stress, Fraunhofer ILT developed a robot-guided laser osteotome, cutting the bone vibration-free and with low noise. The laser cutting process can be performed by a Q-switched short pulse-laser in the mid-infrared (MIR) spectral range. To protect the risk structures behind the bone, an OCT sensor measures the residual bone thickness to control the cutting depth. The system can be modified to address other operations such as spinal surgery or the resection of bone tumors..

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EUV Application Cleanroom for fundamental industrial research and development

Extreme ultraviolet (EUV) radiation is used to produce the most advanced integrated circuits and is at the forefront of modern research and technology. To meet the challenges of both fundamental and industrial research, RWTH Aachen University and the Fraunhofer ILT have established the EUV Application Cleanroom, in which unique experimental EUV setups have been realized utilizing in-house EUV radiation sources. The addressed research questions include the following: spectral characterization of EUV sources with ultra-broadband EUV spectrographs; accelerated lifetime testing of materials and optical components under high irradiation levels in the EUV-HIEX setup; investigation of the fundamentals of EUV material interaction by mass and photoelectron spectroscopy and corresponding simulation framework; and characterization of ultrathin films with sub-nm accuracy in the broadband EUV reflectometer. Finally, EUV photoresist characterization with sub-30 nm resolution is performed in the EUV interference lithography setup.

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Battery LAB – Laser-based manufacturing processes in battery production

The increasing demand for high-performance batteries has led to the need for state-of-the-art processing technologies to meet evolving standards. Energy efficiency, environmental sustainability and digitalization are the key criteria that these technologies must meet. The use of laser radiation is proving to be a versatile solution that can fulfil these requirements, making it a cornerstone technology for the next generation of LIB and solid-state battery production.

In our battery laboratory, we demonstrate the range of laser processes and analysis, such as:

- Cell manufacturing processes (laser drying, sintering, structuring, ablation, and cutting of electrodes)
- Assembly of complete battery modules (laser welding of cylindrical, prismatic or pouch cells, modules, and cell housings)
- Testing equipment

Using laser technology increases the efficiency and precision of battery production and emphasizes our commitment to sustainable, innovative processes.

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E300

Solid state battery structuring in controlled glovebox atmosphere for increased performance

Our Battery LAB presents advanced laser-based manufacturing and prototyping processes for next-generation energy storage materials. Solid-state batteries replace conventional liquid or gel-based electrolytes with solid electrolytes and offer great potential for higher energy density. Even though they are still in the development phase, laser processing can serve as a key technology for future battery manufacturing. Ultrashort pulsed (USP) laser structuring is particularly important because phase preservation is critical when processing sensitive solid-state battery materials. USP lasers enable precise surface modification with minimal thermal stress, thereby helping to reduce interfacial resistance. The lab includes two glovebox systems under a controlled argon atmosphere: one for cell prototyping and thin-film deposition, and one for laser structuring under an inert atmosphere.

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E300

Integration of additively manufactured temperature sensors for monitoring laser-based inline processes

Laser welding of battery electrode foils generates highly localized heat that is difficult to monitor with external sensors. Ultra-thin metallic temperature sensors are digitally printed directly onto copper or aluminum foils and locally laser-sintered. In the demonstrator, these foils are welded while the integrated sensors capture the transient temperature profile exactly at the weld. After cell assembly, the same embedded sensors enable long-term monitoring of internal battery temperatures during real operation and over the entire lifetime. The concept provides high-resolution data for inline process control, advanced battery management, early detection of thermal hotspots and improved safety, efficiency and durability of traction batteries.

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Hydrogen LAB – Laser processes for hydrogen technology

Green hydrogen, produced through water electrolysis using renewable electricity, is the energy carrier of the future. Potential applications include mobility and domestic energy supply based on fuel cells. Alongside technological advancements, achieving broad market penetration requires significant cost reductions and increased production speeds throughout the value chains of electrolyzers, fuel cells and their components. Highly productive laser processes play a decisive role in automating and scaling up these manufacturing processes. Our Hydrogen LAB is equipped with modern laser-based machinery for coating, microstructuring, cutting and joining metal and compound bipolar plates, energy-efficient drying of catalyst-coated membranes, crystallization or annealing of proton-conducting thin-films as well as leak-tightness and fuel cell testing equipment. There are also numerous exhibits showcasing the various stages involved in producing a bipolar plate.

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Large surface structuring and decoating with polygon scanner for bipolar plates

Bipolar plates (BPP) are key components for fuel cells. Their functions include supplying reaction gases, removal of products, cooling, and electrical connection. Increasing the efficiency of the BPP, therefore, has a direct impact on stack performance. To increase performance, a distinction must be made between two industrial systems: For metallic BPPs made of stainless steel alloys, targeted surface structuring increases the reactive area, improves contact with the gas diffusion layer, and better dissipates disruptive products. Compound BPPs made of graphite-filled thermoplastics impress with their corrosion resistance, but have reduced conductivity. To compensate for this, the insulating polymer matrix must be removed over the entire surface, for which USP laser radiation has proven to be ideally suited. The industry-required surface rates can be achieved with the polygon system shown.

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Laser-based manufacturing of reduced graphene oxide thin films as corrosion resistant coatings for metallic bipolar plates

Graphene oxide (GO) belongs to the emerging class of graphene-based 2D nanomaterials and serves as a precursor for reduced graphene oxide (rGO). Due to the tunability of its surface properties, rGO thin films are applied across a wide range of functional surface applications. In contrast to other graphene-based nanomaterials, GO thin films can be deposited from dispersions using methods such as spray or dip coating. Through various reaction mechanisms, these GO layers can be converted into rGO films, which exhibit high electrical conductivity and chemical stability. Laser-based reduction of GO enables high-processing rates and the use of thin, temperature-sensitive substrates such as metal and polymer foils. In the presented process, corrosion-protective rGO coatings are applied to metallic bipolar plates for PEM fuel cells, manufactured under ambient conditions without vacuum systems or precious metals.

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Laser-based drying of electrodes for hydrogen applications

The increasing demand for emission-free energy is driving the need for efficient production methods for hydrogen fuel cells. Electrode manufacturing represents a significant bottleneck because it involves the wet deposition of thin electrode films onto temperature-sensitive substrates, followed by drying in convection ovens. This process is both time and energy intensive. Laser-based drying offers a highly efficient heat transfer mechanism to the wet electrode layer, resulting in an increase in drying rate while preserving the electrode's electrochemical properties. In the presented process, 15 µm thick wet electrode films are dried within seconds by large-area laser irradiation, with drying temperature regulated via a closed-loop control system.

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Cascaded USP Systems

The sequential integration of various scanning technologies has proven to enhance quality and reduce processing time in manufacturing procedures. Additionally, steering the laser beam with cascaded scan systems at high frequency rates exploits the potential of pulsed beam sources. A demonstration platform has been constructed, integrating a scanner head, linear stage, acousto-optical deflector, and an ultrashort pulse laser source. The development approach aims to offer a system solution for the trajectory planning of each device and flexible scan parameter settings using advanced control architecture. The main improvement lies in the full synchronization of all devices during processing and the ability to adapt the motion of the steering systems for multipurpose applications. The platform is currently managed by a single interface to validate the advantages of synchronized scanning over traditional approaches.

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Joining porous layers and mesh structures for next-generation electrolyzers

Welding of porous transport layers (PLTs) is a critical step in the manufacture of PEM electrolyzers and fuel cells. Due to their porous structure and limited thickness, PLTs are highly sensitive to excessive heat input. Uncontrolled welding may cause pore collapse and structural densification, which can influence the functionality of the cells. Laser beam welding is commonly applied because of its localized energy input and precise positioning. Key parameters, such as laser power, welding time, and shielding conditions, must be carefully optimized to ensure mechanical integrity and gas tightness while preserving the porous structure.

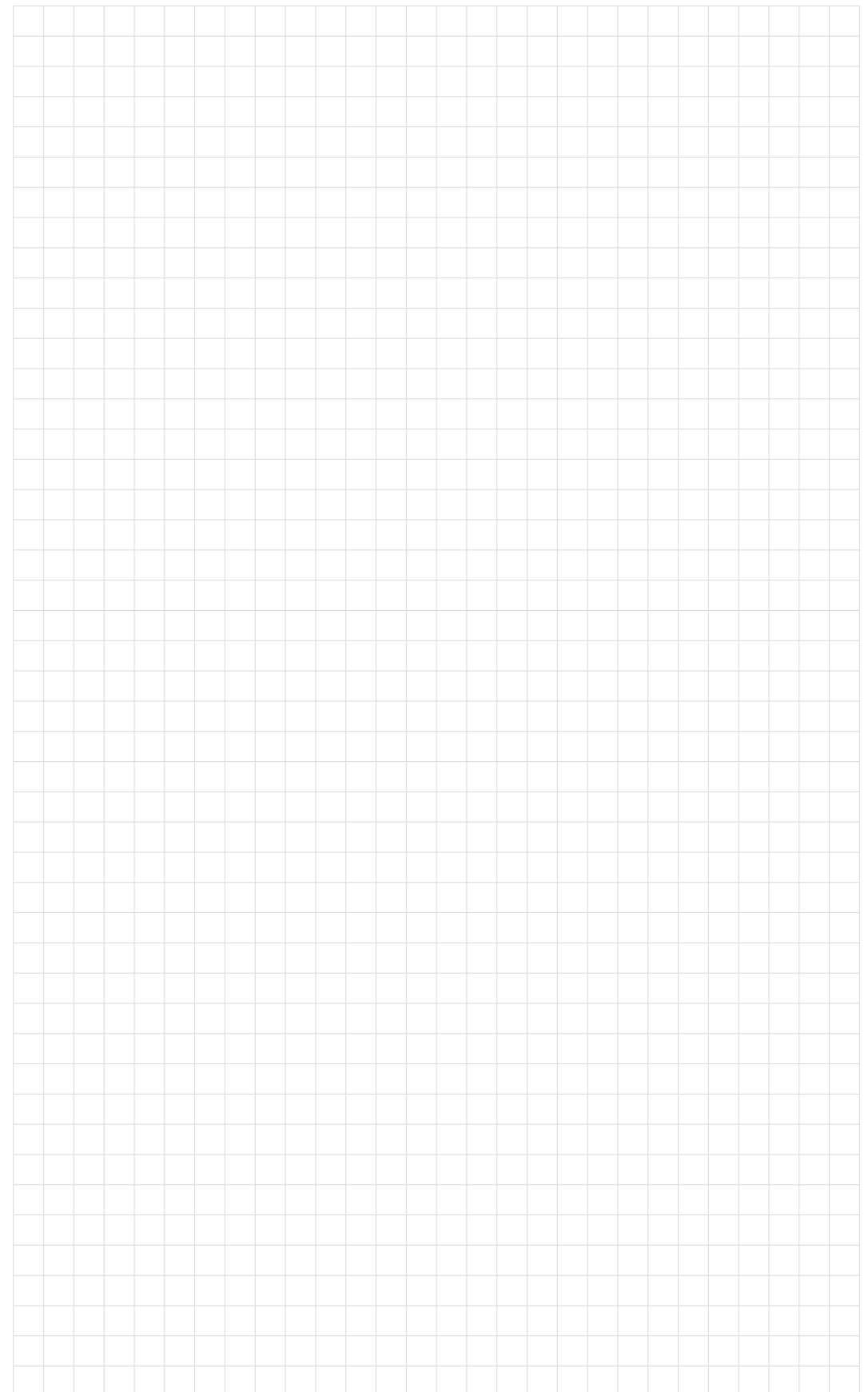
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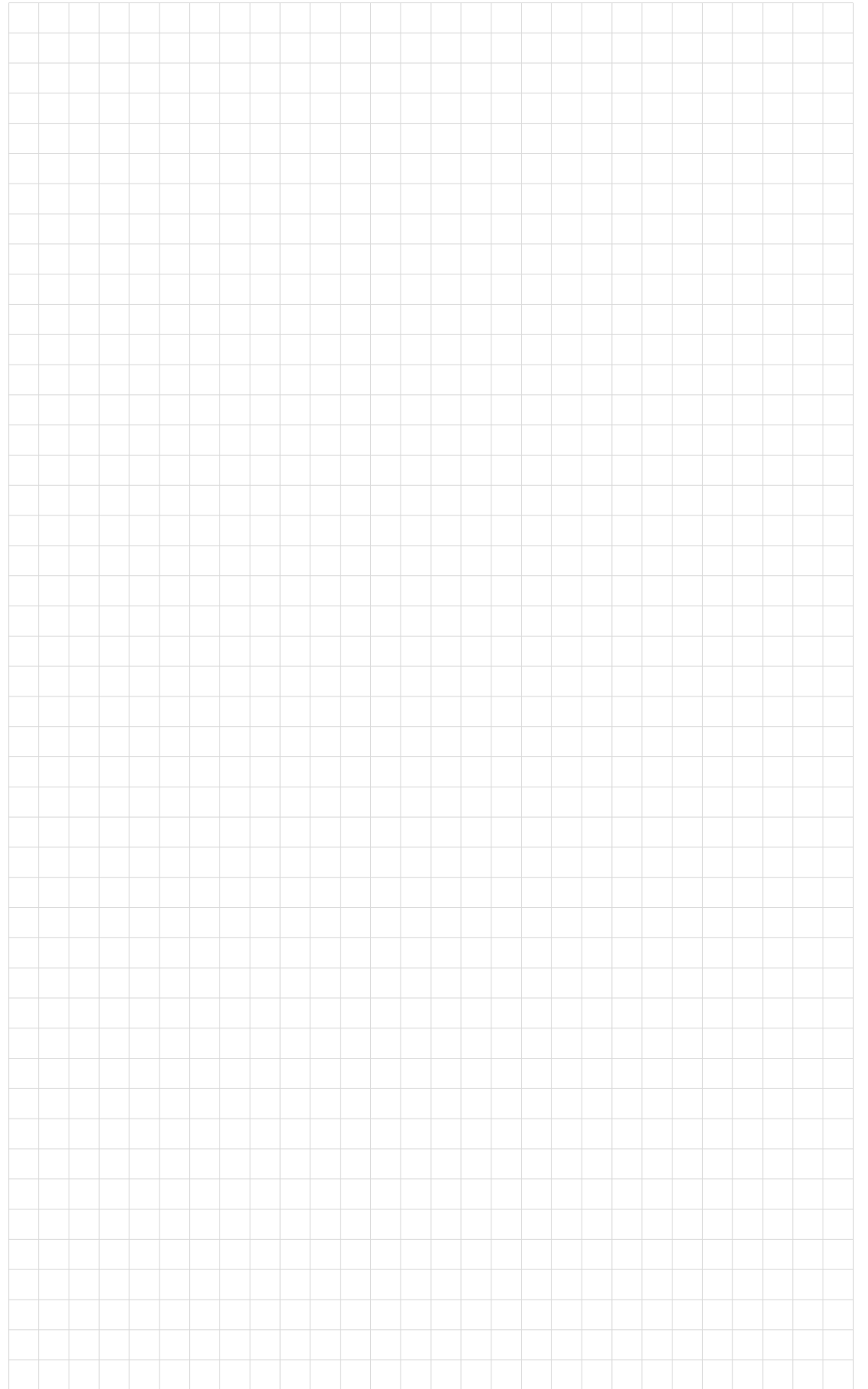
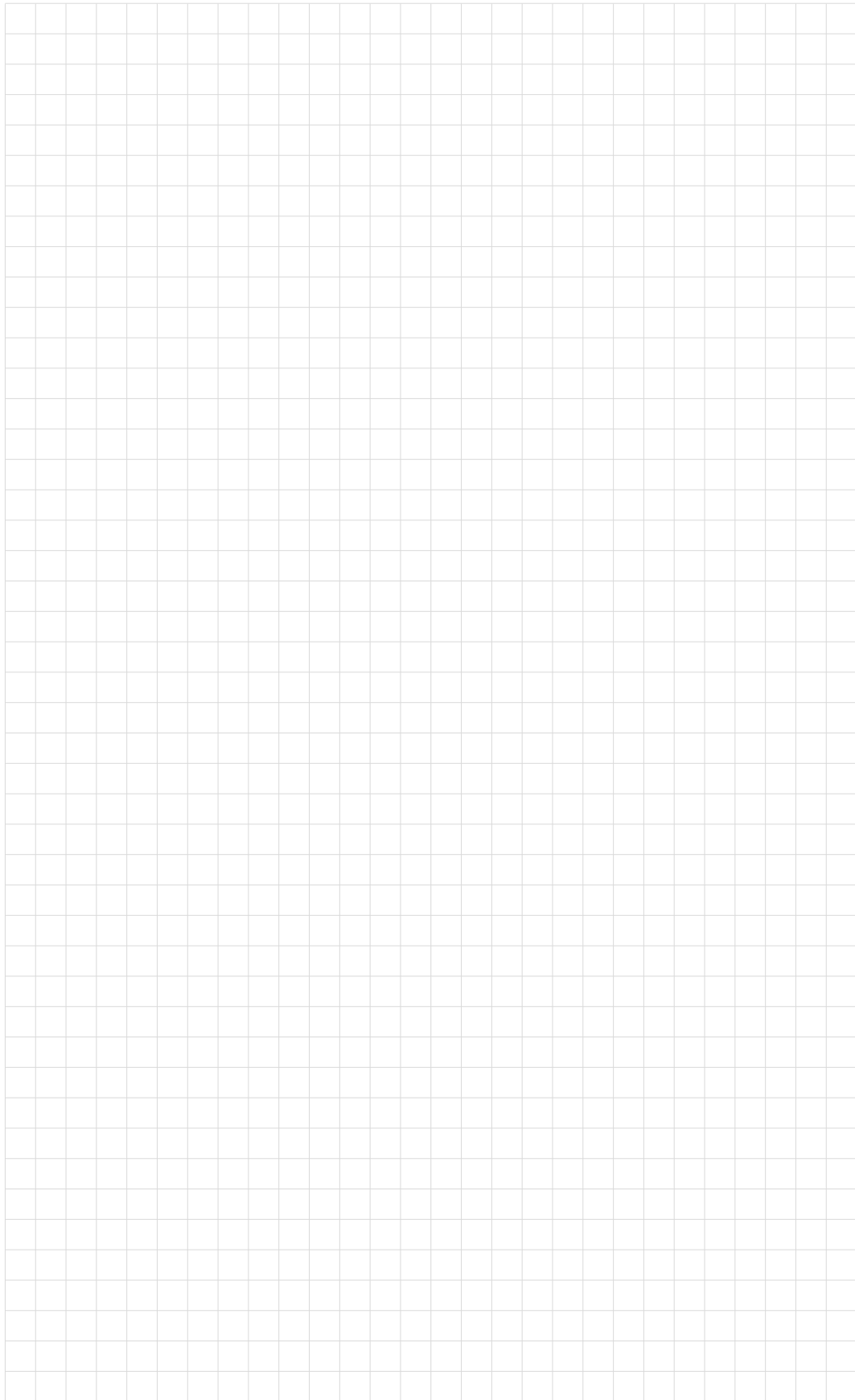
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Published by

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SAVE THE DATES!

The Laser Community meets again:

- AKL'28, May 3–5, 2028
- AKL'30, May 8–10, 2030
- AKL'32, May 5–7, 2032

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AKL'26

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