PRESS RELEASE

Fraunhofer ILT at the Laser World of Photonics 2025

From June 24 to 27, 2025, experts from the fields of laser technology and photonics will come together at the Laser World of Photonics, World of Quantum, World of Photonics Congress and the automatica in Munich, the latter of which is being held in parallel. The Fraunhofer Institute for Laser Technology ILT in Aachen will use the stage to focus on important future markets and fields of innovation in photonics. The Aachen-based institute will be represented with stands in four exhibition halls, forward-looking exhibits and numerous specialist presentations at the congress. It will also participate in the application panels in the exhibition halls and at the special shows "Photonics meets Robotics: AI Success Stories" in Hall A3.433 and "MedtecLIVE" in Hall A4.218.

It is impossible to imagine the modern world without laser technology and photonics. Not only do they provide central technological building blocks for digitalization and communication, but they also guarantee that the quality of industrial production can be monitored continuously. Furthermore, they are indispensable in laboratories and clinics as well as in aerospace, lighting, environmental and energy technology or sensor and measurement technology. However, despite its ubiquity, photonics is facing largely untapped future markets and fields of innovation which have hundreds of billions of euros in sales potential. Whether laser-based inertial fusion, AI-supported cyberphotonics, quantum technologies, secondary sources or the megatrend of sustainability, light as a tool plays a central role.

Fraunhofer ILT will use the 27th Laser World of Photonics to draw attention to the markets of the future and corresponding laser-based solutions for them. One focus will be on the central technological building blocks for each of these markets – the laser beam sources themselves.

High-energy lasers, secondary sources and powerful USP lasers

Fraunhofer ILT is continuing to develop lasers for novel laser-based X-ray and neutron sources (so-called secondary sources). These sources are intended to make mobile systems for neutron and X-ray imaging possible, one initial application of which is for inspecting the contents of nuclear waste containers. By combining X-ray and neutron radiation, the institute can help industry determine not only the geometry of the contents but also their material composition. There are numerous other applications in

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industry and society. In the future, for example, the process could be used to inspect infrastructure, such as bridges, or to analyze the contents of containers at airports and seaports. The containers would then no longer have to be opened to find explosives or drugs, for example.

Experts at Fraunhofer ILT are also currently continuing to develop and optimize ultrashort pulse (USP) lasers for industrial use. Here, they are achieving average laser powers of more than 2 kW at pulse repetition rates of 100 kHz or more, which allows large surface structures or micro-holes to be produced economically, precisely and flexibly. Relevant applications can be found in microelectronics, for example, but also in water filtration.

Another important field of innovation: high-power diode lasers, which will be needed to pump high-energy lasers in the fusion power plants of the future. In laser fusion, the radiation from several high-energy lasers is focused on tiny fuel pellets to ignite the fusion process. While the above-mentioned applications require pulse energies of a few joules to a few tens of joules, laser energies in the megajoule range are needed to generate the energy needed for inertial confinement fusion. Such systems are made up of a large number of individual lasers with pulse energies ranging from a few 100 joules to a few kilojoules. Depending on the fusion principle, pulse durations in the femto-, pico- or nanosecond range are required. In order to achieve the goals of laser fusion, research not only has to increase the laser power, but also to scale up the production processes for optics and laser diodes cost-efficiently. Experts at Fraunhofer ILT are working on these topics together with partners from industry and research.

At its main stand in Hall A3.431, Fraunhofer ILT will be showcasing solutions for the future fields of fusion and secondary sources, among others. The researchers will also be sharing their knowledge in specialist presentations at the "Lasers and Optics" forum in Hall A2.

Complete process chain in optics production

Optics manufacturing is facing new challenges: higher laser power, extreme conditions in fusion power plants and increasingly complex optics for medical technology, quantum technology as well as for semiconductor production. At Fraunhofer ILT, fully laser-based process chains are being developed for this purpose – from raw glass to ready-to-assemble optics.

Mechanical production optimized for spherical, i.e. semi-circular, lenses has reached its limits, especially with specifically designed aspheres and free-form optics. This is where

the freely programmable, non-contact laser processes have an advantage, in terms of process duration, costs and quality: Their short melting time creates very smooth surfaces without microcracks and imperfections, which are particularly detrimental to highly stressed optics.

In addition to switching from the principles of mechanics to those of light, researchers at Fraunhofer ILT are also driving forward the use of artificial intelligence in optics production. This begins with the automated design of complex optics and beam paths in a fraction of the time previously required and should extend to process optimization for maximum efficiency and quality in the not-so-distant future. The institute sees the key in precisely adjusting parameters and sequences during the ongoing process in real-time in order to produce customized optics for the high-tech markets of the future cost-efficiently.

Fraunhofer ILT will be showcasing solutions and exhibits from laser-based optics manufacturing in Hall A3.431 and at the "Lasers and Optics" forum in Hall A2, "Laser Material Processing" in Hall B3 and at the "LiM - Lasers in Manufacturing" conference during the congress. The institute is also making a significant contribution to the special show "Photonics meets Robotics: AI Success Stories" in Hall A3.433.

MedtecLIVE special show: robot-assisted laser procedures for gentle surgery

A team at Fraunhofer ILT has developed a robot-assisted laser procedure for laser-based awake craniotomy. To test complex brain functions during neurosurgical procedures, surgeons have to perform them on awake, locally anesthetized patients. However, opening the skull while the patient awake is extremely stressful. A new robot-assisted and optically precisely monitored laser procedure developed by Fraunhofer ILT 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 together with industrial partners. To ensure that the laser beam actually only ablates bone tissue and that the underlying structures remain intact, the institute is using an OCT (optical coherence tomography) measurement system to monitor the laser cutting process.

The procedure is currently being further developed for operations on the spine. The researchers want to miniaturize the existing applicator for this purpose and design it as an ergonomic hand piece so that surgeons can also perform the automated cutting process manually. A collaborative robotic system will support the surgeons. The research team plans to use the sensors and actuators of a collaborative robot (cobot) to provide feedback during the non-contact laser cutting process. This is because the

cobot's force-torque sensors determine the force acting on the robot arm. On this basis, the actuator system can then provide the surgeon with haptic feedback during manual guidance of the laser applicator. The laser surgery system will also be linked with 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.

The demonstrator for robot-assisted laser craniotomy can be seen at MedtechLIVE in Hall A4.218. Also look out for the "Forum Biophotonics and Medical Applications" in Hall B2, where leading scientists from Fraunhofer ILT will be presenting this topic in specialist lectures.

World of Quantum – not without Fraunhofer ILT

With the "Strategic Mission Initiative Quantum Technology," Fraunhofer ILT is taking a strategic approach to the future market of quantum technology. It will be presenting ideas and results at the World of Quantum in Hall A1. These include a project that makes use of entangled quanta of different wavelengths for testing ceramic workpieces using optical coherence tomography. The basic idea: Photons in the mid-infrared (MIR) wavelength range show good transmission in otherwise highly scattering materials, but are difficult to detect. In the near infrared range (NIR), the opposite is true. If a ceramic workpiece is scanned with the MIR-Idler photons, they penetrate deeper than light of shorter wavelengths and the backscattered light carries information on defects such as cracks or inclusions hidden beneath the surface. These in turn can be read out from the entangled NIR photons using low-noise measurement technology. What already works in the laboratory should ensure higher speeds, resolutions and greater depth of information in in-process quality inspections in the future.

Fraunhofer ILT will also be showcasing technological components of a network node for the quantum internet of the future, which it is continuing to develop with research partners from Delft in the Netherlands. After two nodes were built in The Hague and Delft, which successfully exchanged entangled quanta via conventional telecom fibers, the Aachen-based institute recently put a third node into operation. Funded by the state of North Rhine-Westphalia, the research team is now planning to integrate it into a local network in order to develop it further with partners from industry and science in a manner based on real-world applications. They are focusing on photonic components and network technologies, including low-noise quantum frequency converters (QFC), single photon sources and complex optical components. There are plans to integrate the node into a "Metropolitan Scale Quantum Network" in the future. Such regional networks are regarded as the nuclei of the future quantum internet, in which entangled quanta protect transmitted data from unauthorized access. The activities in

North Rhine-Westphalia are closely linked to the local initiative EIN.Quantum.NRW, which is funded by the state government. Fraunhofer ILT coordinated a roadmapping process that resulted in a detailed position paper in January 2025.

The researchers will be presenting their quantum technology activities as part of the Quantum Alley in Hall A1 and at the EIN.Quantum.NRW joint stand in Hall A1.139. They will also hold various specialist presentations at the "Forum World of Quantum" in Hall A1 and at CLEO®/Europe-EQEC as part of the World of Photonics Congress.

Fraunhofer ILT is an active partner in the LIMES Cluster

The LIMES cluster combines several EU projects that are developing sustainable laser machining processes. In the METAMORPHA project, Fraunhofer ILT is driving forward reliable, highly productive material processing. One approach to this is using liquid crystal phase modulators for beam shaping, which can freely program the beam profile of a laser. For example, periodic patterns can be generated at high speed by optically "stamping" their unit cells. In this way, the laser can functionalize surfaces, thereby making environmentally harmful coatings and protective layers no longer necessary. In addition, inline process monitoring and intelligent control technology can pave the way for zero-defect production. The institute aims to scale up industrial laser processes more quickly, increase productivity and ultimately gain a competitive edge over conventional manufacturing processes. Energy and resource efficiency also contribute to this, as programmable laser beams reduce power requirements by around a third. And unlike many alternative production processes, non-contact laser processing causes neither chemical waste nor wear and tear. You will find the LIMES Cluster with the participation of Fraunhofer ILT in Hall B3.342.

"Cluster of Excellence Advanced Photon Sources CAPS"

In the "Fraunhofer Cluster of Excellence Advanced Photon Sources CAPS," Fraunhofer ILT is working together with 20 other institutes of the Fraunhofer-Gesellschaft on ultrashort pulse lasers and their applications. Under the leadership of the Fraunhofer Institutes for Laser Technology ILT and for Applied Optics and Precision Engineering IOF, CAPS is developing laser sources and the associated process technology for medium laser powers up to 20 kW. Their fields of application lie in the future markets and innovation fields of photonics.

The Fraunhofer "Cluster of Excellence Advanced Photon Sources CAPS" will be exhibiting in Hall A2.415 and presenting, among other things, the large-area and highly productive USP processing of metal sheets. This process uses a USP laser with an average output of 1 kW.

Fraunhofer ILT at seven stands this year – where to find us

Talk to our experts in Munich and find out more about our solutions for the energy industry, automotive technology and mobility, aerospace, microelectronics, medical technology and health as well as quantum technology: A3.431 (main stand), A3.433 "Photonics meets Robotics: AI Success Stories," A2.415 "Cluster of Excellence Advanced Photon Sources CAPS," A4.218 MedtecLIVE, Hall A1 Quantum Future Boulevard and A1.139 EIN.Quantum.NRW, B3.342 LIMES Cluster. Don't miss the presentations by our researchers on the various panels and at the World of Photonics Congress!

Here you will find press releases on other topics that we are presenting in Munich:

- „Boosting efficiency in mining with AI and automation“ | https://s.fhg.de/AwJr
- „More efficient and brilliant diode lasers thanks to fiber Bragg gratings“ | https://s.fhg.de/DefC
- „Tracking greenhouse gases with a laser“ | https://s.fhg.de/NKea
- „From raw material processing to recycling: new approaches in battery production“ | https://s.fhg.de/t56R
- „Aerospace in transition: How laser technology is shaping the industry“ https://s.fhg.de/y3pT
- „What is happening in my laser process? Making the invisible visible with synchrotron radiation“ | https://s.fhg.de/BSnY
- „This is how the optics of the future are created – from glass to final assembly“ | https://s.fhg.de/SYQB
- „AI for Photonics at the Laser World of Photonics 2025“ | https://s.fhg.de/zkBT

Picture 1:
Joint Fraunhofer booth at the Laser World of Photonics in Munich 2023.
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Picture 2:
At the Laser World of Quantum 2023, Fraunhofer ILT presented, among other things, a noise-reduced frequency converter for the quantum internet.
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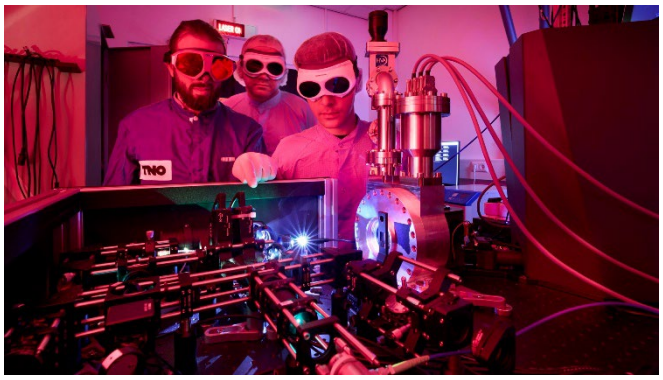

Picture 3:
TNO and Fraunhofer ILT have intensified their close collaboration in the NRW-funded project N-QUIK. Their optimized network node for the quantum internet of the future will serve as a test field and node for the first "Metropolitan Scale Quantum Networks" in Aachen.
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Picture 4:
High-risk: Surgical opening of the vertebral body. The robotically assisted, hand-guided laser surgery system developed at Fraunhofer ILT is intended to replace mechanical high-speed milling and minimize surgical risks. Talk to our experts at MedtecLIVE!
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