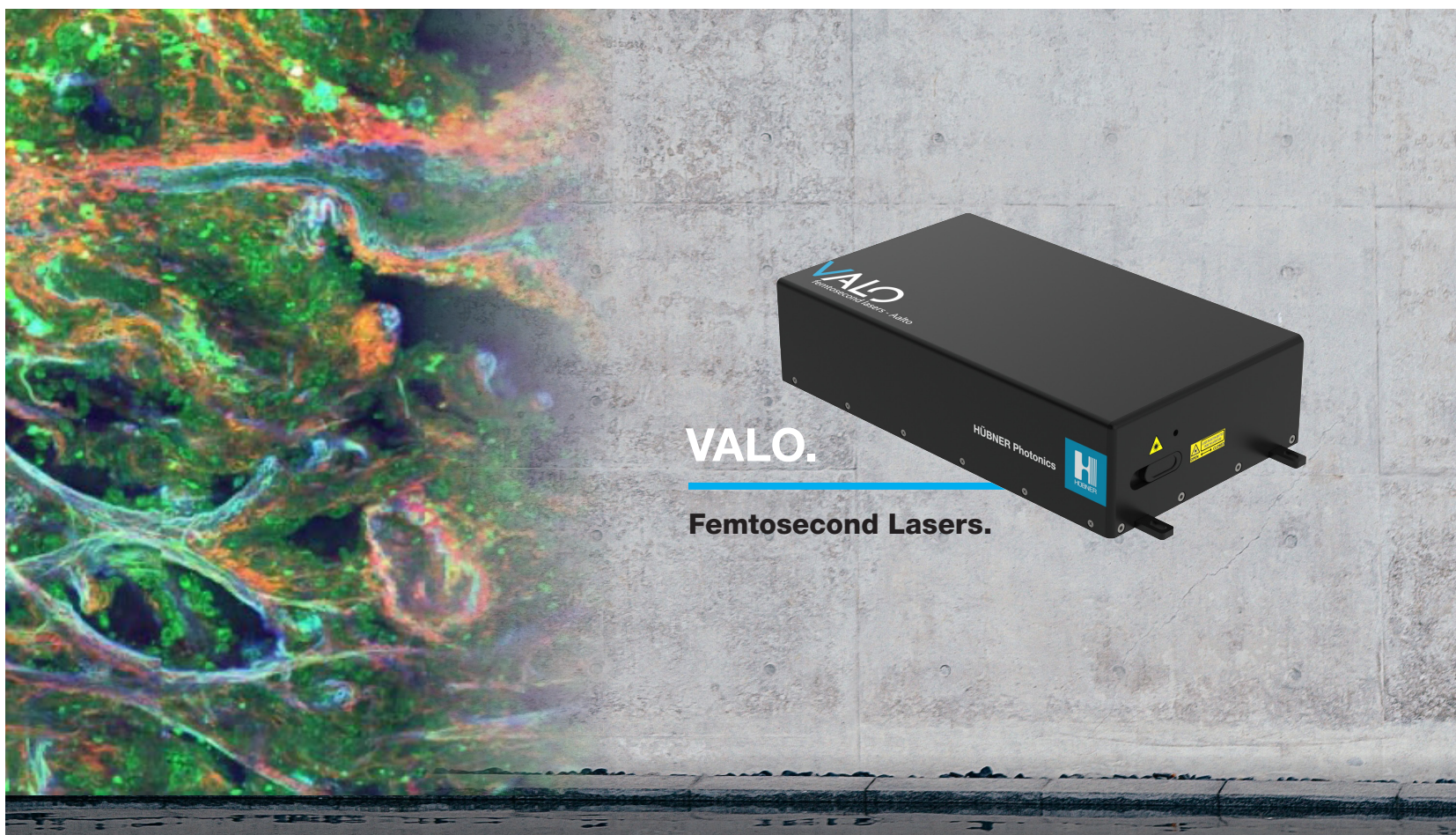


PhotonicsViews

OPTICS • PHOTONICS • LASER TECHNOLOGY



VALO.

Femtosecond Lasers.

COVER STORY

Rapid cancer diagnosis with simultaneous two and three-photon imaging

HÜBNER Photonics
hubner-photonics.com



TECHNOLOGY FEATURE

Photonics – a key enabling technology in the quantum world

SPECTROSCOPY

Boosting efficiency and data quality – lasers for LIBS aluminum recycling

LASER MICROMACHINING

SSAIL brings innovations to chip packaging, displays, and PCBs

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MOPA Fiber Laser M8 Series



20W-50W

► Pulse Width: 1-350ns ◀



120W-300W

► Pulse Width: 6-200ns ◀

Key Features

- **High Peak Power & Narrow Pulse**
More concentrated energy makes smaller heat-affected zone
- **Robust Single Pulse**
More efficient processing of metal/non-metal materials
- **Precision Control**
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Applications



Remove Oxidation



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Plate Engraving



Ceramic Deep
Engraving



Glass Drilling

Web:
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sales@jptoe.com



Scan the QR code to
view YouTube

Automation and photonics: a powerful synergy

Three leading trade fairs will once again take place simultaneously at the Munich exhibition center, with Automatica, World of Quantum, and Laser World of Photonics opening their doors to visitors from around the world on June 24.

Without a doubt, this combination is a challenge from an organizational and logistical perspective – professionally, it is a huge gain. Automation and photonics are becoming ever more interconnected. Lasers have become indispensable in numerous industrial processes. The achievable output power of continuous-wave lasers is constantly rising, while the cost per kilowatt of laser power is declining. At the same time, manufacturers of ultrashort pulse lasers are achieving higher power levels at shorter wavelengths, such as green, ultraviolet, or deep UV.

Lasers are progressively becoming the most economical tool for many applications thanks to their low-maintenance and virtually wear-free operation. Laser-based solutions are proving to be essential in automated industrial processes where high throughput and extreme precision are required.

But the pressure on laser manufacturers is increasing: they must optimize their own production processes to remain cost-effective and price competitive. And this is where the circle closes: the photonics industry relies on automation technology to enhance manufacturing efficiency, while automation technology depends on lasers as essential tools within its systems.

A visit beyond one's own industry to the six halls of Automatica is certainly worthwhile, not least because it is fascinating to see how key topics such as artificial intelligence, data analytics, and sustainability are being addressed across different sectors.

The third trade fair, World of Quantum, steps into the spotlight when it comes to artificial intelligence and the computing power required for it. Lasers are essential in quantum photonics to generate, manipulate, and measure qubits with high precision. They have already proven their value as an enabling technology for manifold operations in this exciting area of research.

Let us all take the opportunity to explore the other trade fairs. Shifting perspectives fosters creativity, and interdisciplinary collaboration paves the way for innovation. We look forward to engaging discussions in Munich!

J. Niederhofer

Jürgen Niederhofer



Source: MKS Instruments

Jürgen Niederhofer

Managing Director – General Manager,
High Q Laser and Newport Spectra-Physics GmbH,
subsidiaries of MKS Instruments, Inc.

Member of the industrial advisory committee,
Laser World of Photonics



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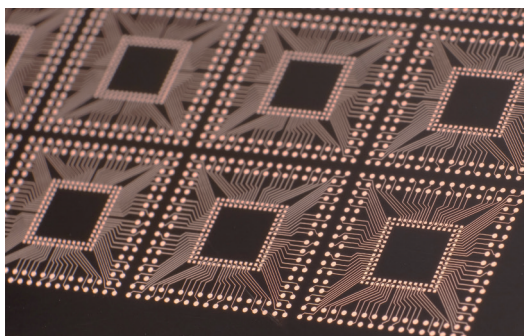


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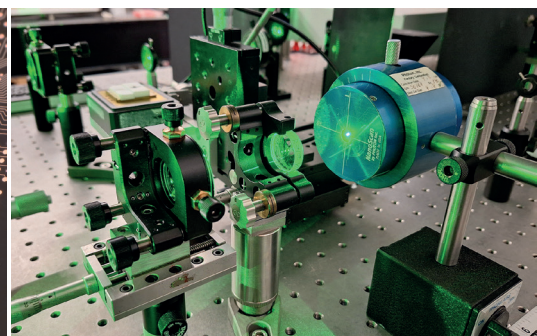
OPTICS • PHOTONICS • LASER TECHNOLOGY



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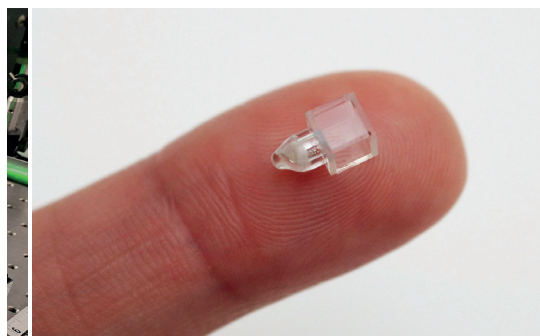
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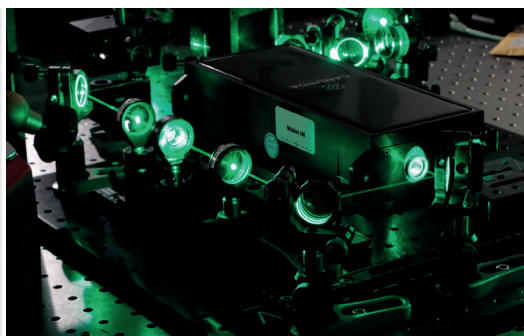
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Gwenn Pallier & Clémentine Maurier

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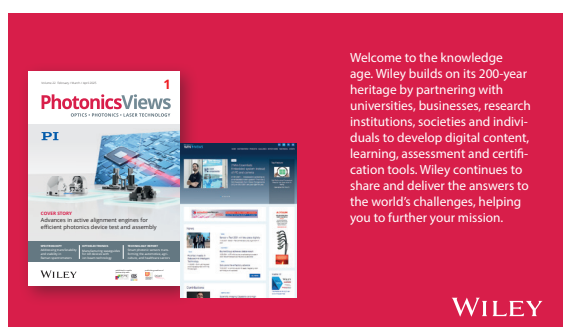
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The laser is a success story and some chapters of it were written in Aachen



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Cover:

A new generation of compact ultrafast laser systems capable of simultaneous two and three-photon microscopy – including two-photon fluorescence (2PF), second harmonic generation (SHG), three-photon fluorescence (3PF), and third harmonic generation (THG) imaging – offer exciting potential to accelerate biomedical research and clinical diagnostics

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Additive manufacturing industry optimistic despite challenges

“Our member companies continue to demonstrate remarkable stability and adaptability in a changing market environment,” explains Dr Markus Heering, managing director of the VDMA Additive Manufacturing Working Group. The working group’s spring 2025 survey shows that the

additive manufacturing industry remains optimistic despite some challenges. The survey was conducted until March 28, i.e. before the US tariffs were introduced. One result is that more companies reported positive sales than in the previous fall survey. Nevertheless, 34 % of companies reported declining sales for the last twelve months. In the past six months, however, the negative turnover of member companies was only 20 %. “We are therefore seeing a slight trend towards more positive business,” explains Dr Heering.

Optimism remains at a high level and has even increased further in the last six months. Looking ahead to the next 24 months, 77 % of respondents expect growth in the domestic

market. In terms of exports, 64 % of our member companies expect an increase over the next 24 months – in contrast to 58 % in the fall survey last year.

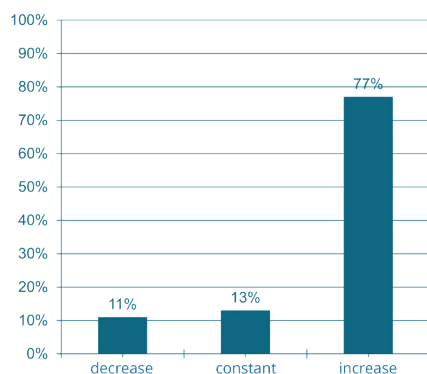
The EU-27 is the most important export region for almost 70 % of member companies, followed by the US (64 %) and European non-EU countries (29 %). “We are observing the great importance of the USA as an export market. The future will show how exports to the US will change,” explains the managing director of the working group.

The most relevant competitors come from China and the USA. Almost half of the member companies have Chinese additive manufacturing competitors, while 43 % see themselves in competition with Amer-

ican additive manufacturing providers. “We are even seeing a slight increase here compared to the previous survey. Competition from China is becoming more and more noticeable,” Dr Heering sums up.

Despite the generally difficult economic situation, many companies want to invest more again. Next year, 40 % plan to spend more money on investments. The most positive effect on the additive manufacturing business will come from technological developments (60 %), followed by new applications and new markets. One in five companies also hopes that research and development activities will provide positive impetus in the current year.

www.vdma.org



“How does your company expect the domestic market in the AM sector to develop over the next 24 months?”

€ 15 M to integrate photonics into products

A new investment from the European Commission is helping innovators improve the performance of their products through a proven ‘one-stop-shop’ photonics innovation factory. Called PhotonHub Phactory, the new 15 million euro initiative dramatically lowers the barrier to entry into photonics, offering EU subsidies that can cover up to 85 % of project costs to help companies achieve a wider and faster uptake, integration, and deployment of photonic technologies, boost competitiveness and foster new business.

With more than thirty European partners, the new framework covers the entire

value chain from early-stage concept and prototyping to upscaling. It spans a wide range of cutting-edge technology platforms, facilitating open access and guided orientation to the broadest possible range of photonics expertise, equipment and technologies.

Led by Brussels Photonics (B-Phot) at Vrije Universiteit Brussel, the initiative builds on the success of PhotonHub Europe, which to date has helped over a hundred companies deliver more than 750 million euros in new revenues, create a thousand jobs and raise 250 million euros in venture capital in just four years.

www.photonhub.eu



PhotonHub Experience Center cleanroom

€ 227 M from the EU for AMS Osram facility

The European Commission approved funding for a semiconductor manufacturing facility for AMS Osram under the European Chips Act. The official funding approval from the Austrian Ministry of Economy and Labor, which is responsible for the payment of the funding, is now expected shortly. The company plans to use the funding of up to 227 million euros approved by the European Commission to sustainably strengthen the development and production site in Premstaetten, South-East Austria. In total, the company plans to invest 567 million euros in the project by 2030, when full production will begin at the headquarters in Styria.

The new plant at the production site in Premstaetten is intended to further expand the leading role of the Austrian semiconductor industry. In the future, the semiconductor manufacturing facility will produce highly differentiated next-genera-

tion optoelectronic sensors that are qualified for applications in medical technology and the automotive industry. In addition, the production of products for industry or for use in consumer goods is planned. It combines outstanding technologies – CMOS, filter, and through silicon vias (TSV) – and works according to a tool-box concept.

Depending on the product, the different capabilities can be combined individually as required for energy-efficient imaging and optoelectronic products with a reduced form factor, more functions on a single component and outstanding electrical performance. The construction of the additional cleanroom at the Premstaetten site, with an area of 1,800 square meters for CMOS production, will also double filter capacity and increase TSV capacity by a factor of four.

<https://ams-osram.com>

Photonics is “a strategic asset for Europe’s competitiveness, resilience and security”

Speaking via video link to leading scientists and innovators in Brussels to celebrate two decades of the European Technology Platform, Photonics21, the European Commission’s Executive Vice-President for Tech Sovereignty, Security and Democracy Henna Virkkunen urged the sector to prepare for closer alignment with Europe’s semiconductor ecosystem in FP10 and to demonstrate how photonics can deliver tangible European value.

“Photonics is not only a field of scientific inquiry but a strategic asset for the European Union. Its applications permeate various sectors, contributing to our resilience, competitiveness and security,” the Commissioner said.

This year’s milestone annual meeting brought together hundreds of leaders from industry, academia, and policy. It served as a platform to reflect on twenty years of progress while charting the course for the upcoming Framework Programme 10 (FP10).

Over the past decade, Photonics21 has played a key role in shaping major public-private investments through the Photonics Public Private Partnership (PPP) with the European Commission, channelling more than one billion euros into photonics research and innovation activities.

Shaping FP10 priorities

Looking ahead to the next EU research and innovation programme, Virkkunen called for photonics to “remain a key part of Europe’s strategic technology agenda,” ensuring the continent’s continued leadership in critical technologies.

Since its inception in 2005, Photonics21 has played a pivotal role in uniting stakeholders across Europe to advance photonics research and innovation. During this period, it has strategically coordinated Europe’s leading photonics players to influence EU research through Horizon 2020 and Horizon Europe while positioning Europe as a global leader in tech-



Dr Lutz Aschke, President of Photonics21, at the 20th anniversary event (Source: Photonics21 / Iris Haidau, Babylonla)

nologies like laser manufacturing, optical communications, sensors, quantum photonics, and biomedical imaging.

A celebration of light

The event was comprised of keynote speeches from Gustav Kalbe, acting director at DG CNECT, European Commission, and Michael Förtsch, CEO of Qant. A fireside chat moderated by Maryline Fiaschi, CEO of ScienceBusiness, delved into the future of photonics within the European funding ecosystem.

This year’s Photonics21 Innovation Award was awarded to Victor

Rodriguez, a postdoctoral researcher at the Institute of Optics (IO-CSIC) in Madrid for developing a breakthrough method for fast and precise vision prescriptions.

The second day focused on funding opportunities, featuring presentations by Werner Steinhögl, head of microelectronics and photonics industry at DG Connect, and Yves Gigase, head of programmes at Chips JU, the EU’s joint undertaking supporting semiconductor innovation. Valerio Pruneri from ICFO also introduced PIXEurope, a new PICs pilot line initiative.

<https://www.photonics21.org>

Good-bye PhotonicsViews, enter Physics’ Best, inspect

After this final issue of PhotonicsViews, Wiley Audience Solutions will increase the reach for topics from the fields of laser technology, optics, and photonics. In fall 2025, articles, news and product information will be published as part of the **Physics’ Best** magazine series with a circulation mix – print and digital – of 70,000 contacts (PhotonicsViews: 40,000).

inspect (circulation mix: 50,000) and its special editions **inspect Europe** and **inspect America** are also available for topics and products from the fields of materials, process, and product inspection, as well as image

processing, camera technology and imaging at various wavelengths. The established photonics community, i.e. all readers of PhotonicsViews, will therefore continue to be informed about the familiar topics.

Decision-makers will also be provided with all the information they need about photonics via the specialist portals **WileyIndustryNews.com** and **pro-physik.de** as well as the bi-weekly newsletters. Special mailings, webinars, virtual conferences and job fairs offer additional opportunities for companies to reach the relevant target groups.

Staff continuity is also ensured – editor-in-chief Dr



The editors of Wiley’s physics, photonics, and technology titles Oliver Dreissigacker, Maïke Pfalz, and David Löh (l-r)

Oliver Dreissigacker, account manager Alexandra Wojtowska and their team will continue to be the point of

contact for everything to do with photonics.

www.pro-physik.de
WileyIndustryNews.com/en

Inauguration of the Jenoptik micro-optics fab for the semicon equipment industry

After around two and a half years of construction, the Jenoptik group has completed its largest single investment in recent history and officially inaugurated its new factory (or “fab”) in Dresden. By expanding its production and research and development capacities for innovative micro-optics, the company is supporting production technologies with state-of-the-art, high-precision sensors for high-performance chips, e.g., for applications in AI.

The new fab was officially opened on May 6 in the presence of customers, partners, construction stakeholders, neighbors, and rep-



Opening in Dresden (l-r) Jenoptik executive board member Ralf Kuschnerreit, Lord Mayor Dirk Hilbert, Minister President Michael Kretschmer, and Jenoptik CEO Stefan Traeger

resentatives from business, politics, and government agencies of the Free State of Saxony and the City of Dresden. Together with the Minister President of the Free State of Saxony, Michael

Kretschmer, and the Lord Mayor of the City of Dresden, Dirk Hilbert, Jenoptik president and CEO Dr Stefan Traeger and site manager Dr Andreas Morak pressed the symbolic start button,

which opened the fab with a short light show. Additionally, Jenoptik invited around two hundred employees from its micro-optics business in Dresden and Jena to a joint employee celebration to mark the opening the following day.

Jenoptik invested just under 100 million euros in the new site, which has a total net floor space of 11,000 sqm, including 2,000 sqm for clean room production. In addition, significant investments were made in state-of-the-art production equipment, some of which was relocated and some of which was expanded.

www.jenoptik.de

Bosch and Element Six establish quantum sensor company

For more than ten years, Bosch has been researching in the field of quantum technology, and it is playing a decisive part in commercializing quantum sensors. Since 2023, it has had a development collaboration with Element Six, the world's leading solutions provider of synthetic diamonds. Bosch is now significantly extending this alliance and establishing a joint venture to be known as Bosch Quantum Sens-

ing. The joint venture will be based on the in-house start-up of the same name, which Bosch set up in 2022. Domiciled in Ludwigsburg, Germany, Bosch Quantum Sensing currently employs

thirty associates. Bosch itself will be the lead partner and be responsible for operations. Element Six will hold a 25 % stake. It has been agreed that further financial details will not be disclosed. The establishment of the new company is still subject to official approval.

Synthetic diamonds are a key component of Bosch quantum sensors. In stepping up its partnership with Element Six, Bosch is making a determined move toward the commercialization of quantum sensors. Even now, the latest Bosch quantum sensor prototype is the most compact of its kind for the level of sensitivity required – it is the same size as a modern smartphone. It could enable robust mobile navigation solutions in future, complementary to conventional GPS systems. The long-term goal of Bosch Quantum Sensing is to make quantum sensors so small that they can be integrated onto a chip.

www.e6.com

www.bosch-quantumsensing.com

FOC&T becomes part of the Photona Group



Dr Florian Blobner, CPO Photona, Patrick Paul, CEO Photona & Laser Components Germany, Anton Pautz, company founder FOC&T, Dr Lars Mechold, FOC&T managing director

The Photona Group is expanding its expertise in fiber technology and acquiring 100 % of the shares in the Bavarian fiber technology manufacturer FOC&T GmbH. The expertise and portfolio of the two companies complement each other perfectly: while the group of companies from Olching near Munich has so far concentrated primarily on the industrial and aerospace sectors, FOC&T focuses on ready-made cables for medical technology and has unique mechanical expertise in connector production. The jobs at FOC&T in Burghausen will be retained.

Dr Lars Mechold, authorized signatory and technical director at Laser Components Germany, is the new managing director. Company founder and former executive director Anton Pautz will be available to the company as a consultant out of retirement. “We are looking forward to working closely with Mr Pautz,” says Mechold. “He has shaped the company for more than twenty years. We are pleased that his technical expertise and knowledge of technical processes will continue to be available to us. This will ensure a smooth transition.”

www.lasercomponents.com

www.foc-t.de



Siobhán Duffy, CEO of Element Six (l), Katrin Kobe, managing director of Bosch Quantum Sensing

ing. The joint venture will be based on the in-house start-up of the same name, which Bosch set up in 2022. Domiciled in Ludwigsburg, Germany, Bosch Quantum Sensing currently employs

Trumpf enters market for flexible automation solutions

The German high-tech company is now offering its laser systems as automated complete solutions for end users. Users can reduce their cycle times and save costs in 3D laser material processing by using the versatile automation solutions from this high-tech company. "Our laser machines are highly productive. By automating our systems, we are now also offering our customers the opportunity to become more efficient in the upstream and downstream production steps. Thanks to our extensive experience, broad planning expertise and close cooperation with our partner Autom8 during implementation, we ensure that our customers receive a customized solution," says Martina Gassenmeier, responsible for sales of automation solutions for laser technology at Trumpf. The

company is demonstrating a typical automation solution at their in-house Intech exhibition. This consists of a 3D laser cutting machine, a robot for component handling and a camera-based quality control system.

Demand for automation solutions is constantly growing, especially in the field of hot-formed parts for car body construction, where the handling of ever-larger components often presents production planners with challenges. Trumpf offers its services to companies that have little experience in automating their production, coordinates on-site installation together with the automation specialist Autom8, and is responsible for project management throughout the entire process.

www.trumpf.com

Imec and TNO launch the Holst Centre Photonics Lab

The independent nano-electronics R&D hub Imec and the Netherlands Organization for Applied Scientific Research TNO have launched the Holst Centre Photonics Lab, a state-of-the-art facility dedicated to integrated photonics research and development in the Netherlands. By advancing photonics research and fostering collaboration between industry and academia, the lab aims to bridge the gap between innovation and industrialization for applications in sectors such as automotive, healthcare, and data communications. The new lab is located at High Tech Campus Eindhoven and is partly funded by PhotonDelta.

The launch marks an important milestone in the Dutch commitment to integrated photonics innovation.

Building on the PhotonDelta National Growth Fund plan initiative, which has propelled integrated photonics R&D in the Netherlands for over two and a half years, the lab establishes a solid foundation for cutting-edge research and aims to foster strategic collaboration between industry and academia.

By combining Imec's expertise in areas such as tape-out validation, on-chip laser development, system testing, and application validation with TNO's strengths in laser characterization, freespace optics, and photonic chip integration, the lab brings together complementary capabilities across the full innovation chain. (Source: PhotonDelta)

www.imec-int.com
www.tno.nl

Happy Birthday, Schäfter + Kirchhoff!

Founded on May 5, 1955, Schäfter + Kirchhoff began as a company for classic lens design and customer-specific optical solutions. The focus gradually shifted to today's product lines, which are still manufactured in Hamburg and distributed worldwide: polarization-maintaining fiber optics, lasers for industrial image processing, line scan cameras, as well as scanner and inspection systems. Seventy years later, the company celebrated its birthday with a big thank you to its customers, a large cake for its employees and a short journey through its history.

When the company was founded in 1955 by the two optical engineers Paul Schäfter and Kurt Kirchhoff, it excelled in the production of special optics that were used, for example, for projection on cinema screens or in high-quality binoculars

and some of which can still be seen in museums today. With the change of company owner to Gregor Federau in 1976, the focus slowly shifted from individual contract manufacturing to the compa-



Source: Suk

ny's own product lines, such as the Multicube system, which is still in use today, or the so-called panoramic line scan camera. The company remained in private ownership until 2016, when it was transferred to the non-profit Gregor Federau Foundation of the former company owner to promote child and youth welfare.

www.sukhamburg.com



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www.dumaoptronics.com

Laseroptik was granted Coherent's global supplier excellence award



Coherent Supplier Award

The German coating experts have been recognized for "Outstanding Quality 2025". The award honors the achievements regarding short lead times and reliability, responsiveness, reaction speed of trouble shooting and elimination of quality issues. On behalf of Coherent's EVP Gary Kapusta and European director strategic supply chain Dr Paul Ilten, the award was handed over during a ceremony by Julia Strozyk and Dirk Herbke, strategic sourcing managers, to Laseroptik's Dr Wolfgang Ebert, Daniel Höhne, and Mark Krause.

The Coherent representatives expressed their appreciation in an official statement: "We thank you for your collaboration and the effort your company made to meet our high expectations of a Coherent valued supplier."

Dr Wolfgang Ebert gratefully expressed: "We feel honored by this award for an essential category, namely quality. We have been working for Coherent sites for more than forty years and developed unique optics manufacturing capabilities for their demands. I thank Coherent for their appreciation and their continued trust in us." Laseroptik is a renowned manufacturer of



(l-r) Mark Krause, Julia Strozyk, Dr Wolfgang Ebert, Dirk Herbke, Daniel Höhne

optical coatings and laser optics from VUV to IR and employs more than forty coating machines with six different coating methods. Founded in 1984 as a spin-off from Hanover University,

the company produces up to 180,000 coated optics per year, mainly for laser applications in industry, medicine, space and research.

www.laseroptik.com

Sponsored content: Laseroptik

DeepEn wins Leibniz Start-up Prize 2025



The award-winning founding team of DeepEn, Sergey Turtaev, Jiri Hofbrucker, Hana Cizmarova, Tomáš Čížmár and Patrick Westermann with Leibniz VP Sebastian Lenz and Leibniz President Martina Brockmeier (r-l)

Deep insights into the brain and other organs – with unprecedented resolution and minimal invasiveness: this is made possible by DeepEn GmbH from Jena. Its technology opens up new opportunities for neuroscientific research and medicine. Behind it is a spin-off from the Leibniz Institute of Photonic Technology (Leibniz IPHT) in Jena, which has developed the world's thinnest microscopy device. For this innovation, DeepEn has been awarded the Leibniz Association's 2025 Start-up Prize, endowed with 50,000

euros. The start-up, which was founded in 2024, plans to use the prize money to prepare for the market launch of the microendoscope, NeuroDeep, at the end of 2025.

With the help of precise holographic light control, optical fibers with the diameter of a human hair can be used as powerful imaging devices in deep-seated regions of the body. DeepEn will initially primarily market its NeuroDeep laboratory system, which is aimed at private and public labs.

www.leibniz-gemeinschaft.de

Laser technology successful at Fraunhofer awards

The 50,000 euro Fraunhofer Founder Award was presented to Fusion Bionic on February 19. Dr Sarah Klein from the Fraunhofer Institute for Laser Technology won 3rd place in the prestigious Hugo Geiger Prize for the improvement of high-power fiber lasers and diode lasers thanks to fiber Bragg gratings.

The Fraunhofer Founder Award recognized Fusion Bionic, a 2021 spin-off of the Fraunhofer Institute for Material and Beam Technology IWS and Dresden Uni-

versity of Technology. Its laser-based surface functionalization method is inspired by natural surfaces such as the lotus leaf, sharkskin, springtails and the morpho butterfly, which enable advanced surface features such as self-cleaning, anti-icing, antibacterial action, decoration, drag reduction and more. Fusion Bionic uses innovative laser technology – direct laser interference patterning (DLIP) – to transfer these effects to technical surfaces.

www.fraunhoferventure.de



(l-r) Bavarian Minister of State Hubert Aiwanger, Benjamin Krupop, Dr Sabri Alamri, Laura Kunze (Fusion Bionic), Dr Alex von Frankenberg (HTGF), Tim Kunze (Bionic), and Fraunhofer President Prof Dr Holger Hanselka

Source: Fraunhofer Venture

New CEO for Exail's photonics business line

Bruno Desruelle brings extensive expertise in photonics and quantum technology, having played a pivotal role in shaping Exail's photonics strategy and leading its quantum systems division. As the founder of Muquans, a pioneering quantum technology start-up integrated into Exail in 2021, Bruno has been instrumental in advancing innovative solutions within the group.

Desruelle's career spans over a decade of leadership in photonics and quantum innovations. He completed his PhD under the supervision of Alain Aspect and then began his professional journey at Corning, where he specialized in optical telecommunications and



Bruno Desruelle

doped-fiber amplifiers. He later joined Thales Optronique as a development manager. At the French Defense Procurement Agency, he served as a program manager in photonics, contributing to several projects. In 2011, he founded Muquans, successfully leading it for over a decade before joining Exail.

www.exail.com

Laserline expands its management

The developer and manufacturer of diode lasers for industrial material processing has expanded its management team. Dr Claus Narr became a further

Dr Narr started as an assistant to the management supporting it in establishing the branch in Shanghai, China, and in expanding production and



(l-r) Dr Christoph Ullmann, Dr Claus Narr, Volker Krause

managing director alongside company founders Dr Christoph Ullmann and Volker Krause in January. He completed his doctorate in mechanical engineering at RWTH Aachen University and, during his time at the Laboratory for Machine Tools, was group leader for production logistics as well as managing director of the RWTH startup myOpenFactory. Narr has been working at Laserline since 2011 and has held a variety of key positions.

administrative capacities at the headquarters in Mülheim-Kärlich, Germany. He then took over the production of compact diode lasers, and later became head of quality management and service. Most recently, he was head of production and service. In 2021, he was appointed managing director of the new subsidiary Backes Electronic. As a member of the management team, he will support managing the operational business.

www.laserline.com

New managing director for Blackbird

In February 2025, Rüdiger Brockmann was appointed to the management board of Blackbird and takes over the business from Karl Christian Messer, who has led the company since 2017 and has driven the international growth of the company with its own branch in Shanghai, China, and the technological development of the products.

Dr Rüdiger Brockmann has more than thirty years of experience in the industry and laser sector. He studied applied physics and mechanical engineering and earned his PhD in laser microwelding. He has held various top management positions in large groups as well as mid-sized companies. As one of the pioneers of remote laser welding in the automotive industry, Brockmann has extensive expertise and an in-depth understanding of the technology.

"I am delighted that we were able to bring Dr Brockmann on board as my successor. He is not only an experienced manager but also a

skilled practitioner with a track record of excellence," says Messer, Blackbird's previous managing director. "With his experience, methodological knowledge and leadership skills, Blackbird is ideally equipped for the forefront of technological developments in laser welding and complementary OCT applications," Messer continues.



Rüdiger Brockmann (l), Karl Christian Messer

"A joint transitional period allows me to benefit from my predecessor's experience, paving the way for me to integrate smoothly and efficiently into Blackbird and existing customer relationships," added Brockmann.

www.blackbird-robotics.de

Christophe Seuret to head Lasea Switzerland

The arrival marks a new stage for the Swiss subsidiary, which plays a key role in the group's strategy. Located in the heart of French-speaking Switzerland, it benefits from its unique proximity to its customers. Lasea intends to continue its expansion and strengthen its presence in the luxury, medical and electronics sectors.

Christophe Seuret holds a doctorate in nanomaterial physics and photonics from ETH Zurich and has 25 years of experience in the sectors of microtechnology, luxury goods, and electronics. His career path demonstrates his strong commitment to innovation and industrial excellence.



Dr Christophe Seuret

Seuret has held several senior positions: recently he was in charge of commercial and technological development at a company active in innovative materials for microtechnology, contributing to the growth and innovation of the company.

www.lasea.eu

AMS Technologies reorganizes management team



Tomasz Stefańczyk, Michael Lee, Maik Frede, Klaus Maier, CEO Jan Meise, CFO/COO Philipp Weber, and Christoph Schelzke

The solution provider and distributor specializing in optical technologies, thermal management, and power electronics, from Planegg, Germany, has made strategic changes and additions to its leadership team.

Dr Maik Frede, who joined in early 2024 through the acquisition of Neolase, has been appointed vice president engineering. In this role, he enables the company to deliver complete photonic systems comprising lasers, amplifiers, control technologies, and thermal management solutions.

The new vice president sales Michael Lee will succeed Klaus Maier, who will retire in the second half of 2025 after a transitional period.

Christoph Schelzke has been promoted to vice president operations. He will continue to oversee purchasing, supply chain management, quality management, production, logistics, and customer service.

Tomasz Stefańczyk, previously head of engineering, has been appointed director of digital transformation.

<https://shop.amstechnologies.com>

Stollenwerk takes over at Fraunhofer ILT from Haefner

Prof Haefner, the previous managing director of the Fraunhofer institute for Laser Technology ILT, assumed his new role as a member of the board for research and transfer at the Fraunhofer Society on February 17 this year. At the same time, Dr Stollenwerk took over as interim managing director of the institute.

Prof Haefner has led the Fraunhofer Institute for Laser Technology ILT in Aachen since November 2019. In this role, the internationally recognized laser physicist has significantly contributed to the modernization and advancement of the institute as a leading organization in applied laser technology for which he initiated the comprehensive structural and strategic 'Future Proofing ILT' process to position the institute for new research topics and applications.

Dr Jochen Stollenwerk is a physicist who earned



Dr Jochen Stollenwerk

his doctorate in 2001 at the Faculty of Mechanical Engineering at RWTH Aachen University. After moving to Trumpf Laser Marking Systems, he returned to Aachen in 2004 and played a key role in establishing the RWTH chair of optical systems technology TOS, where he served as senior chief engineer until the beginning of 2024. At the same time, he held various positions at the Fraunhofer ILT. Since 2020, he has been working on Prof Haefner's staff and was appointed deputy director in March 2024.

www.ilt.fraunhofer.de

Fisba appoints Martin Forrer as CTO, Daniel Gray as its new North America president

Dr Martin Forrer became chief technology officer and head of development at Fisba in March 2025. In this position, he holds responsibility for commercial offers, product development and technical projects. He structures the services required by R&D with the resources, ideas and potential and deploys efficient teams to successfully implement customer projects.

Forrer is also responsible for long-term and strategic

business development with a focus on innovative and scalable solutions and technologies in photonics.

He previously led and was responsible for product research and development at Fisba as CTO for 13 years, including new processes for successful customer-specific solutions. Forrer holds a diploma in physics from ETH Zurich and a PhD from the Institute of Applied Physics at the University of Bern. In 2006, he obtained a Master of Technology Entrepreneurship from the IMD Business School in Lausanne.

Dan Gray, formerly the founder and president of Gray Optics – a company acquired by Fisba in 2023 – was appointed the new president for Fisba North America in April, and brings extensive

expertise and a strong track record to his new position. The acquisition expanded Fisba's engineering and development capabilities in North America.

In his new role, Gray will oversee the entire North America operation, including, sales, administration, engineering, quality, and production with the primary goal of strengthening the company's market presence in the region.

Gray holds a bachelor's, master's, and PhD in optics from the University of Rochester, with a focus on biomedical optics and ophthalmology. He has over twenty years of experience developing precision optical systems for medical, biometric, consumer, and industrial markets.



Dan Gray

"Dan's profound expertise in precision optical systems and early-stage product development makes him the ideal leader for our North American strategy," said Fisba's CEO Markus Hersche. He extends its gratitude to the previous head of Fisba North America, Wallace Latimer, who has accepted the CCO position at Ocean Optics.

www.fisba.com



Dr Martin Forrer

Series 60FC-SF fiber couplers now available with shorter focal lengths

The series 60FC-SF fiber couplers from Schäfter + Kirchhoff with a superfine thread are ideal for demanding applications that require a precise focus setting. These fiber couplers are now available with shorter focal length achromats of 3.1 mm and 4 mm. Both achromats are available with three different broadband AR-coatings, covering the range from UV to IR.

The fiber couplers can be used as collimators for laser radiation from a single-mode fiber and also as fiber couplers with high pointing stability. The adjustment of the focal setting has been improved and is highly defined. It ensures



high coupling efficiency even when the divergence or the wavelength of the laser source varies.

The distance between the fiber end-face and the collimating optics is ad-

justed using a threaded ring with a super-fine thread of 0.35 mm pitch, and the enhanced mechanics result in increased pointing stability and reduced backlash during focus setting. The lens in these fiber collimators is spring-loaded, and the linear bearing ensures that the lens does not rotate when adjusting the focus.

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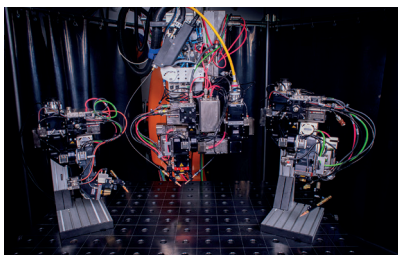
e-mail: info@sukhamburg.com

Web: www.sukhamburg.com

Laser World of Photonics, B2.315

Scansonic: Celebrating 25 years of expertise in laser-based metal processing

At Laser World of Photonics, Scansonic is presenting its expanded portfolio. In response to the growing demands of e-mobility, Scansonic has extended its industry-leading ALO4 system with several new variants. The ALO4-O features beam oscillation technology, allowing for wider joint cross-sections and improved seam strength. The ALO4-L, equipped with a longer telescopic arm, is specifically engineered for deep and hard-to-reach joints. Making its debut in Munich is the ALO4-F, designed for particularly confined areas such as corner joints in battery housings. With these additions, Scansonic now covers all joining processes required for modern battery housing production. Through the cooperation with its partners Dinse for wire feed systems and Brightlight Laser



Systems for fiber lasers, customers can obtain complete and integrated system solutions from a single source.

Also on display is a high-performance battery welding system developed by Bergmann & Steffen. This turnkey solution for laser welding cylindrical cells combines advanced image processing and fast clamping technology with Scansonic's FCW system. The FCW platform stands out with its adjustable number of laser

spots, making it ideally suited to high-volume manufacturing processes with high quality requirements. Typical applications include battery cells, cold plates, and copper hairpins for electric motors.

Beyond these core highlights, Scansonic will also present its latest optics for laser cutting and laser cladding. The portfolio is further complemented by optical seam tracking sensors for automated arc welding, enabling accurate and efficient robotic manufacturing processes.

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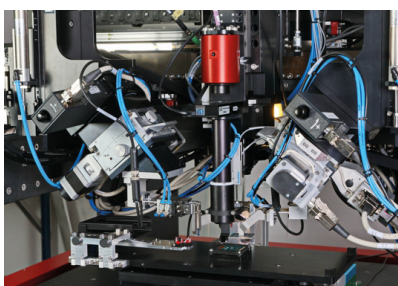
Web: www.scansonic.de

Laser World of Photonics, B3.313

Complex optical alignment in a tiny space

Nanosystec designs and builds high-precision assembly and test stations. These use accurate motion control and joining techniques such as precision laser welding, laser soldering and microgluing with UV curing. Precision cutting and fine balancing solutions complete the portfolio. The systems are used worldwide in optoelectronics and medical applications, the automotive industry, and aerospace.

Two different Nanosystec gluing stations align and assemble up to thirty individual optical components in a butterfly housing using automated subprocesses. This customized combination provides the perfect configuration to meet the process requirements.



The VersaGlue station uses high-performance machine vision algorithms to precisely pick-and-place half of the components in the micron regime. The heat conductive resin needs to be applied evenly to maintain the optical path parallel to the bottom of the housing. In

addition, the uniform resin line guarantees good heat transfer. Optical power, beam parameters and the optical spectrum serve as feedback signals for the active alignment and positioning of the demanding optics. Machine vision combined with sensor measurements ensure a well-defined starting position, followed by assembly with submicron precision.

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Laser World of Photonics, A2.350

Sampling the unsampleable – profiling multikilowatt laser beams

A novel air-cooled rotating beam sampler enables real-time, non-contact profiling of high-power laser beams

A novel beam sampling system for high-power laser beams enables accurate profiling with minimal disturbance. Using a rotating or linearly driven beam sampler combined with air cooling and synchronized detection, the system supports real-time, multikilowatt laser analysis with less than 1 % beam loss.

Accurately measuring high-power laser beams remains a formidable challenge due to the potential for sensor damage and beam distortion. Traditional methods using needle-like or opaque sampling devices often disturb the beam path or require lengthy scanning durations. To address this, a new beam sampling and profiling system has been developed that enables momentary, low-disturbance sampling of high-power laser beams.

This sampler swiftly traverses the beam for a brief period, capturing a momentary sample that is then reflected to a preferred measuring device such as a camera beam profiler. By capturing a snapshot of the beam, the camera determines the beam size efficiently. The device is inherently cooled by the rotating sampler's movement in the air, coupled with the assistance of external cooling nozzles. It comprises a low-reflectivity mirror, a mechanical arrangement for precise positioning of the mirror, a rotating or linear motor, an additional low-reflectivity mirror, a beam profiling camera, and the necessary microcontroller and algorithm for image processing and calculating the beam profiles.

Beam sampling challenges at high power

Standard beam profilers struggle when exposed to the intensities of kilowatt-class lasers. Conventional beam splitters and samplers suffer thermal distortion, while opaque methods like knife edges obstruct the beam and are unsuitable for live measurements. As beam powers increase, so does the need for instantaneous, undisturbed sampling.

Rotating beam sampler concept

At the core of the proposed system is a rotating beam sampler designed to pass briefly through the laser beam (Fig. 1). This sampler reflects less than 1 % of the beam to a camera-based profiler, preserving the main beam integrity. The drum-mounted sampler rotates rapidly, minimizing its thermal exposure time. Cooling is achieved both passively via air movement and actively using dedicated windjet nozzles that simultaneously drive the drum's rotation.

Fig. 1 shows the system layout using a rotating wheel to rapidly drive the beam sampler through the high-power laser beam. As the beam sampler traverses the laser beam, it divides the beam into two components: one that continues through with over 99 % of the power, and the other that is redirected orthogonally to a laser beam profiler with significantly less power (less than 1 %). The beam sampler which is firmly attached to a rotating drum collects a sample of the beam and directs it to the laser beam profiler for measuring the laser's profile. The circumference of the rotating drum is significantly larger than dimensions

of the beam sampler by a factor of ten. The linear stage allows the beam profiler to sample the beam along its propagation axis, and a bracket connects the beam profiler to the stage. These components are situated on a mechanical plate. The windjet cools the beam sampler while simultaneously rotating its drum. The beam sampler's dimensions are much smaller than the drum's circumference, ensuring that the sampling time through the beam during each full rotation is very brief. Additionally, the windjet further cools the device and rotates the drum. The sampled beam is directed to the camera for analysis, while the main beam remains mostly undisturbed, facilitating real-time measurements. The drums's rotation is generated by an air blower pointed at the built in blades. The generated pressurized air has the dual purpose of cooling the rotating beam sampler as well as driving the drum. An optical switch mounted on the frame and a flag fitted to the rotating drum used to provide synchronization between the rotating drum and the sampling position.

The configuration shown in Fig. 2 utilizes a window-like beam sampler mounted on a precision linear stage, enabling profiling of the laser beam along its propagation axis. The windjet provides continuous air cooling during motion, ensuring thermal stability and extending the durability of the optical interface. This linear implementation allows flexible integration in setups where rotating mechanisms are impractical, offering high-resolution beam analysis across various positions. The

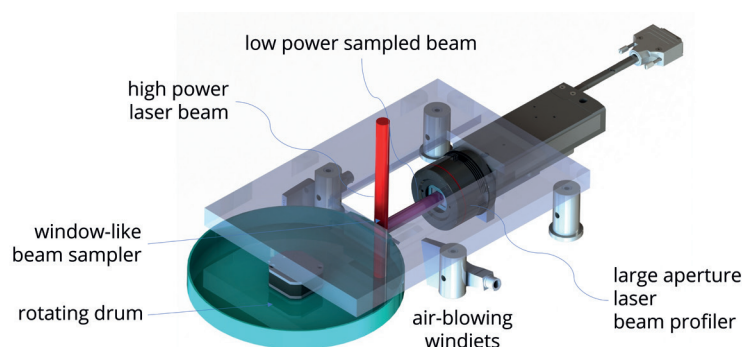


Fig. 1 A novel air-cooled rotating beam sampler for high-power laser beams measurements

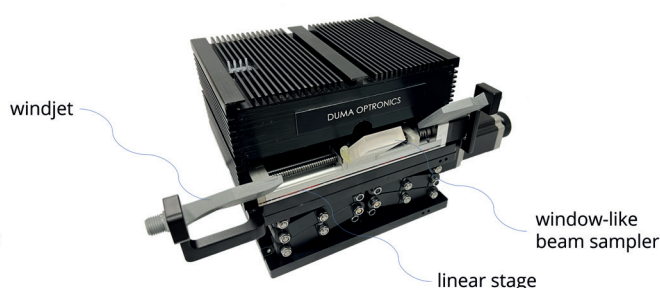


Fig. 2 Linear motion configuration (Source both images: Duma Optronics)

modular design supports synchronization with external triggers for time-resolved measurements.

Real-time multispectral profiling

The system supports broadband and multispectral analysis by leveraging low-reflectivity optics and mosaic sensors. A microcontroller governs the

synchronization, motor control, and image processing pipeline. Thanks to its modularity, the system can be adapted for either online monitoring or offline standalone diagnostics.

- [1] ISO 11146: Lasers and laser-related equipment – Test methods for laser beam widths
- [2] USPTO Patent 12247869 - Sampling high power beam profiling

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Pulses from conventional laser diodes using a laser driver IC

Blue and green pulses for time-resolved fluorescence diagnostics by way of gain switching

Laser current drivers as integrated circuits enable extremely short, precisely defined laser pulses in the nanosecond and even picosecond range – based on the physical principle of gain switching. iC-Haus extends its proven HS series of laser diode driver integrated circuits with the new iC-HSB. This is the first member of the series to allow a supply voltage of up to 15 V for the laser diode, which means that laser diodes down into the UV spectral range are now driven efficiently and safely.

Gain switching is a method of generating ultrashort laser pulses by driving laser diodes with short current pulses. The gain in the laser material is temporarily increased above the lasing threshold, resulting in a coherent light pulse within picoseconds. In principle, this technique works with laser diodes of any wavelength, but it requires very precise control of the current amplitude and pulse length, also at the higher operating voltages required for the short wavelengths.



Source: iC-Haus

diodes, the iC-HSB now opens up applications for blue, green and UV laser diodes, for example for the excitation of fluorophores such as derivatives of the green fluorescent protein (GFP) and 5-TAMRA. Such markers label gene probes, antibodies, or proteins and are essential for immunoassays. Short, intense laser pulses enable particularly high temporal resolution and sensitivity in detection.

the often time-consuming search for the optimum pulse parameters. In a production environment, this process can be automated using the programmable laser diode driver ICs.

Thanks to its compact design, the iC-HSB reduces the space required on the circuit board and thereby supports the miniaturization of modern analytical devices – right down to mobile point-of-care systems.

Fluorescence spectroscopy applications

These wavelengths are crucial for numerous applications in life sciences, medical technology and laboratory diagnostics. While previous models such as the iC-HS02 and iC-HS05 are suitable for red and infrared laser

Easy commissioning through convenient parameterization

In addition to its excellent electrical properties, the iC-HSB also offers outstandingly convenient parameterization: currents up to 600 mA and pulse lengths down to 100 ps can be set in fine increments. This greatly simplifies

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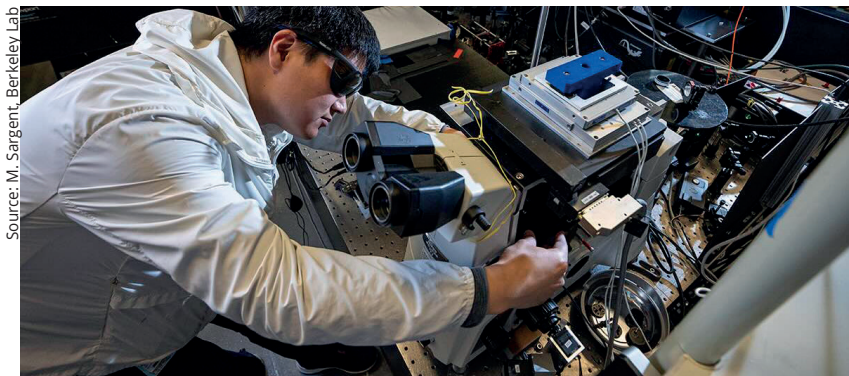


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Photonic avalanches for optical computers

New approach could pave the way for optical transistors and memory for optical computing



Source: M. Sargent, Berkeley Lab
Xiao Qi in the laser room at the Molecular Foundry. Qi used the setup to develop a new optical computing material from nanoparticles that exhibit photon avalanching

A research team co-led by Lawrence Berkeley National Laboratory, Columbia University, and Universidad Autónoma de Madrid has developed a new optical computing material from photon avalanching nanoparticles, paving the way for fabricating optical memory and transistors on a nanometer scale comparable to current microelectronics. This approach offers a path toward realizing smaller, faster components for next-generation computers by taking advantage of intrinsic optical bistability.

“This is the first practical demonstration of intrinsic optical bistability in nanoscale materials,” said Emory Chan from Berkeley Lab’s Molecular Foundry.

Chan and the team’s recent study suggests that the new photon avalanching nanoparticles could overcome the challenges in realizing intrinsic optical bistability (IOB) at the nanoscale. During their experiments the researchers fabricated 30-nanometer particles from a potassium-lead-halide material doped with neodymium. When the

nanoparticles were excited with light from an infrared laser, they exhibited photon avalanching, in which a small increase in laser power results in a giant, disproportionate increase in the light emitted by the nanoparticles.

Now, the team found that their new nanoparticles were over three times more nonlinear than those original avalanching nanoparticles, “the highest nonlinearities that anyone has ever observed in a material,” Chan said. To the researchers’ surprise, further experiments in the current study showed that these nanoparticles not only exhibit photon avalanching properties when excited above a given laser power threshold, but they also continue to emit brightly even when the laser power is reduced below that threshold, and only turn off completely at very low laser powers. (Source: LBL)

A. Skripka et al.: Intrinsic optical bistability of photon avalanching nanocrystals, *Nat. Photon.* 19, 212 (2025); DOI: 10.1038/s41566-024-01577-x

<https://foundry.lbl.gov>

Lightening the load of augmented reality glasses

New design achieves a wider incident angle range compared to the previous limit

The adoption of wearable augmented reality (AR) devices has lagged over time due to the weight of the batteries and electronic components. An international team of scientists developed AR glasses with technology to receive images beamed from a projector, to resolve some of the existing limitations

of such glasses, such as their weight and bulk.

In previous designs, cameras could display clear images on light-receiving AR glasses that were angled only five degrees away from the light source. The scientists overcame this limitation by integrating a diffractive waveguide to control how light is directed in their light-receiving AR glasses, expanding the head orientation capacity from 5° to approximately 20° to 30°.

Specifically, the light-receiving mechanism of the team’s AR glasses is split into two components: screen and waveguide optics. First, projected light is received by a diffuser that uniformly directs light toward a lens focused on waveguides in the glasses’ material. This light first hits a diffractive waveguide, which moves the image light toward gratings located on the eye surface of the glasses. These gratings are responsible for extracting image light and

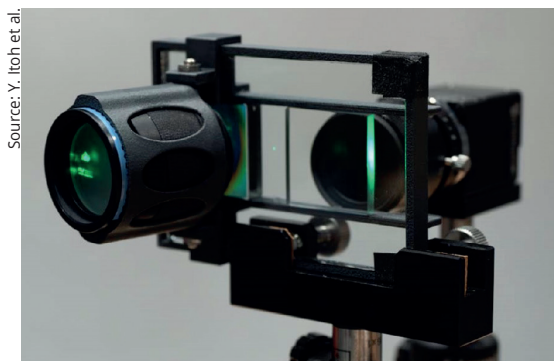
directing it to the user’s eyes to create an AR image.

The researchers created a prototype to test their technology, projecting a 7 mm image onto the receiving glasses from 1.5 m away using a laser-scanning projector angled between zero and 40° away from the projector.

Ideally, future testing setups will monitor the position of the light-receiving glasses, and steerable projectors will move and beam images to light-receiving AR glasses accordingly, further enhancing their utility in a three-dimensional environment. Different light sources with improved resolution can also be used to improve image quality. (Source: U. Tokyo)

Y. Itoh et al.: Slim Diffractive Waveguide Glasses for Beaming Displays with Enhanced Head Orientation Tolerance, *IEEE VR 2025* conference paper: March 8-12, 2025

<https://augvislab.github.io>



Source: Y. Itoh et al.
Thin optical receiving system for AR glasses. The system receives projected images from a dedicated projector placed in the environment and delivers AR visuals to the user

Quantum dots for lidar sensors

Silver telluride colloidal quantum dots for a better shortwave infrared photodetection

Applications for the shortwave infrared (SWIR) frequency regime include light detection and ranging (lidar), space localization and mapping, adverse weather imaging for surveillance and automotive safety, environmental monitoring, and many others. However, SWIR light is currently confined to niche areas, like scientific instrumentation and military use, mainly because SWIR photodetectors rely on expensive and difficult-to-manufacture materials. In the past few years, colloidal quantum dots have emerged as an alternative for mainstream consumer electronics.

While toxic heavy-metals have typically been used, quantum dots can also be made with environmentally friendly materials such as silver telluride (Ag_2Te). In fact, silver telluride colloidal quantum dots show device performance comparable to their toxic counterparts, but they are still in their infancy. Now, ICFO researchers Yongjie Wang, Hao Wu, Carmelita Rodà, Lucheng Peng, Nima Taghipour, and Miguel Dosil, led by Gerasimos Konstantatos, have demonstrated a new method to create silver telluride colloidal quantum dots that addresses these challenges. The team also developed the first proof-of-concept SWIR lidar using colloidal quantum dots made of non-toxic materials, successfully measuring distances over ten meters with decimeter resolution. The study marks a key step toward practical, cost-effective, and environmentally-friendly lidar systems for consumer and automotive markets.

Silver telluride colloidal quantum dots have traditionally faced three challenges: high dark current, limited linear dynamic range and response speed. For lidar applications, this ultimately limits the ability to detect distant objects, as greater distances or atmospheric interference lead to more signal attenuation. The linear dynamic range refers to the range between the minimum and maximum detectable light intensity. The wider the range, the higher is the contrast of the scene the SWIR detector can sense and visualize. Thirdly, the response speed of a photodetector measures how quickly it can react to changes in incident light intensity. A fast response facilitates accurate distance measurement and optical telecom, among other things.

The researchers drastically improved all three features compared to the previous record. Specifically, they achieved a dark current density of less than 500 nA/cm^2 , an external quantum efficiency at $1,400 \text{ nm}$ of 30 %, an LDR in excess of 150 dB and a time response as fast as 25 ns. These successful results encouraged them to build a proof-of-concept SWIR lidar, using, for the first time, colloidal quantum dots made of materials compliant with the “Restriction of Hazardous Substances” directive. The device measured distances over ten-meters with decimeter resolution.

Future research will focus on achieving even faster response times, higher quantum efficiency and more reliable operation under realistic temperature and humidity conditions. These advancements, including the present study, will bring us one step closer to the ultimate goal: a widespread adoption of SWIR light in consumer electronics.

Y. Wang et al.: Shortwave Infrared Light Detection and Ranging Using Silver Telluride Quantum Dots, *Adv. Mat.*, online 31 March 2025; DOI: 10.1002/adma.202500977

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Touching holograms

Threedimensional graphics in air can be manipulated with the hands



A 3D image of a car is grabbed and rotated by a user

Elodie Bouzbib from Public University of Navarra (UPNA) and her colleagues have succeeded, for the first time, in displaying threedimensional graphics in air that can be manipulated with the hands. “What we see in films and call holograms are typically volumetric displays,” says Bouzbib. “These are graphics that appear in mid-air and can be viewed from various angles without

the need to wear virtual reality glasses. They are called true 3D graphics.”

“Commercial prototypes of volumetric displays already exist, such as those from Voxon Photonics or Brightvox, but none allow for direct interaction with the holograms,” the team points out.

Volumetric displays have a fast oscillating sheet – a diffuser. Images are projected synchronously at high

speed – 2,880 images per second. Thanks to the persistence of vision, the images projected onto the diffuser at different heights are perceived as a complete volume. “The problem,” notes the research team, “is that the diffuser is usually rigid, and if it comes into contact with our hand while oscillating, it may break or cause injury.” To address this, the team has replaced the rigid diffuser with an elastic one after testing different materials for their optical and mechanical properties. The challenge is that “elastic materials deform and require image correction,” adds Bouzbib. (Source: UPNA).

E. Bouzbib et al.: FlexiVol: a Volumetric Display with an Elastic Diffuser to Enable Reach-Through Interaction, CHI Conf. Human Factors in Comp. Sys. (CHI '25), ACM SIGCHI, April 2025, Yokohama, Japan; DOI: 10.1145/3706598.3714315

<https://upnalab.com>

Doubling down on metasurfaces

Bilayer device of titanium dioxide can control many forms of polarized light

Almost a decade ago, Harvard engineers unveiled the world's first visible-spectrum metasurfaces. Now, researchers at the Harvard John A. Paulson School of Engineering and Applied Sciences (SEAS) are doubling down, literally, on metasurface technology by creating a bilayer metasurface, made of two stacked layers of titanium dioxide nanostructures. Under a microscope, the new device looks like a dense array of stepped skyscrapers.

After Federico Capasso's team reported their first working metalens that can bend visible light almost a

decade ago, they licensed the technology and started a company, Metalenz. They have since demonstrated a host of potential applications, including an endoscope, an artificial eye, and a telescope lens. However, the single-layer nanostructure design is limited. For example, previous metasurfaces put specific requirements on the manipulation of light's polarization in order to control the light's behavior.

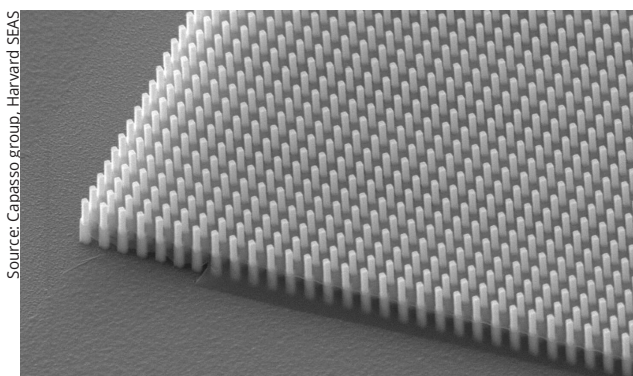
Using the facilities of the Center for Nanoscale Systems at Harvard, the team that included former postdoctoral researchers Ahmed Dorrah and

Joon-Suh Park has now come up with a fabrication process for freestanding, sturdy structures of two metasurfaces that hold strongly together but do not affect each other chemically. While such multi-level patterning has been common in the silicon semiconductor world, it had not been as well explored in optics and metaoptics.

To demonstrate the power of their device, the team devised an experiment in which they used their bilayer metalens to act on polarized light in the same way that a complicated system of waveplates and mirrors does. In future experiments, the team could expand into even more layers to exert control over other aspects of light, such as extreme broadband operation with high efficiency across the entire visible and near infrared spectrum, opening the door to even more sophisticated light-based functionalities. (Source: Harvard)

A. H. Dorrah et al.: Free-standing bilayer metasurfaces in the visible, *Nat. Commun.* 16, 3126 (2025); DOI: 10.1038/s41467-025-58205-7

<https://capasso.seas.harvard.edu>



A scanning electron microscope image of a bilayer titanium dioxide metasurface

EPIC honors members at its annual meeting

At the photonics association's assembly in Barcelona, awards were presented to the CEOs of NIL Technology, IMM Photonics, and the founder of Amplitude Laser



EPIC President Basil Garabet presents the EPIC CEO Award 2025 to Theodor Nielsen



Elizabeth Illy (l) and Estefania Cervantes (r) with award winner Christian Raith



Eric Mottay is presented with the EPIC Lifetime Achievement Award 2025

Source all images: EPIC

IMM Photonics with CEO Christian Raith is the winner of the inaugural European Photonics Industry Consortium's Sustainability Award 2025 for their outstanding contributions to environmental, social, and economic sustainability. Established in 1992, IMM Photonics specializes in the development and production of optical and optoelectronic components and modules, and since 2015 they have been pursuing a corporate policy of sustainability.

Theodor Nielsen, founder and CEO of NIL Technology is the recipient of the EPIC CEO Award 2025. The award recognizes Nielsen's outstanding leadership and contributions to the photonics industry, particularly in the manufacture of nanoscale, high-precision optical elements and components.

Eric Mottay was honored with the 2025 EPIC Lifetime Achievement Award for his outstanding contributions and leadership in develop-

ing ultrafast laser technologies and machine learning in laser microprocessing. After graduating from École Supérieure d'Optique near Paris in 1985, Mottay specialized in laser development and manufacturing, and in 2001 he founded Amplitude Laser. Under his leadership, the company became a global leader in ultrafast lasers, catering to scientific, medical, and industrial applications.

www.epic-photonics.com

EPIC welcomes new members to its board of directors

European Photonics Industry Consortium (EPIC) appointed CSO of Exosens and the President of CNR

At its 2025 annual general meeting, held in Barcelona, Spain, the European Photonics Industry Consortium (EPIC) appointed Claire Valentin, chief strategy officer at Exosens, as a new member of the association's board of directors.

Claire Valentin's strategic expertise is to strengthen EPIC's connections to high-growth photonics sectors –

defense, space, medical, and industrial applications – and help EPIC members navigate commercialization and business expansion. After graduating from the Institut d'Optique with a degree in engineering and optics in 1990, Claire spent ten years at the French Ministry of Defense managing R&D projects in electronics and optics. She then held

senior marketing positions at Alcatel Optronics, Thales, Essilor, Cimulec, and Sofradir – now Lynred. In 2021, she was appointed chief strategy officer at Photonis – rebranded as Exosens in 2023.

The second addition to the board is Maria Chiara Carrozza, president of CNR, the Italian national research council. Having served as the Italian Minister for Education and Research, and since 2021 as president of the Italian research council, Carrozza brings an impressive blend of academic, political, and industry expertise.

In 1994, Carrozza received a PhD in engineering from the Scuola Superiore Sant'Anna (SSSA), and since 2006, she has been a full professor. From 2007 to 2013 she was rector of SSSA, and between 2013 and 2014, she served as Italian Minister for Education and Research. In 2021, Carrozza was appointed President of the Italian National Research Council (CNR).

www.epic-photonics.com

Source: EPIC



Leading EPIC (l-r) Carlos Lee, Ulrike Helfferich, Nicoletta Casanova, Maria Chiara Carrozza, Shahida Imani, Adam Piotrowski, Claire Valentin, and Basil Garabet

Advancing photonics for defense and security

EPIC and Thales unite industry leaders in Palaiseau, France



Group photo of all attendees at the meeting held at the Thales facilities (Source: EPIC)

How can Europe build its strategic autonomy and collaborate effectively on the international stage? This was one of the recurring questions during the two-day 'EPIC Technology Meeting on Disruptive Optics at Thales' in April. It is clear this is a vital path forward, and many EPIC members – especially system integrators – are already leading the charge.

However, another major front also requires urgent attention: material autonomy. For example, it is challenging to source critical materials such as

Germanium or Gallium for sensors. It is evident that solving this difficulty requires a concerted effort from the entire ecosystem.

All the attendees openly exchanged ideas and projects during the meeting – something not often seen in forums focused on this topic. This openness reflects a strong willingness to collaborate on a broader scale.

It was exciting to see the real progress that companies are making! We saw impressive advancements in the application of innovative optics, from

the design and integration of meta-surfaces to developments in freeform optics. We also explored uses such as document security, which might seem niche but in fact holds real market potential for photonics companies. That session was particularly insightful for identifying growth levers.

We will meet again during Laser World of Photonics to continue the discussion on critical technology for Europe's security. Check the agenda of our upcoming events below.

<https://epic-photonics.com>

Save the date for EPIC upcoming events:

EPIC Events at Laser World of Photonics and World of Quantum 2025:

24 June 2025, Munich, Germany

- EPIC Meeting on Defense – Critical Technologies for Europe's Security at Laser World of Photonics
- Integrated Photonics Applications Stage at Laser World of Photonics

25 June 2025, Munich, Germany

- EPIC TechSession at World of Quantum – Insights Forum
- EPIC Technology Meeting on Innovative Optics: from Materials to Components at Laser World of Photonics
- Integrated Photonics Applications Stage at Laser World of Photonics
- EPIC Sustainability Workgroup Meeting at Laser World of Photonics
- EPIC Workgroup on HR Meeting at the Laser World of Photonics

- EPIC Coffee Break on Tariffs impact for photonics industry at Laser World of Photonics

26 June 2025, Munich, Germany

- EPIC CEO Exhibitor Breakfast at Laser World of Photonics
- EPIC Technology Workshop on Laser Micromachining Applications at Laser World of Photonics
- Integrated Photonics Applications Stage at Laser World of Photonics
- EPIC Marketing Coffee Break at Laser World of Photonics

27 June 2025, Munich, Germany

- Integrated Photonics Applications Stage at Laser World of Photonics
- Booth Tour for Young Talent at World of Quantum

- 7 July 2025, online event
EPIC Online Technology Meeting on Photonics for Smart Farming

- 15 July 2025, online event
EPIC Online Meeting discussing "What is the impact of US tariffs on the European photonics industry?"
- 8 September 2025, online event
EPIC Online Technology Meeting on Quantum Sensors
- 9–10 September 2025, Taipei
EPIC Members Delegation to Taiwan
- 10–11 September 2025, Milan, Italy
EPIC Technology Meeting on Industrial Laser Processes at Optoprism
- 15 September 2025, online event
EPIC Online Technology Meeting on Photonics for Mid-IR Developments for Spectroscopy, Sensing and Monitoring
- 16–18 September 2025, Bengaluru, India
EPIC Members Delegation to India

For the list of all events, visit

<https://epic-photonics.com/epic-events>



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“Our commitment to sustainability and social responsibility enhances our reputation”

Pascal Grahmert, managing director of Jabil Optics Germany, a provider of design and engineering services for opto-electronic devices from concept to mass production, talks to EPIC photonics technologies program manager Jérémy Picot-Clément.

Pascal, tell us a bit about your background and appointment at Jabil please.

Grahmert: I began my professional career in 2002 after completing my degree in industrial engineering at the University of Applied Sciences in Jena as assistant to the business unit direc-

tor at Schott, a specialty glass manufacturer. A few years later, I transitioned to Zeiss as a research and development controller in their display technologies unit. At this time, this business unit focused on developing and manufacturing optical engines for business projectors. In 2006, Zeiss entered a joint venture with Jabil to commercialize projection and display technologies. Jabil, a global player in engineering, supply chain, and manufacturing solutions, acquired full ownership in 2008. Sypro Optics was born, which was later re-branded as Jabil Optics Germany, and I was appointed managing director in 2017.

How is Jabil Optics Germany developing?

Grahmert: We leverage our expertise in optics to support customers in industrializing their products. We specialize in the miniaturization of optical components and the integration of complex optics into the smallest of spaces, particularly for AR and lidar applications. Our workforce has grown from around sixty employees at the time of the takeover by Jabil to around 120 employees today, and the trend is rising.

Globally recognized for our deep knowledge in advanced optics and dedication to engineering, design, and manufacturing excellence, Jabil Optics Germany is the

preferred partner for leading brands in the automotive, consumer, healthcare, and security industries. Our services include cutting-edge optical design, progressive process development, detailed supply chain management, and meticulous manufacturing, empowering us to meet our customers' most demanding challenges head-on. Our passion for optical innovation leads to new solutions and opportunities.

What challenges are you facing and how do you adapt to the staff's needs?

Grahmert: Integrating into Jabil's management structure and adapting to a new corporate culture presented unique opportunities for growth and learning. One of the key challenges was aligning operational strategies with Jabil's emphasis on quarterly financial performance. This required a shift in focus and the adoption of new business practices.

Successful cultural integration often involves understanding and bridging differences in values, work styles, and decision-making processes – open communication and collaboration were essential in navigating these differences. We fostered an environment where employees could share their perspectives and ideas, promoting a sense of unity and mutual respect.

Building trust and collaboration between teams was another important aspect. Encouraging cross-functional teamwork and celebrating successes helped to create a cohesive and inclusive workplace. Despite these challenges, we successfully aligned with Jabil's broader objectives, retaining key talent and maintaining a positive work culture. Our ability to adapt and embrace new practices has been a significant factor in our continued success.

What are the factors for your success in the market?

Grahmert: Our success is attributed to our skilled workforce, extensive experi-





Source all images: Jabil

Jabil Optics laboratories at their facilities in Jena, Germany

ence in optics, and deep understanding of what is needed to bring a product to a mass production phase. Our ability to solve the most difficult design and engineering challenges for our customers is a testament to our expertise and the dedication of our great team. Being part of a strong international company has provided access to a robust supply chain and strategic advantages.

Effective project management is another critical success factor. Based on our many years of working with start-ups and leading brands, we have focused on offering our customers agile project management tools, or rather the perfect customization of project management tools to their needs and requirements.

Innovation and continuous improvement are key to our success. By fostering a culture of creativity and encouraging the exploration of new ideas, we stay at the forefront of technological advancements. This approach not only drives growth but also helps us to develop cutting-edge solutions that meet the evolving needs of our customers.

Additionally, our commitment to sustainability and social responsibility enhances our reputation and attracts top talent. By engaging in community development and environmental initiatives, we demonstrate our dedication to making a positive impact beyond business.

What are your company's unique features and capabilities?

Grahnert: We stand out due to our comprehensive approach to optical engineering and manufacturing. We offer a full range of services from design

and prototyping to mass production. Our expertise in active alignment, a critical process to ensure precision in optical assemblies, sets us apart in the industry. We offer customized active alignment machines built in-house. Being part of Jabil's global network provides access to advanced manufacturing technologies and a robust supply chain, allowing us to deliver high-quality, scalable solutions to our customers.

We support various markets, including consumer electronics, automotive, industrial, and healthcare. Our expertise in AR technology, high-end cameras, and lidar-based ADAS applications has driven growth. We have also developed solutions for 3D sensing modules and miniaturized cameras for medical devices.

What is Jabil's approach to talent acquisition and recruitment?

Company

Jabil Optics Germany

Strategically located in 'Optics Valley', Jabil's Optical Technology group in Jena provides in-depth optics knowledge to customers worldwide. Customers leverage its proven expertise in miniaturized projection engines and specialized camera systems. By developing long-term relationships and collaborating on design, it creates a variety of differentiated products and helps customers grow their revenue and margins by skillfully combining design, engineering, and manufacturing services.

www.jabil.com

Grahnert: Jena is globally renowned for its rich optics history and is often called the 'Optics Valley'. Consequently, many optics companies are located in the area. Besides optics, Jena is also well-known for its e-commerce sector, leading to high competition for talent, so we have focused on enhancing our reputation and offering competitive benefits to attract top talent. Participation in local events and improved marketing efforts have increased our visibility. A positive work environment and strong management practices have further bolstered our reputation. We emphasize recruiting the right people and maintaining a collaborative work culture that values teamwork both internally and with customers. We also offer many employee benefits, such as reduced weekly working hours (36 instead of 40) to enhance the work-life balance. We engage in many volunteering initiatives too, like garbage collection, supporting local associations such as orphanages, attending local sports events, and others.

What is your personal advice for future entrepreneurs?

Grahnert: I advise aspiring entrepreneurs to remain open-minded and flexible, recognizing the importance of adaptability in a rapidly changing world. It is crucial to have a well-structured business plan that serves as a roadmap for success by outlining goals and strategies. But since no one can predict the future, it is important to realize from the outset that this plan will change depending on your activities and changing circumstances.

Securing adequate funding is also crucial because it provides the financial resources needed to turn ideas into reality. Engaging early with partners who are experts in their fields can offer valuable insights and support, helping to navigate challenges and to seize opportunities.

Building a capable team and fostering a positive reputation are also essential. Surrounding yourself with skilled and motivated individuals can drive innovation and ensure the successful execution of business strategies.

*

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Why the laser revolution is far from over

Andreas Tünnermann on the future of photonics: AI, quantum, and ever better fiber lasers

Source: FhIOF / Anna Schroll



While laser technology has reached maturity in some fields, it still is a game changer for many others. Professor Andreas Tünnermann, director of the Fraunhofer IOF, discusses how photonics is stepping into new roles by becoming a crucial enabler for AI, and why the evolution of fiber lasers is far from over.

Prof Dr Andreas Tünnermann, director of the Fraunhofer Institute for Applied Optics and Precision Engineering IOF in Jena

We have already seen a lot of political changes in 2025. What changes do you see in the photonics landscape, in research, and industry?

Tünnermann: The first thing I see is a certain maturity of laser technology. The laser has become the gold standard for many stages of material processing, in medicine or in data transfer to name just a few. We see lasers being used as a standard tool in battery welding or in data transmission on the Internet. The lasers in such cases have become commodities, sold with standardized specifications at ever lower prices.

For us as researchers, this has a lot of interesting consequences. For one, we work hand-in-hand with industry to improve laser systems and deliver more power, other wavelengths, or bet-

ter beam shapes. The same holds for any optical component or optical system. And we also see new applications arising and progress in various fields of photonic-related research.

We now have the chance to control single quantum systems, for example; we can use nano optical devices to control the optical function. With such advanced technological developments, we have the opportunity to start new developments that will have a great impact on different markets.

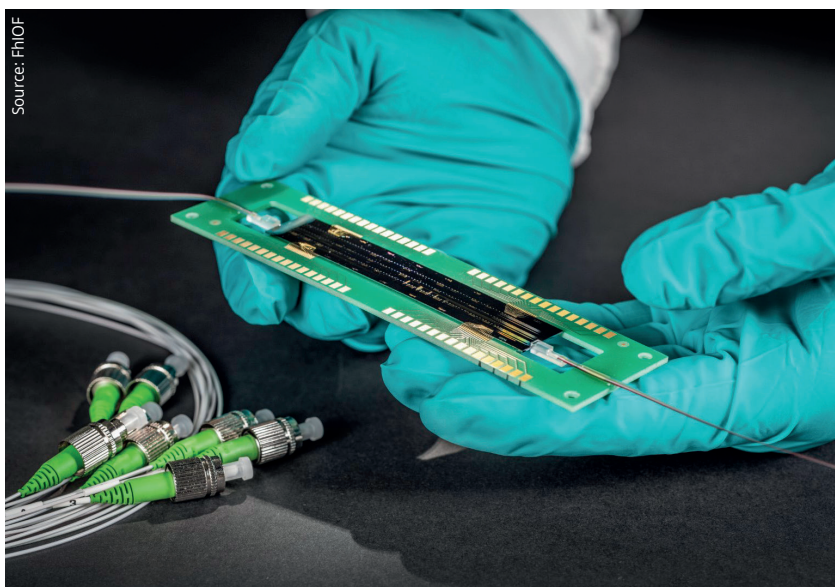
Many trends relate to manufacturing technology. In Europe, and in Germany particularly, we are developing the next generation of manufacturing technology where we will see collaborative production with machines and workers working hand-in-hand, based on the opportunities arising from new

sensors combined with AI technology. Integrated photonic technology will play a big role in the efficient acquisition of 3D data at the workplace and its efficient processing.

These are just a few examples – photonics is a lively field of research and development. The maturity of some of its core technologies is enabling more sophistication in research and many new industrial applications.

You mentioned AI, certainly one of the biggest current trends. How will photonics change under the influence of AI?

Tünnermann: AI offers new opportunities, for example in creative processes such as optical design where it can help to find optimal solutions in a multi parameter space. More importantly,



Photonic neuromorphic chips could solve the energy crisis in AI development

it will impact the control of processes, such as quality control during manufacture. Using automated microscopy, imaging, and deep learning, AI will help to identify parts of a wafer that are out of specification before the chips are sent through an expensive process to make laser diodes, for example.

AI affects whole value chains this way. You can think about digital twins taken by 3D technology: you may plan and test production lines with such digital twins; AI will analyze problems there in comparison with patterns from existing production lines; machines will be monitored and deviations there will be used to predict maintenance intervals. These ideas are already implemented in industry. For the future though, it will be very important to avoid a hype situation. We must track the real benefits of AI in its various areas of application. This will be important to get around a 'valley of death' that we have seen in other technologies.

If we change the viewpoint, photonic technologies might change AI developments. Could you comment on photonic chips and the opportunities that photonic technology opens up for AI?

Tünnermann: This is a huge area where I personally see that photonics will have a great impact on the development of AI technology, but also of advanced high performance computing. Current road maps for AI hardware development show a huge increase in energy consumption. This can be related to the conventional von Neumann archi-

ture of most AI processors that is effective for adding and storing data, but not for learning processes in neural networks. It was shown twenty years ago that neuromorphic computing schemes are more efficient, and this is something that fits very well with photonics, because the neuromorphic computing scheme can be realized in a purely photonic structure based on optical waveguides in photonic integrated circuits.

Photonic integrated circuits operate at the speed of light and with low energy loss. Therefore, photonic neuromorphic chips could solve the energy crisis in AI development. But there are still many questions to be answered: what kind of materials will we use, or how can we manage the efficient con-

nectivity of the photonic structures to the electronic world, for example? These aspects will be important drivers for photonic developments in the future. And I have to say, it is an area where we in Europe can be important partners for future developments, and it could also be a door opener for quantum computing systems.

Quantum technology has received a lot of funding. Where do we stand today in quantum technology and when will we see industrial systems using quantum technology?

Tünnermann: For quantum technology you have to run a marathon and then you will have a positive return on your investment in the future. The public attention in some areas has already declined, but we also see benefits for society and for the industry in applying these quantum technologies. It will be a long time for quantum computing, but also some fields of quantum sensing, before they can compete with conventional technology. The universal quantum computer will not be coming within the next decade, and it appears as if venture capitalists are reducing their investments because they have realized that this is not a short run.

That is a more general view. It is quite different if you look more closely at the field of quantum communication. There we have an established market. We see standards based on the quantum technology in communication systems evolving to provide high security levels. So we certainly passed the 'valley of death' there.



Digital twins (as seen in the background), taken by 3D sensors and supported by AI, may plan and test production lines

Quantum communication is evolving on the ground, in the air and in space. Space technology is extremely interesting these days because this goes beyond quantum communication. A completely new technology backbone is developing with the large satellite constellations. What do you think about the evolving opportunities for photonics with these large constellations?

Tünnermann: At Fraunhofer IOF, we have a long tradition in optical technology for space applications. First it was about calculating the position of a satellite by observing the stars; now it is about laser-based communication in space. In the most extreme case, such a device has to point a laser at another satellite passing by at 25,000 km/h.

Inter-satellite communication has used microwaves so far; laser communication will allow for much higher data rates. This technology has been developed to an industrial level. I guess there will be no satellite in the upcoming constellations without several laser communication terminals. And quantum technologies can give connections an ultimate level of encryption.

You are an expert on fiber lasers, which are the workhorses of laser materials processing today. Do you think fiber lasers are mature, or is there more to come? What potential do you see for fiber lasers?

Tünnermann: Indeed, I have been working on fiber laser systems since the early 1990s. It was interesting for me to see that this kind of old technology has evolved to such a level of maturity. Fiber laser development in recent years was on the one hand defined by



Source: fhIOF

In order to further research quantum technology specifically for applications in space, the latest research building of Fraunhofer IOF in Jena has its own optical ground station

the needs of manufacturing technology; on the other hand, it was related to challenges in optical communication systems. This resulted in systems with wavelengths around one micrometer because this is the most efficient way to generate coherent photons with a bright beam quality. For data transmission, we are talking about 1.5 micrometer technology because this matches the transmission bands of conventional optical fibers.

I think that we will see new developments in both areas. For example, we have the chance to realize low-loss optical fibers based on microstructured fiber technology – this will revolutionize the optical fiber networks. Such solutions expand the operational window for optical fibers. In combination with advanced optical amplifier systems, this would lead to much broader

data bands and higher data rates to be used in communication or data processing. We might see high-power systems with other wavelengths being used in production technology. They are also relevant for areas such as lithography or secondary sources: the interaction of a laser beam and the target material is more efficient if you go for longer wavelengths.

We are presently working on ultra-fast thulium-based systems at two micrometers with average powers in the range of several kilowatts. This wavelength increases the process efficiency of machining applications such as cutting. We will also have the chance to rethink the secondary sources that are used nowadays for EUV lithography based on fiber lasers at two microns, probably up to three micrometers, with a much higher overall system efficiency compared to today's CO₂ pump lasers.

And I think that coherent combination will give us the opportunity to increase the output power of the systems in cw operation, but also in pulsed operation, and far beyond the limits of single fibers. This would be important for scientific applications such as particle accelerators, laser fusion research or even gravitational wave detectors. New fiber lasers could do both, offering increased overall efficiency and wavelengths optimized for research. So I think fiber lasers have come a long way to where we see them today, but there is a lot more to come.

Andreas Tünnermann

Prof Dr Andreas Tünnermann is a German physicist and university lecturer. From 1992 to 1998, he headed the development department of the Laser Zentrum Hannover, and obtained his doctorate in 1997. In 1998, he accepted a professorship at the Friedrich Schiller University Jena as a professor of applied physics and took over the management of the Institute for Applied Physics. He has also been the director of the Fraunhofer Institute for Applied Optics and Precision Engineering IOF in Jena since 2003. He has received numerous awards for his outstanding achievements, including the Gottfried Wilhelm Leibniz Prize in 2005, the ERC Advanced Grant by the European Research Council in 2015, and the Cross of the Order of Merit of the Federal Republic of Germany in 2024.

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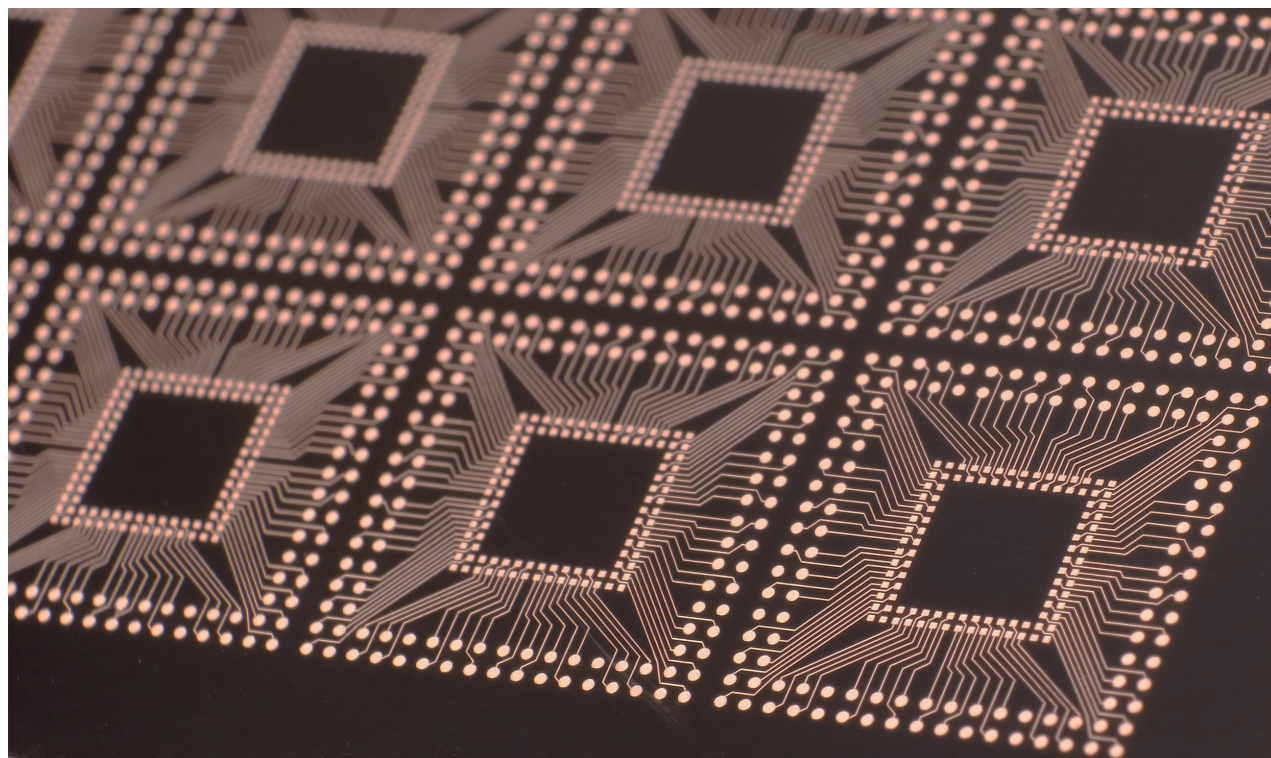
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Electronics on any surface

SSAIL brings innovations to chip packaging, displays, and PCBs

Valdemar Stankevič, Karolis Ratautas, Deividas Andriukaitis, Tadas Kildušis, and Oliver Rohm



Source all images: Topag

A constant challenge in the electronics and semiconductor industry is the ability to create micron-scale electrical traces. While photolithography has long been the standard approach, it comes with complexity and cost. Additive methods like inkjet printing are gaining traction due to their digital and flexible nature, but are currently limited to prototyping or small-scale use because of their slower process speeds. There is a clear need for a technology that combines high resolution and throughput with lower cost and process simplicity, one that can be offered by the SSAIL method.

Selective surface activation induced by laser (SSAIL) is a breakthrough technology for the electronics and semiconductor industry as it enables the creation of copper traces at a resolution of one micrometer and a throughput similar to lithography, but simplifying the process, reducing the cost, and being fully digital, similar to additive technologies. The high adhesion of SSAIL copper traces to any material also opens up new opportunities in displays (on glass or transparent films), chip packaging (on PI, ABE, EMC, Si) and PCB (on FR4, FR5) applications.

State of the art

SSAIL technology is an advanced hybrid technology, leveraging ultrashort-pulse laser surface modification combined with chemical activation and electroless metal deposition [1]. This process enables the direct metallization of non-conductive substrates, eliminating the need for complex photo-lithographic steps and reducing material waste.

The SSAIL process consists of three primary steps. First, an ultrashort-pulse laser selectively modifies the substrate surface, introducing microscale structural and chemical changes that prepare

▲ Fig. 1 Fan-out circuit on EMC material

it for subsequent activation. Next, the laser-modified regions undergo a catalytic activation process in which they are immersed in a solution containing metal precursors that selectively adhere only to the modified areas. Finally, a self-sustaining electroless process deposits a uniform copper layer only on the activated regions, creating conductive traces with exceptional precision. The main process steps are shown in Fig. 2.

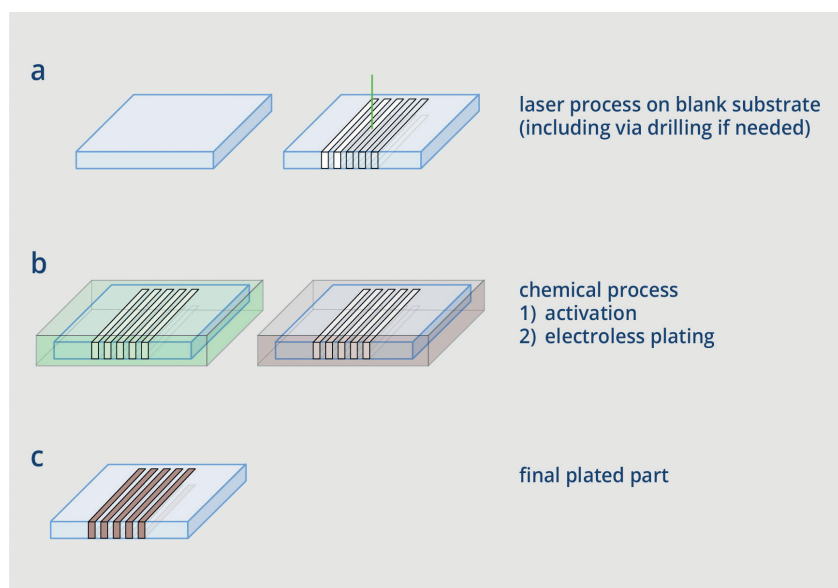


Fig. 2 SSAIL process steps. Each step is needed for SSAIL microtrace formation

Unlocking new possibilities

One of the major advantages of SSAIL technology is its precision and resolution. The ultrashort-pulse laser enables feature sizes down to 1 μm [2], making SSAIL ideal for high-density interconnects (HDI) and complex circuit designs. The process is highly selective and does not require photomasks or photoresists, reducing processing steps, cost, and the time to first part. Moreover, SSAIL can be used on a wide range of substrate materials including glass, ceramics, polymers, and semiconductor wafers, making it highly versatile for different applications. The resulting copper traces exhibit conductivity of 60 – 70 % of bulk copper, thermal stability, and mechanical robustness, which all

contribute to improved reliability and performance. Additionally, it is an eco-friendly manufacturing process because it eliminates the need for the harsh chemicals that are used in conventional photo-lithography or PCB production, thus reducing the environmental impact and promoting sustainability [3].

The versatility of SSAIL technology allows its application in multiple industries, including optoelectronic components where it enables the construction of high-precision conductive pathways for photonic integrated circuits (PICs) and laser diodes. In microelectronics and printed circuit board manufacturing, SSAIL facilitates ultraminiaturized circuit patterns for next-generation electronic devices [4]. Furthermore, SSAIL

supports the advancement of flexible and wearable electronics by enabling direct metallization on flexible substrates [5], paving the way for smart textiles and Internet of Things applications [6]. With its high precision, material versatility, and streamlined process, SSAIL technology is laying the foundation for the next generation of miniaturized, high-performance electronic systems.

Adhesion properties for different materials

The high adhesion force of copper to the substrate is one of the most advanced properties of the SSAIL method. The SSAIL technology achieves exceptionally high adhesion of metal layers due to a combination of chemical and physical mechanisms. The laser treatment induces localized chemical modifications on the dielectric surface, breaking molecular bonds and introducing functional groups such as hydroxyl (-OH) or carboxyl (-COOH). These newly-formed reactive sites enhance the chemical affinity between the substrate and the electroless plating solution, promoting strong covalent and coordination bonding with the deposited metal. The high-intensity laser process also selectively alters the surface roughness at the micro and nanoscale, creating anchoring sites that improve mechanical interlocking. This dual mechanism – chemical bonding through surface activation and physical adhesion via structured roughness – ensures superior adhesion compared to traditional metallization methods [1], making SSAIL

Companies

Ekspla

Celebrating its 30-year anniversary, Ekspla from Vilnius, Lithuania, designs and manufactures advanced laser systems. With a key strength in tailoring products to specific requirements, the company has gained recognition from eighty of the top one hundred universities worldwide. The main product line includes femtosecond, picosecond, and nanosecond lasers for industrial applications, as well as tunable wavelength, spectroscopy, and high-intensity laser systems for scientific applications.

www.ekspla.com

Akoneer

Akoneer is a Lithuanian company that has been designing and manufacturing laser micromachining systems for industrial and scientific applications since 2010. The company is based in Vilnius and creates laser micromachining systems for the electronics and semiconductor industries, as well as for the processing of hard materials such as composites, ceramics, and PCD. The highly customized micromachining workstations incorporate nanosecond, picosecond, and femtosecond laser sources in combination with advanced beam steering to achieve micrometer-scale machining precision and repeatability.

www.akoneer.com

Topag Lasertechnik

Topag represents leading international manufacturers and supplies high-quality pulsed laser systems, optical metrology, and precision optics for laboratories, research facilities, and industrial applications in Germany and Austria. Topag offers targeted consulting from procurement and installation to long-term support – far beyond commissioning. Topag's second pillar is the development and manufacture of its own beam-shaping optics, such as top hat generators and diffractive beam splitters and attenuators. It also realizes customized own optical systems specifically designed to their application.

www.topag.de

Meet us at Laser World of Photonics, Munich. Ekspla: Booth A2.203, Akoneer: Booth B3.216A, Topag: Booth A2.400



Fig. 3 Compact femtosecond laser FemtoLux with only two units – laser head and power supply unit

highly reliable for flexible electronics and advanced circuitry.

No.	Material	Adhesion strength
1	PEEK	36.10 N/mm ²
2	LCP	15.85 N/mm ²
3	Glass	25.23 N/mm ²
4	AlO ₂ ceramic	12.12 N/mm ²
5	PET	5.43 N/mm ²
6	EMC	17.30 N/mm ²
7	PI	18.51 N/mm ²

Table 1 Copper-plated adhesion properties of different materials

A flexible ultrashort laser for SSAIL

At the core of the SSAIL process lies an advanced femtosecond laser source that enables precise surface activation. The FemtoLux industrial femtosecond laser family is a reliable and versatile choice for this application, designed to meet the highest industry standards. Its innovative direct refrigerant cooling (DRC) system eliminates the need for water cooling, reducing maintenance, increasing reliability, and simplifying installation. The main features of FemtoLux include:

- Selectable wavelengths: 1,030, 515, and 343 nm
- Average power up to 50 W

- Pulse durations down to <350 fs
- Repetition rate up to 4 MHz
- Excellent beam quality ($M^2 < 1.2$)
- Excellent power stability (<0.5 % RMS)

FemtoLux can be optimized to meet specific processing requirements, with one example being customized femto-second/picosecond outputs at 1,030 nm, femtoseconds at 515 nm, and picoseconds at 515 nm. Especially at 515 nm, having separate femtosecond and picosecond outputs allows for optimized harmonic conversion, ensuring high pulse energies across different pulse regimes. This flexibility allows SSAIL users to optimize processing conditions for various materials, making FemtoLux a reliable and versatile solution for SSAIL.

Redistribution layer on glass substrate

The demonstrator of a redistribution layer for a chip package on a glass surface was fabricated using SSAIL technology, as shown in Fig. 2. The results of this study are significant for the new-generation semiconductor packaging industry.

The copper thickness can be precisely controlled by adjusting the plating time, with the copper bath plating rate set at 3 $\mu\text{m}/\text{h}$. The cross-sectional

analysis for quality inspection was performed using scanning electron microscopy (SEM) and focused ion beam (FIB) techniques to assess the thickness of the copper.

TGV metallization

A trending application in modern electronics is through-glass via (TGV) development. Glass is an attractive material due to its excellent electrical and mechanical properties, making it well-suited to high-density interconnect applications. However, successful integration of TGVs requires selective hole plating, which can be effectively achieved using SSAIL technology. To validate through-hole copper filling, an array of forty holes with a 0.5 mm pitch and $\sim 30 \mu\text{m}$ diameter was drilled into Eagle XG glass. The holes were initially plated, and individual contact pads were formed on the top surface of the sample. On the back surface, a continuous pad connecting all the holes was created, enabling the electrical testing of each via in the array.

Conclusions

Selective surface activation induced by laser (SSAIL) technology has significant potential across a broad spectrum of applications, effectively addressing current challenges and leveraging its unique advantages. Notably, SSAIL achieves high-resolution patterning down to 1 μm , enabling high-throughput processes suitable for scaling up to mass production in sectors such as display manufacturing, chip packaging, and the production of printed circuit boards (PCB) and flexible printed circuits (FPC). A significant advantage of SSAIL is the exceptional adhesion strength of the metal layers it produces. This superior adhesion results from a dual mechanism that combines chemical and mechanical bonding, offering a significant improvement over traditional metallization methods. Traditional methods often face challenges in ensuring strong adhesion between metal coatings and substrates, which can lead to issues like delamination or peeling. In contrast, SSAIL's approach enhances the durability and performance of the metallized components, making it a highly effective solution for advanced manufacturing needs.

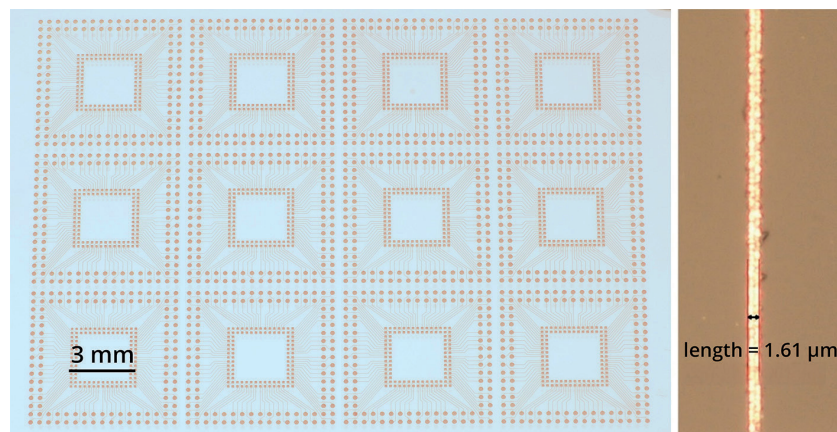


Fig. 4 Fan-out circuit demo on glass material fabricated using SSAIL

DOI 10.1002/phvs.202500014

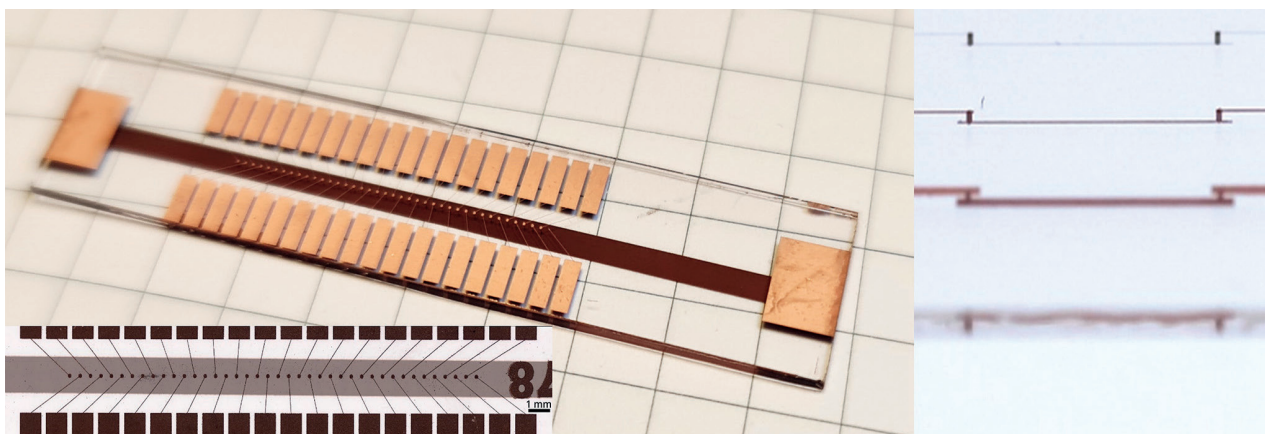


Fig. 5 Metal traces on glass surface connected with laser-processed and plated TGVs of 30 µm diameter

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on femtosecond lasers and micro-fabrication, particularly in industrial applications, he is actively involved in developing innovative femtosecond laser solutions tailored to the specific needs of industrial clients.

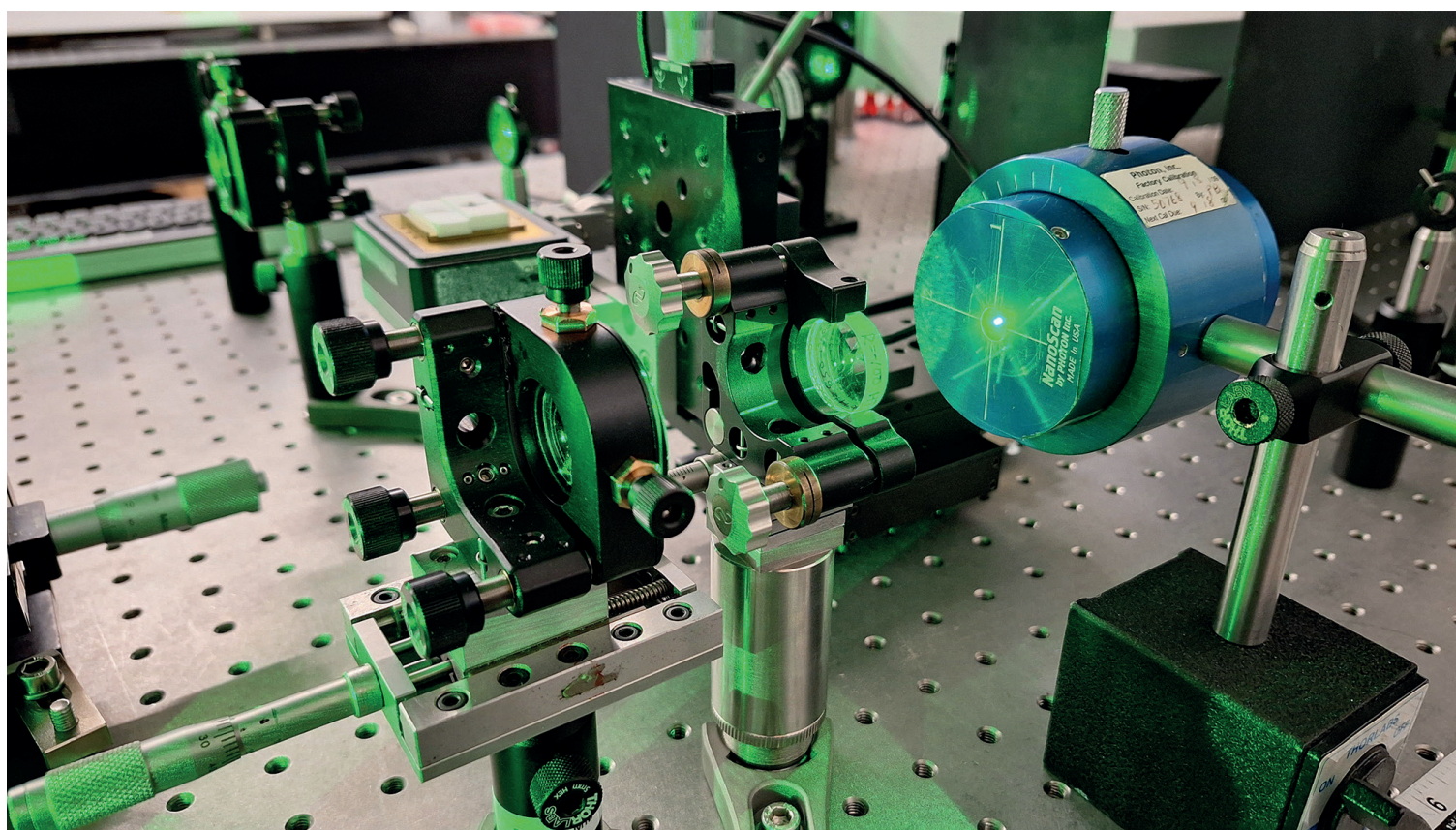
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Utmost flexibility paired with high accuracy

Researchers at ICFO rely on MKS measurement technology



Source all images: ICFO

The invention of the laser paved the way for numerous outstanding developments that have been revolutionizing our lives in many areas. The ongoing research and development as performed by ICFO adds even more options and alternatives to the broad range of existing photonics technologies. Key to all their developments is having accurate tools to measure the light and analyze the beam.

Developing optical parametric oscillators (OPOs) has been an important advancement in photonics as it enables the conversion of an input laser wavelength into widely tunable output radiation over expansive spectral regions. At the ICFO in Barcelona, research is ongoing to develop new light sources that deliver additional wavelength ranges, enable higher output power, or offer pulse durations in the picosecond range. The research team is led by Prof Dr Majid Ebrahim-Zadeh, the mastermind behind the industrial

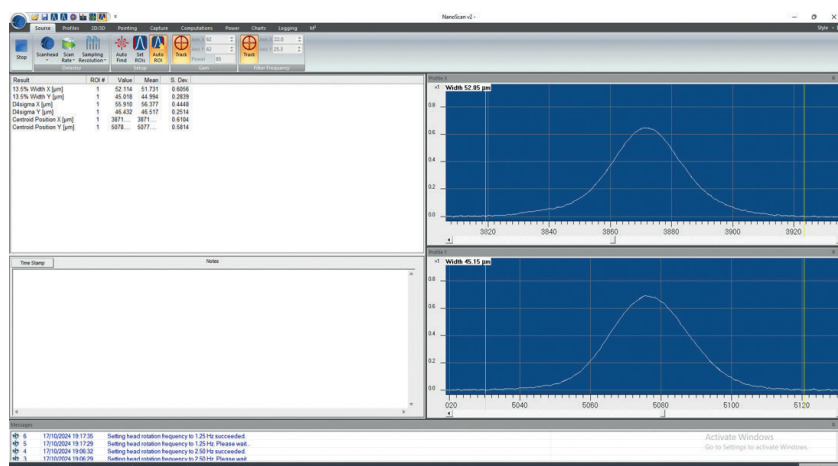
usage of OPOs. His world-leading innovation laid the groundwork for the development of new tools in a wide range of applications such as spectroscopy, imaging, microscopy, or biophotonics, and has had additional impact on research projects in multiple disciplines.

Over the years, the team of theoretical and experimental scientists at ICFO has relied on MKS technology through its Ophir laser measurement devices, above all the Ophir NanoScan Pyro profiling system.

▲ Setup of the Ophir NanoScan scanning-slit profiling system used in the OPO research lab at ICFO

Challenges right from the start

Key to all research and development by the OPO team at ICFO is having laser measurement technology at hand that offers both accurate and fast measurements. Due to the broad wavelength spectrum covered by OPOs, it



Using the Ophir NanoScan beam profiler to verify the Gaussian profile of the beam and to simplify the measurement of the beam diameter at the focus of a lens. Both types of information are crucial for the design of the optical cavity.

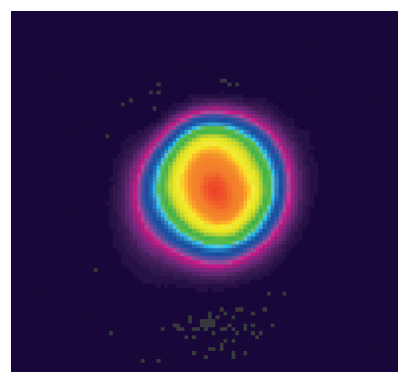
is also important that the measurement devices in the lab can be used over a large spectral range and for small beam waists. Dr Sukeert, a researcher in the OPO team, explains: “Especially when we start a research project with a new laser source, we need to measure quality parameters of the beam such as the M^2 and its beam waist. The Ophir NanoScan Pyro scanning-slit profiling system offers us the utmost flexibility as it covers the complete range of wavelengths in our lab and measures higher powers up to 100 W. It also works with high sensitivity and enables us to measure beam waists from 10 μm onwards.” In addition to its profiling capabilities, the Ophir profiling system measures M^2 using a software wizard. The lab team benefits from this option as it enables the laser sources being delivered to undergo an additional inspection.

The time spent on measurement is especially intense at the beginning of a project as the team needs to optimize the focusing optics to get the desired beam waist. The short measurement time of the NanoScan device pays off

during this critical part of the research, as Dr Sukeert outlines: “As we are working with nonlinear crystals, it is especially important to have an input laser with high beam quality parameters. With knife-edge technology, each measurement would take more than an hour. The Ophir NanoScan profiler, on the other hand, immediately delivers accurate measurement results.”

Measurement is essential

Once the beam waist has been optimized at the beginning of the research project by using the Ophir NanoScan device, it is important to measure the power and to visualize the beam within the duration of a project. The OPO research team also uses MKS measurement devices for this: different power sensors can be combined with an Ophir Vega power and energy meter. The main goal is to maximize the output power in most of the group's projects, which is why the power meters are heavily used. The team also visualizes the beam with an Ophir Pyrocam beam profiler. When it comes to



The ICFO OPO research team uses the Ophir Pyrocam device to visualize laser beams in the mid-infrared region, obtain the beam profile (e.g. Gaussian) and for example to measure the ellipticity of the beam.

the final stage of a project, the Ophir NanoScan device is frequently used to measure the output parameters of the newly developed system and the team is overall very happy with the results and insights that the devices deliver. Ebrahim-Zadeh says: “OPOs are established today as truly versatile and practical light sources across vast spectral regions and in all time scales. They offer a unique capability for addressing a wide range of scientific and technological applications. The need for reliable diagnostic equipment will be critical for the successful development of such systems, both in research labs and in the industry.”

Cooperation in many ways

ICFO's OPO research team has a long history of working with MKS' leading laser and photonics brands. In addition to the various Ophir laser measurement instruments in use, Prof Ebrahim-Zadeh works closely with Spectra-Physics laser engineers, and a variety of Newport optomechanical components are also used in the laboratory.

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Boosting efficiency and data quality – lasers for LIBS aluminum recycling

Flexible MOPA lasers from Neolase improve aluminum sorting speed and accuracy

Torsten Ledig



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Aluminum recycling is crucial for both economic and ecological reasons, offering significant energy savings and reducing raw material scarcity. Among various techniques for sorting aluminum scrap, laser-induced breakdown spectroscopy (LIBS) stands out for its rapid and precise identification of elemental composition. The MOPA approach from Neolase enhances LIBS performance by providing high energies and precise control over pulse parameters, improving data quality and sorting efficiency.

The importance of the recycling industry has heightened in recent years for both environmental and economic reasons. The transition to a sustainable, circular economy is progressing, aiming to minimize downcycling – reusing secondary materials below their original value. At the same time, pressure on supply chains, rising prices, and the scarcity of raw materials make recycled material an attractive, cost-effective, and readily available alternative. Recycling aluminum is particularly appealing due to its high value, widespread use, almost complete recyclability without loss of

properties, and significant energy savings.

However, avoiding downcycling requires scrap metal pieces to be precisely sorted into individual alloys. With aluminum, the differences in material composition between various classes are minimal but significantly impact selling prices. Accurate sorting also makes further processing and melting easier, resulting in higher product quality and, consequently, higher selling prices. To make this economically feasible, recycling companies need automated solutions for quick and accurate sorting.

Analyzing and sorting scrap aluminum

Analyzing the exact classes of the individual metal pieces is a challenging process. Besides the small differences in material composition, aluminum is often mixed with other metals during production, while paint, coatings, or dirt on the surface can make it even more difficult to determine the exact alloy. As available technologies for metal sorting usually detect only certain elements, they are often combined in a multistage process.

The first step is typically to isolate aluminum regardless of the exact class.

Contamination from iron, steel, or heavier metals can be removed by magnetic separation, which divides ferrous from non-ferrous metals, or density separation, which separates aluminum from heavier metals regardless of their ferrous content. X-ray transmission (XRT) is another technique that separates metals by density and thickness. If aluminum scrap needs to be extracted from a stream of mixed waste, eddy current separation can be employed. By generating eddy currents in the aluminum, a repelling force is created that separates the aluminum from other materials with different electrical conductivity.

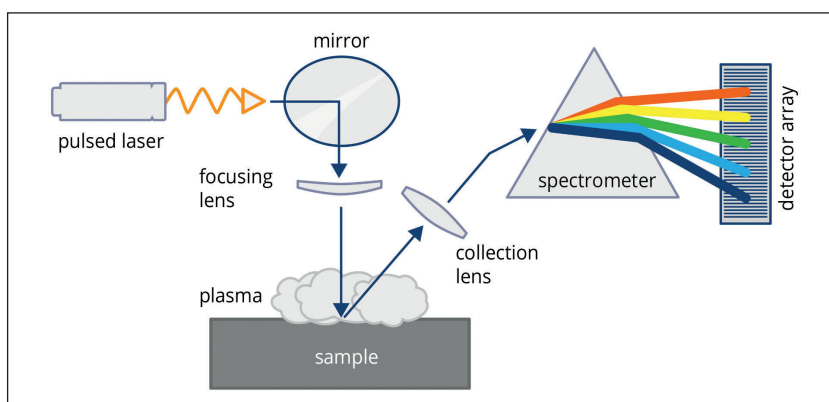
However, as all aluminum alloys are non-ferrous and have a similar density, further processing with different techniques is needed. X-ray fluorescence (XRF) analyzes the elemental composition of metals and works well for sorting different aluminum alloys. XRF is particularly useful to differentiate between various alloyed elements such as copper and zinc, which are both key components in many aluminum alloys.

Laser-induced breakdown spectroscopy (LIBS) is a rapid and precise method of identifying the elemental composition of metals, even in complex mixtures, by analyzing the light emitted from a plasma created by a focused laser pulse. LIBS is particularly useful for sorting metals with similar densities but different elemental compositions, such as various aluminum alloys. In contrast to XRF, LIBS is particularly useful to detect magnesium, another key component in many aluminum alloys.

As XRF and LIBS have their individual strengths in detecting different elements, they are often used in combination or sequentially. LIBS typically offers higher speed and accuracy, as XRF may require more time for analysis and may be less precise in detecting slight variations in alloys. LIBS is also less sensitive to surface contamination such as dirt, paint, or other coatings because the laser can reach the underlying metal for accurate data. XRF systems usually cannot match the accuracy of LIBS systems when analyzing light elements with low atomic numbers (e.g. Be, Li, Al, or Si) due to insufficient usable data.

Laser-induced breakdown spectroscopy

Typically, LIBS systems use a high-energy pulsed laser as the excitation source and focus the laser beam through a lens to generate plasma on the metal surface.



Schematic of a LIBS system

The plasma emits light, which is then collected through a lens and guided into a spectrometer. In the detector array, the spectrum of the light is analyzed to determine the exact alloy of the scrap metal. An automatic sorting mechanism then divides the different alloy classes either for one or more additional sorting procedures or for packing and shipping for further processing. Depending on the exact setup, techniques such as three-dimensional object recognition can also be employed.

Challenges for lasers in aluminum recycling

The main challenge for system providers is to realize fully automated sorting at a speed that allows profitable operation in scrapyards. This creates multiple requirements of the laser. First, the laser must be powerful enough to provide sufficient plasma generation, even on contaminated or coated surfaces. Second, a high repetition rate and high accuracy maximize the throughput in tons per hour, allowing the sorting machine to operate at sufficient speed and minimizing the need for repeated sorting runs. Third, the laser system needs to balance compactness for easy integration into the sorting machine with long-term stability and durability for continuous operation in a harsh environment, without deviations in accuracy or extended downtimes for maintenance.

Laser systems for LIBS sorting

Several laser technologies are available to solve these challenges. Q-switched lasers offer high peak power and short pulse duration, though with somewhat

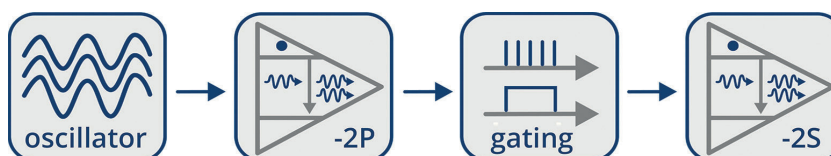
limited control over pulse parameters. Fiber lasers with high repetition rates and excellent beam quality are another option, but typically limited in peak power. Diode-pumped solid-state (DPSS) lasers are compact and provide high-quality beams. For LIBS purposes, the master oscillator and power amplifier (MOPA) architecture offers high energies and the most control over pulse duration and repetition rate, providing the highest flexibility to optimize the LIBS process.

For a concrete example of such a MOPA system, Neolase, an AMS Technologies company, uses a commercial fiber laser or a modulated laser diode as a seeder, combined with the company's own neoVAN DPSS amplifier modules and a modulator to gate the laser pulses into the application.

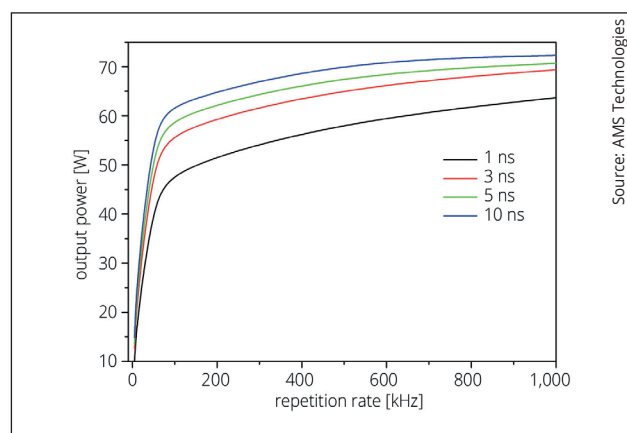
In a typical configuration suitable for LIBS-based aluminum recycling, such a MOPA system can achieve repetition rates up to 1 MHz, more than 1 MW peak power, and an output power of up to 75 W. Several millijoules of pulse energy and tunable pulse durations from about 5 to 100 ns enable a wide parameter range for different metal alloys.

Improving data quality and efficiency with MOPA lasers

The main advantage of DPSS amplifiers over fiber lasers is their higher pulse peak power, which is essential to create a strong plasma plume on the scrap pieces. Neolase has also been working on further optimizations that use the flexibility of the MOPA architecture and can significantly improve data quality and efficiency in the sorting process.



Flux diagram of the Neolase MOPA system



Repetition rate of the Neolase MOPA system



A neoMOS laser head from Neolase

A preablation pulse is an additional laser pulse immediately before the actual analysis pulse. It removes dirt, paint, and other coatings from the scrap metal pieces, helping to achieve a cleaner signal. This is only possible if the laser has a sufficiently high repetition rate to hit the same scrap piece twice in a very short time before the piece moves away on the conveyor belt. The spectrum of available wavelengths enables exact calibration for individual alloys, optimizing plasma generation and in turn leading to a more intense signal that is easier and more accurate to analyze.

Pulse shaping is another way to improve the signal quality. The pulse duration can be adjusted by the seed laser and further shaped by the gain dynamics of the amplifier stages. As a result, typical pulses will have a peak lasting a few nanoseconds, followed by a declining tail with an adjustable slope. For applications that require high peak power, this shaping helps to initiate the laser process and maintain it for a specific time, which can be adjusted by changing the trailing part. The benefit for LIBS is that the plasma plume remains stable for a longer time, resulting in a stronger and more intense signal that is easier to analyze and provides more accurate data.

Typical long term power stability has been determined to be <1 % RMS over an eight-hour period. This not only enables stable operation throughout the day but also allows for the exchange of information between several LIBS systems because the data quality is uniform and stable. This saves time and effort in calibrating the individual systems.

With a beam quality factor M^2 of less than 1.3 in all power modes and a beam roundness of more than 95 %, the necessary predictability of the laser beam propagation is ensured. The energy required to generate the plasma is strongly dependent upon the diameter of the beam focus: the smaller the focus diameter, the lower the pulse energy required to generate plasma, leading to higher fluence and a greater possible working distance.

Compactness and reliability

The compact system, based on the customized MOPA architecture from Neolase, has a footprint of only 617 × 412 mm. It includes a water cooler and a 4U laser electronic unit for parameter control. The system is controlled with neoCON software and complies with OPC-UA to set and monitor all relevant parameters. MOPA systems with DPSS amplifiers from Neolase are used

in various applications and have demonstrated long-term reliability, with some examples operating continuously for over ten years.

Conclusion

In conclusion, LIBS sorting, and particularly the use of DPSS amplifiers and MOPA architecture, significantly improves the efficiency and accuracy of aluminum recycling processes. By addressing challenges such as surface contamination and the need for precise sorting, these systems ensure higher quality recycled materials, contribute to a more sustainable circular economy, and help recycling companies to work profitably. The combination of compactness, reliability, and innovative techniques such as preablation pulses and pulse shaping positions these laser systems as essential tools for modern recycling operations. As the industry continues to evolve, these technologies will play a crucial role in meeting the growing demand for high-quality recycled aluminum.

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Company

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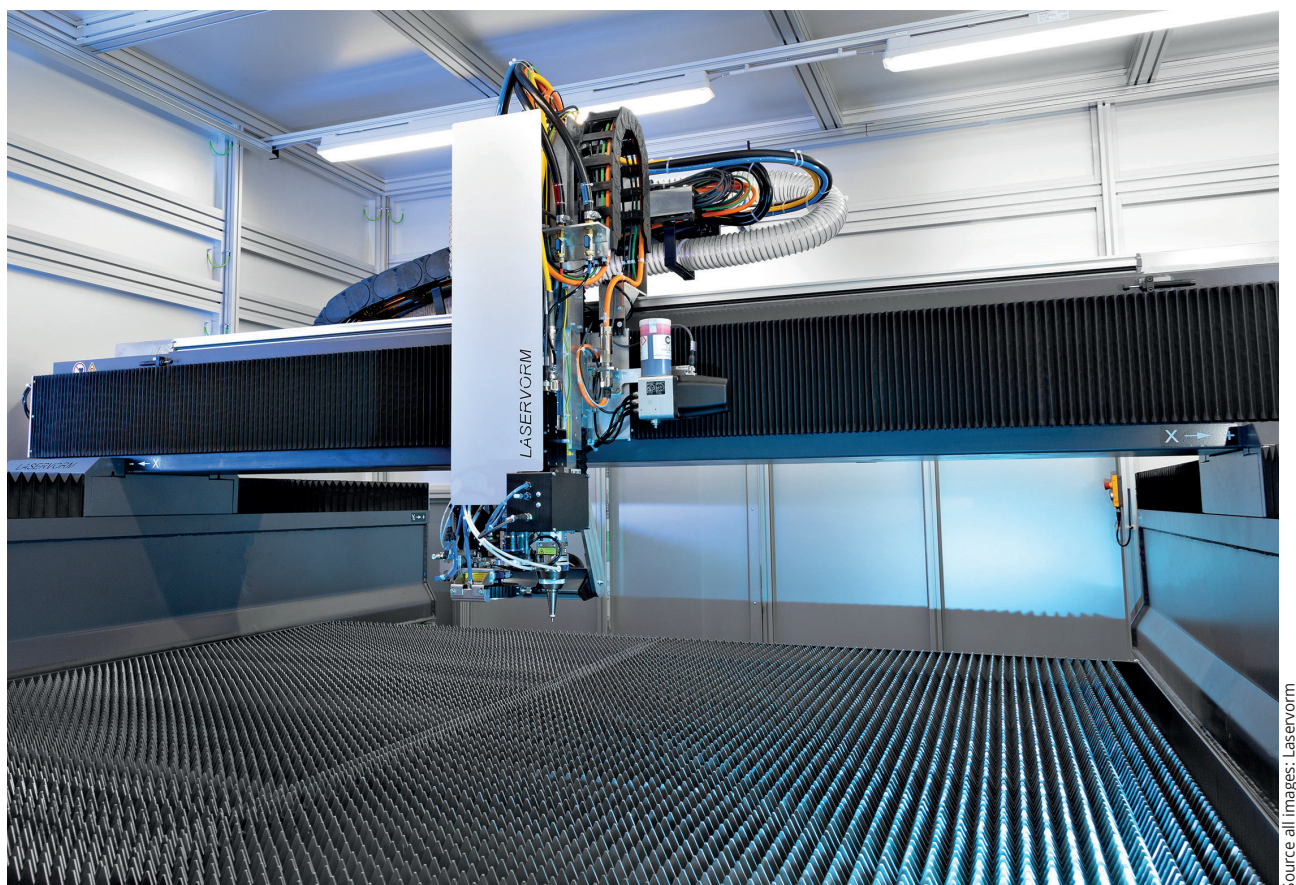
Torsten Ledig has more than two decades of professional experience with laser systems and optical solutions. He joined AMS Technologies in 2007 and has been promoted to senior sales manager for the optical technologies. He studied physics and did his doctorate in kinetic processes in gas discharges at the Friedrich Schiller University Jena (FSU).

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2 in 1: laser cutting and welding in one

Hiwin and Laservorm realize a real heavyweight



Source all images: Laservorm

The machine frame alone weighs seven tons, is one and a half meters high and three meters wide – not everyday dimensions for Laservorm, but still part of its daily routine. The laser machine manufacturer has delivered a universal tandem machine in a gantry system to its customer for alternate laser cutting and laser welding. Included in the delivery: drive technology from Hiwin.

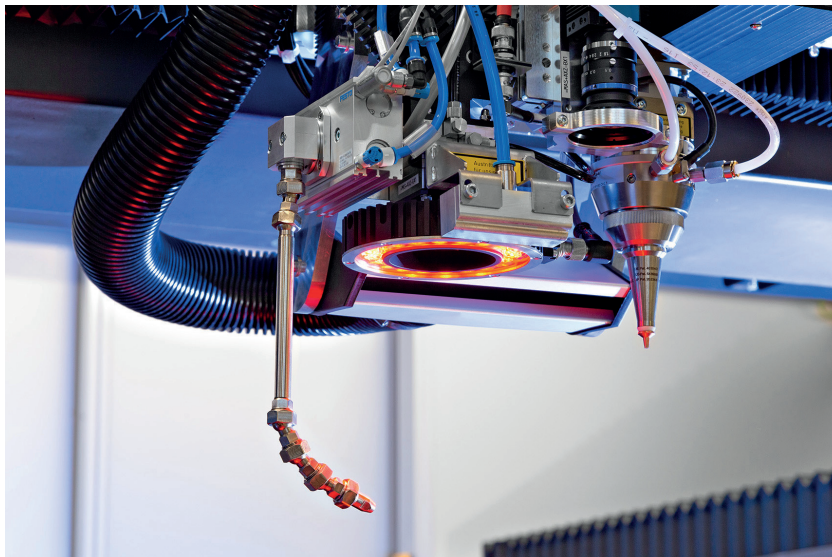
Laser machine construction, laser job order production, and laser machine servicing specializing in the processes of laser welding, laser hardening, and laser deposition welding – a wide range of services offered by the medium-sized family company Laservorm from Altmittweida in Saxony. “We process everything from single pieces to large series with our in-house contract manufacturing,” says Thomas Kimme, managing director of Laservorm. “Thanks to

our expertise, it makes sense to design and manufacture machines like these ourselves.” The recently developed, customer-specific special solution is used by a company that manufactures components for renewable energy.

“We have completely redesigned the x-y-z system, which is very compact for its tasks,” reports David Müller, design engineer at Laservorm. “The combination of laser welding and laser cutting in one machine is not an everyday occur-

▲ 2 in 1: Laservorm and Hiwin have combined laser cutting and laser welding into a universal tandem machine

rence. After all, the two processes have quite different requirements.” The greatest challenge was to combine the two processes into a single machine and in a working area of two by two meters. The solution was a combined laser welding and cutting system in a gantry design



A specially developed Laservorm spinscan technique is used for the welding optics

with a pallet changing system. Chain drives with cams and outriggers ensure that the pallet tables are moved alternately from the outside into the machine and back.

Hiwin as the number one point of contact

The gantry system is composed of an x-axis, two parallel synchronized y-axes and a z-axis. The portal carrier, which is made of steel, is manufactured in a complex and rigid sheet metal construction to ensure the high dynamic response that is essential for this application. Linear guideways and linear motors from

Hiwin are used in the x and y-axes, and the z-axis is also equipped with linear guideways and a ballscrew from the Offenburg-based motion technology specialist. “For more than twenty years, Hiwin has been our partner of choice when it comes to linear guideways,” says Thomas Kimme.

Hiwin linear guides from the HG, QHH and WEW series were installed. “The HG ball guide is the first choice for rail pairs like the ones we use in this application,” reports the Hiwin field representative. “With our SynchMotion technology, our HG series becomes the QH linear guide.” The technology

allows for higher processing speeds, longer relubrication intervals, and improved synchronous performance with lower operating noise. Three blocks are mounted on each of the y-axes to optimally distribute the masses and enormous tensile forces of the drives on the guide. Hiwin WEW guides are used to retract the pallet feeders and to close the machine doors. “Thanks to its rail width and low overall height, the extremely wide ball guide enables the highest moment load capacity, especially in the Mx direction,” says Hiwin’s sales representative, explaining the use of the installed series.

Linear motors from the LMFA series are installed to maintain high acceleration and precision in the parallel y-axis. “We decided on an individual axis design for individual linear motor components,” explains David Müller. “We use water-cooled linear motors, but we use them with convection cooling. We can achieve the required peak forces at this point with the powerful LMFA motors.” The built-in direct drives also achieve significantly higher precision compared to a purely mechanical component, which is why Laservorm decided to use synchronous linear motors here. “The sizing of the motors was done in close coordination with the application engineers from Hiwin. We rely on Hiwin’s expertise here,” says David Müller, looking back on the smooth project phase. Among other things, the installation location of the portal machine, with temperature differences of up to 20 °C, had to be taken into account during the design. Laservorm and Hiwin have therefore included automatic thermal expansion correction. “We are working here with a typical fixed-supported bearing method,” explains the Hiwin field representative.

“We are very grateful for the consistently competent exchange with Hiwin,” acknowledges Laservorm designer David Müller. “And the short delivery times, along with the top-notch service, are major advantages that Hiwin offers as a supplier,” adds Laservorm’s managing director Thomas Kimme. “We have had other experiences during our company history. In special machine construction, such services are of absolute importance.”

Special machine from A to Z

Always prepared for special cases, the laser machine manufacturer is also continuously expanding its expertise

Companies

Laservorm

The business of Laservorm falls under the heading ‘Lasers in material processing’. The medium-sized family-owned company is active in three main business areas: laser machine construction, laser job order production, and service for laser machines, specializing in the processes of laser welding, laser hardening, and laser deposition welding. Laservorm offers its customers solutions from a single source, from technology development to the start of production, as well as services – for the entire service life of the machine.

www.laservorm.com

Hiwin

Hiwin creates and drives motion – with its products and its mindset. Specializing in standardized and customized drive technology products, they made it their business to find the right and most efficient way to get things moving worldwide, from medical technology to photovoltaics, from machine tools to automotive to batteries. The product portfolio includes ballscrews, linear guideways, linear axes, linear motors and servo drives, as well as complete positioning and motion systems, all from a single source, with manufacturing sites in Germany, Europe, and around the world.

www.hiwin.de



Hiwin supplies linear guideways and linear motors for the construction of the 10-ton portal machine

in laser and optical concepts. “The combination of laser welding and laser cutting was challenging, especially in an optical design,” says designer Müller. “We configured and designed laser components that we bought in-house.” This resulted in two different laser optics with different focal point positions for the portal machine. An additional focus adjustment along the z-axis (focus shifter) makes the focal point of the optics variable. A beam switch developed in-house switches the laser light between the two beam paths. A specially developed Laservorm spinscan technique is used for the welding optics: it enables two-dimensional deflection of the beam and simultaneous power modulation, which can bridge large gaps during the joining process, for example. “The built-in combination of spinscan and focus shifter offers outstanding technological freedom for welding applications,” says David Müller. It provides many options for challenging joining processes with small contact surfaces and high gap dimensions, and contributes significantly to a uniform and stable weld.

Miniature guides from Hiwin are also used in the beam switch: “We have installed our miniature guide, which is part of our MG series and is sometimes no larger than a paperclip, in order to position the switch precisely and with high repetition accuracy,” adds Hiwin’s sales representative to David Müller’s explanations. Laservorm also develops and programs the control software for

its systems itself: “We use a central control system to ensure that our systems work together in sync, just like a good orchestra,” says Thomas Kimme, adding to the laser specialist’s expertise.

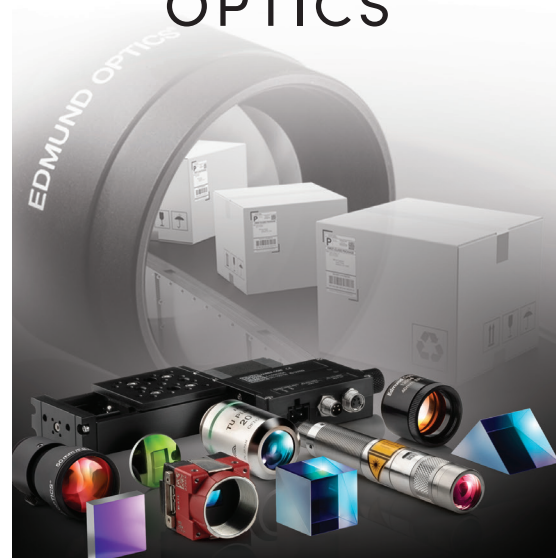
In addition to the very successful stroke / length ratio of this machine – especially the y-axis (2,120 / 3,000) – and the compatibility of the two laser cutting and welding processes, the integrated large-volume extraction system is also worthy of mention. “The requirements for the purity of the filtered exhaust gases, which are contaminated with particles hazardous to health, are particularly high here,” reports David Müller. “We now have an extraction capacity of 10,000 cubic meters per hour. That is quite something.”

Together with the drive technology specialist Hiwin, Laservorm has set up a real heavyweight in a new dimension here. Both companies have been in business for more than thirty years and can look back on long and successful cooperation. “This was certainly not the last major project that we have realized together,” says Thomas Kimme with a wink.

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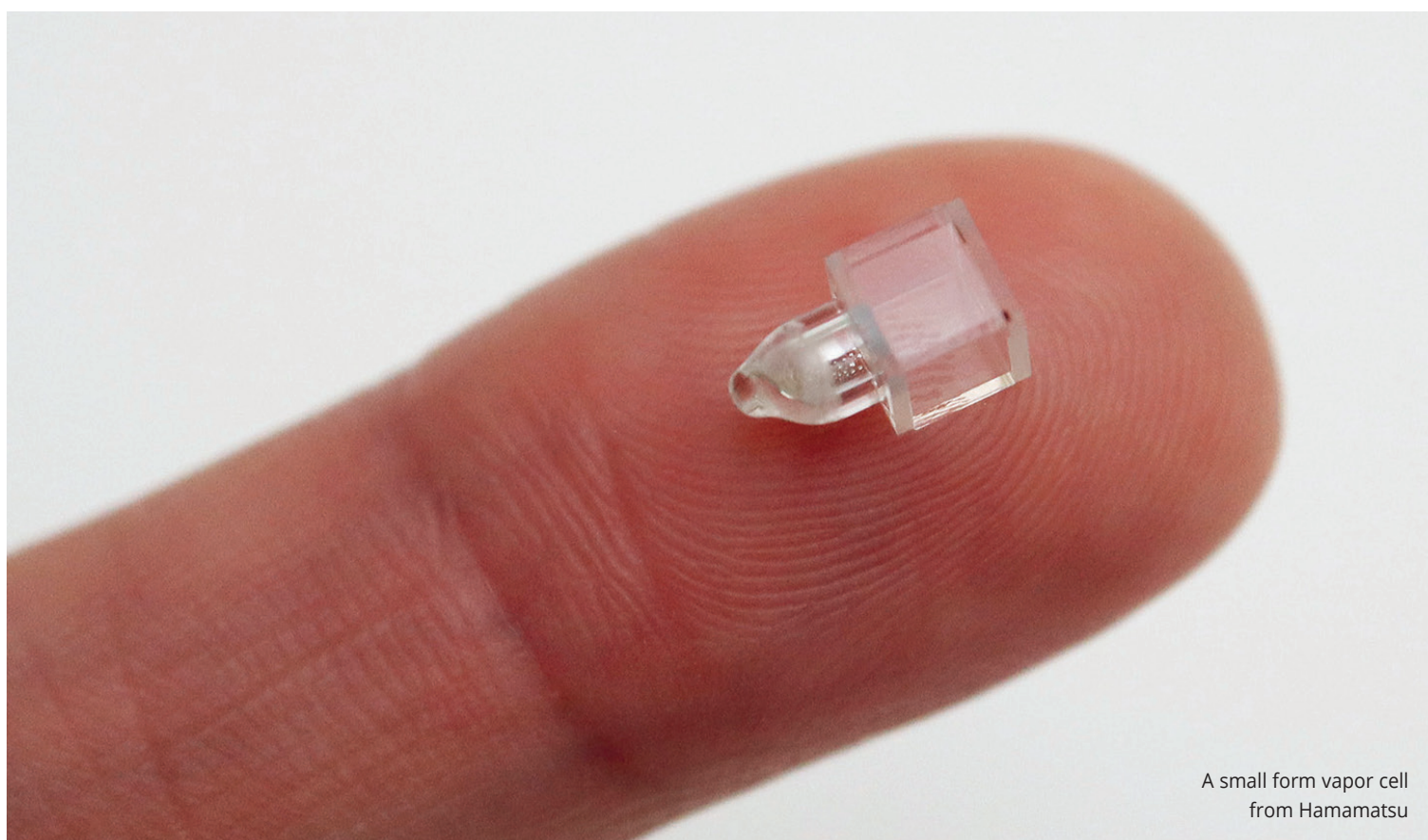
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Photonics – a key enabling technology in the quantum world

Inside Hamamatsu Photonics' expanding portfolio of quantum technology

Naveen Balla



Source all images: Hamamatsu Photonics

A small form vapor cell from Hamamatsu

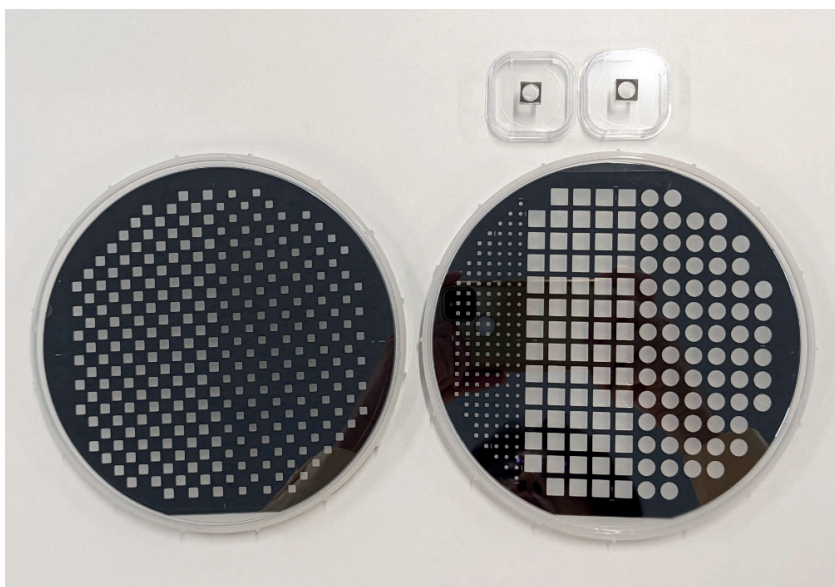
Photonics plays a vital role in enabling quantum technologies across computing, sensing, and secure communication. This article explores Hamamatsu Photonics' expanding portfolio, from vapor cell-based sensors to advanced lasers and imaging systems. It highlights how the company's innovations are helping to bridge the gap between research and real-world quantum applications.

The transition of quantum technology from research labs to industrial applications has been phenomenal in recent years. This trend is clearly reflected in public funding, venture capital investments, and patent applications for quantum applications [1]. Broadly, quantum technology refers to a collection of innovations that exploit quantum phenomena like entanglement,

tunneling, and superposition to achieve tangible outcomes beyond limits set by classical systems. A few relatable examples include:

- quantum computers that can solve complex problems faster than present-day supercomputers,
- high-precision time measurement for the synchronization of communications,
- measurement of minute magnetic fields using sensors that fit in the palm of your hand rather than occupying an entire room,
- secure communications that are practically immune to interception.

Central to all these quantum technologies is a medium that exhibits quantized behavior. In neutral atom computing,



Hamamatsu's wafer-based vapor cells

this medium consists of a collection of trapped atoms; in ion computing, it comprises trapped ions; in certain types of atomic clocks, it is a collection of alkali atoms in vapor phase. Photonics technology plays a crucial role in interacting with and manipulating these delicate quantum media while also exhibiting quantized behavior and acting as a reliable carrier of information for networks of quantum devices. In other instances, such as in photonic quantum computing or quantum communications, individual photons themselves act as the quantized medium. In addition, photons can transfer information over long distances with minimal losses compared to electrons, and they are unaffected by electromagnetic fields. In essence, photonics is integral to the advancement of several quantum technologies.

A trusted partner in quantum technology

Hamamatsu Photonics has been a trusted partner of the scientific research community since its inception. As a result, the company has developed some of the best photonic technologies available today, and continues to lead on this path. At the same time, Hamamatsu is no stranger to the requirements of industrial, medical, and semiconductor applications, which are also key markets for the company. High-volume production and quality control of robust optoelectronic products and systems are an integral part of Hamamatsu's business. With its legacy, expertise, and capabilities, Hamamatsu Photonics is well-po-

sitioned to be a photonics partner in the development of quantum technologies.

Vapor cell technology: a key contribution to quantum innovation

Shining examples of Hamamatsu's contribution to quantum technology are its vapor cell products. In the photonics world, Hamamatsu Photonics is synonymous with photomultiplier tubes (PMTs) that are based on vacuum tube technology. Building on this legacy, the company has developed deep expertise in manufacturing vapor cells of different shapes and sizes, with different coatings, and containing diverse trapped alkali vapors and buffer gases.

When combined with light sources, detectors, optical elements, and electronics, these vapor cells can be molded into quantum sensors for specific applications. Hamamatsu recently presented its optically pumped magnetometer (OPM) at Photonics West 2025 based on this vapor cell technology [2]. This OPM, packed into a compact volume of less than 8.5 cm³, boasts a magnetic field sensitivity of 20 fT/√Hz, making it suitable for biomedical functional imaging [3].

Hamamatsu is working with Cerca Magnetics [4], a startup from the University of Nottingham, to commercialize OPM for magnetoencephalography (MEG), which non-invasively maps neuronal activity of the brain. The compact size of OPMs allows them to be assembled onto a 3D-printed headset, making MEG measurements more lightweight, portable, and comfortable

for patients. OPM revolutionizes MEG measurements when one compares it to the existing MEG machinery that relies on a large, liquid helium-based magnetic sensor. Hamamatsu's OPM technology will be on display along with the core vapor cell technology at Hamamatsu's booth at the Laser World of Photonics 2025 in Munich. Hamamatsu is also in the process of developing other types of quantum sensors based on the core vapor cell technology and is open to industrial collaborations.

Beyond vapor cells: Hamamatsu's extensive quantum portfolio

Hamamatsu's contributions to quantum technology extends beyond vapor cell technology. While not all of these can be listed here, a few notable innovations can be highlighted –

- **Liquid crystal on silicon spatial light modulators (LCOS SLMs):** These modulators are used to trap large numbers of atoms for neutral atom computing applications. Hamamatsu's LCOS SLMs are known for their low phase jitter, which ensures stable traps, and their high laser power handling capability, which aids in scaling up the power of quantum computers.
- **High-speed, low-noise cameras for qubit readout:** Neutral atom computers require constant monitoring of trap stability and qubit states during operation, both of which are accomplished using high-speed low-noise cameras from Hamamatsu. The

Company

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OPM detection heads for
MEG application

latest innovation, qCMOS technology, has been particularly disruptive in providing a unique combination of precision, speed, and resolution. Whether diagnosing and reading out ion or neutral atom traps or determining the precise number of photons absorbed in a given pixel for a quantum imaging setup, the ORCA camera series offers the right solution. Hamamatsu recently partnered with Quantum Machines to integrate ORCA cameras into their quantum computing hardware [5].

- **Single-frequency lasers for quantum state manipulation:** Single-frequency lasers are used to manipulate quantum states in neutral atom computers, ion computers, atomic clocks, and other quantum systems. With the acquisition of NKT Photonics,

Hamamatsu now offers a range of single-frequency, mode-hop-free, and ultrastable fiber lasers. The Koheras HARMONIK HP series provides high-power UV and VIS fiber lasers, known for their narrow linewidth light and industrial reliability. They also have a robust design, low noise, and high OSNR, and are ideal for quantum computing, sensing, metrology, and communications.

Commitment to quantum innovation and collaboration

Hamamatsu's commitment to advancing quantum technology is evident through these innovations and partnerships. Beyond these examples, the company continues to develop cutting-edge photonic solutions tailored for quantum applications.

Our engineers are always keen to discuss these technologies as well as custom solutions through one-to-one interactions. If you would like to explore collaboration opportunities or learn more about our offerings, please reach out to us at info@hamamatsu.eu and drop by our booth at the Laser World of Photonics this June at the Messe Munich.

*

Naveen Balla would like to humbly acknowledge the input of his Hamamatsu colleagues in the preparation of this article.

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Naveen Balla has been working with Hamamatsu Photonics Europe for nearly five years. Before joining Hamamatsu, he spent 13 years in photonics research. At Hamamatsu, Dr Balla manages a range of product families, mainly from the laser division. This involves formulating business development strategies based on detailed analyses of technologies, applications, value chains, and market reports. He also participates in the development of new applications and the pursuit of new technologies at Hamamatsu.

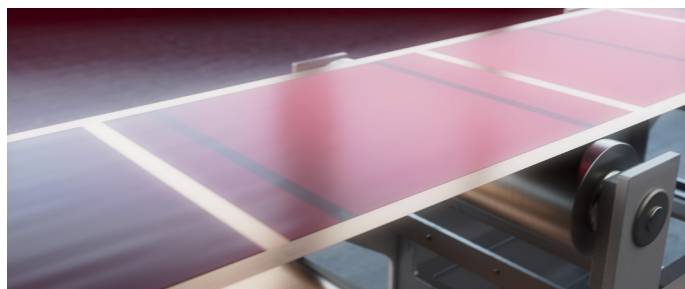


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Direct Diode Lasers The Future of Heat Treatment

Heat treatment with direct diode lasers as an alternative to convection ovens? What was hardly considered until recently could well be the future. Rising energy costs and stricter climate protection regulations are increasingly calling the economic and ecological viability of oven processes into question – especially where ovens still rely on fossil fuels. As a result, the search for alternatives has intensified for traditional oven-based heat treatments such as battery electrode drying, curing polymer coatings and powder coatings, wafer annealing, and sintering.



New Standards in Energy Efficiency

Modern direct diode lasers, such as the Laserline LDL systems, open up new possibilities in this area. They combine sustainability and cost-effectiveness with excellent process results and can be used both for purely laser-based processes and for hybrid processes that combine laser and oven technologies. The technological approach itself is not new. Laserline developed direct diode laser systems around 25 years ago, which are still in operation today. This approach was also used later, for example in composite manufacturing. However, the new LDL direct diode lasers now offer a previously unknown level of flexibility, enabling an even broader range of applications.

A key advantage of all direct diode lasers is that they eliminate the need for fiber and the associated power losses. This reduces acquisition and

operating costs, increases reliability, and simplifies system integration. In addition, Laserline LDL systems set new standards in efficiency: The direct photon emission of the diode edge emitters used achieves a wall-plug efficiency of over 56 percent. Furthermore, the LDL direct diode lasers support both remote processes (over 1000 mm) and very small working distances of just 300 mm. Combined with the highly compact design of the lasers, this allows for direct integration into existing oven systems. As a result, retrofit solutions can be implemented that allow the use of direct diode lasers while continuing to use existing systems.

Modular System Architecture, Highly Flexible Beam Shaping

The flexibility of Laserline LDL direct diode lasers is further enhanced by their modular system architecture and the wide range of beam shaping options offered by the integrated optics. The lasers are available with output powers ranging from 10 to over 34 kW and can be controlled within milliseconds between 10 and 100 percent of their power. Integrated beam shape control makes it possible to independently control the output of one to more than eight irradiation modules. This spot-trimming function paves the way for customized and demand-optimized energy distribution, which either ensures uniform intensity distribution across the entire spot or enables targeted intensity increases at the center or edges. These versatile options allow the laser system to be precisely adapted to a wide range of process requirements.



The new Laserline LDL direct diode lasers provide users with laser solutions that offer a genuine alternative or addition to conventional oven processes. By integrating process monitoring tools such as external pyrometers for closed-loop temperature control, energy efficiency, flexibility, and process quality can be further enhanced. Laserline LDL direct diode lasers thus mark a decisive step toward sustainable heat treatment processes.

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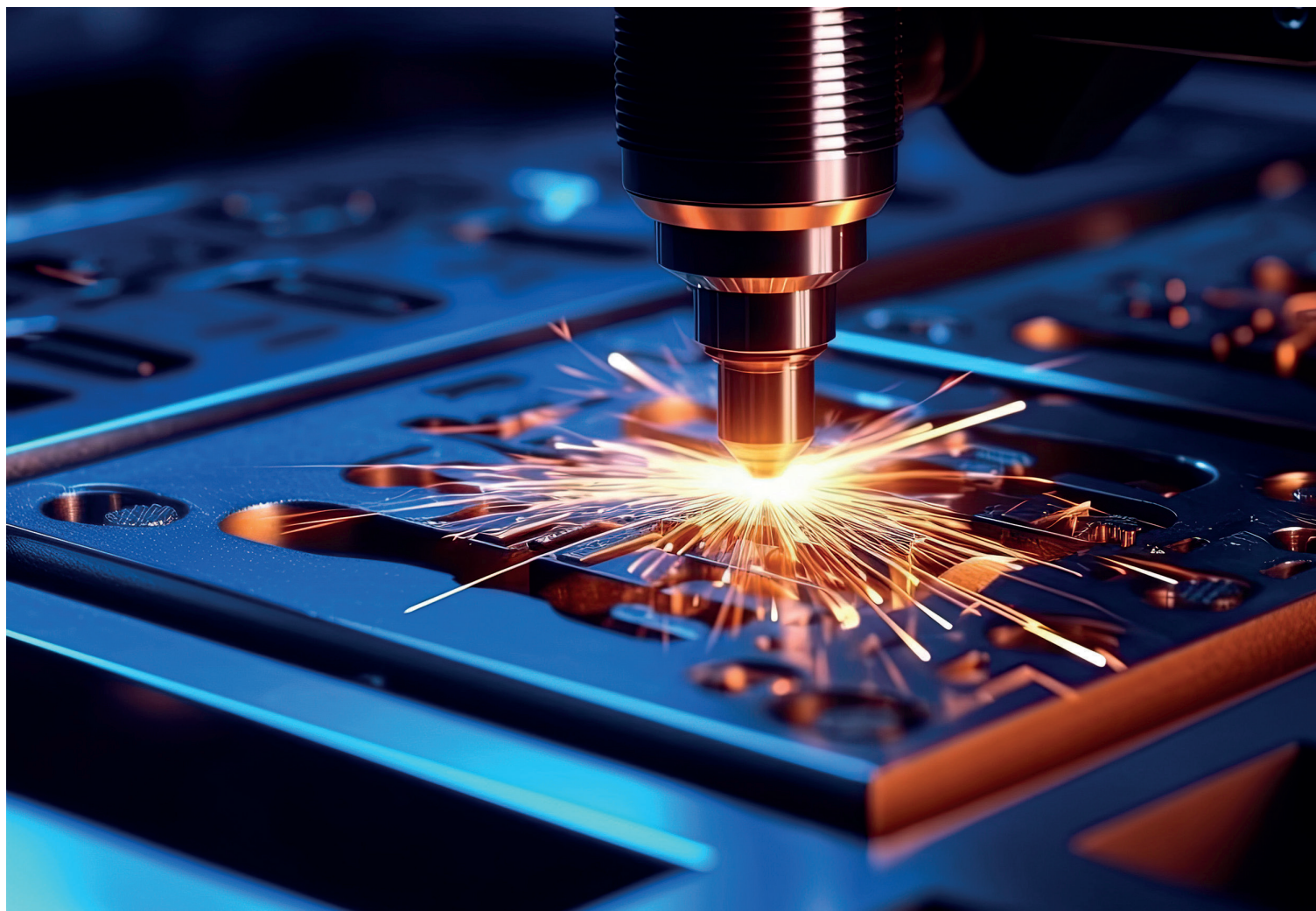
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Why laser beam shape matters

The performance of laser systems is significantly affected by the laser's beam shape

Anna Hetzelt & Sara Castillo



Source: Livinsky - stock.adobe.com

Laser beam shaping refers to the process of altering the spatial distribution of a laser beam's intensity to achieve a desired irradiance profile at a target plane. This manipulation is an essential step in ensuring the beam's characteristics align with the specific requirements of the application. Various approaches, such as the use of refractive and diffractive optical elements, are used to reshape the beam while maintaining efficiency.

The shape of a laser beam, especially when used in material processing or medical applications, plays a pivotal role. The beam's shape directly influences the interaction with the material in applications such as laser welding, cutting,

drilling, and cleaning, and therefore the quality, precision, and efficiency of the process. Depending on the application, the interaction with the material can be the absorption of energy in the material, or the melting, vaporization, or sublima-

▲ In laser material processing, the correct shape of the laser beam is essential for reliable and accurate results. Beam shaping optics are available to define a well-shaped beam

tion of the material targeted by the laser beam. Results are more predictable and accurate with a beam shape tailored to the application at hand, and the cuts and edges produced by the beam are sharper and more precise. In medical applications, procedures such as laser eye surgery and dermatological treatments also rely on precise beam profiles to ensure patient safety and optimal results. If tissue needs to be removed, it is key for the success of the procedure and the well-being of the patient that only the affected tissue is irradiated by the laser, leaving healthy tissue intact. However, introducing a beam shaping element increases system complexity and cost, so it is important to take all application requirements into consideration when planning a laser system. An overview of the most commonly used beam shapes is provided here, along with a closer look at the different optics that can be utilized for laser beam shaping.

Common laser beam shapes and their use

When a beam leaves the laser cavity, the spatial intensity distribution is typically a Gaussian distribution. This is a nonuniform distribution of energy with the highest intensity in the middle of the beam and a lower intensity towards the edges (Fig. 1). A beam of Gaussian distribution can propagate over long distances and through various optical components without changing its profile, although its spot diameter becomes larger as the propagation distance increases. Since no beam shaping optics are required, this type of beam distribution is cheap and easy to achieve. The central, most intense region of a Gaussian beam – especially when tightly focused by an aspheric lens – can reach high energy concentrations

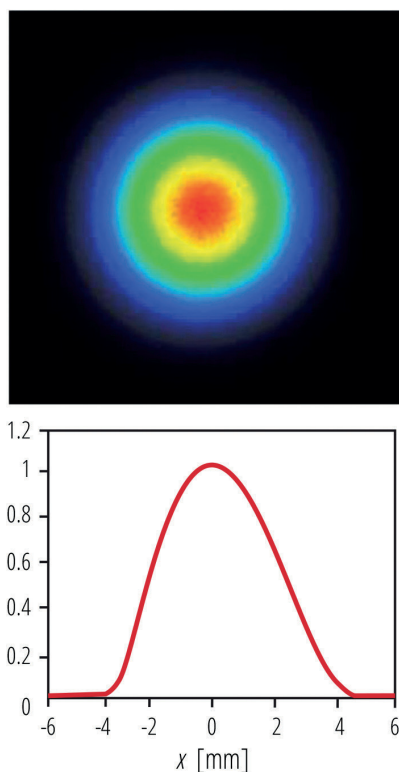


Fig. 1 In a Gaussian beam profile, irradiance decreases with distance from the center following a Gaussian distribution

at the focal point, enabling precise and efficient material removal. Because of this, Gaussian beams are often used in laser cutting and engraving applications that require a particularly powerful focal spot. However, the nonuniform intensity distribution of the Gaussian beam can be a drawback in processes that require uniform energy delivery as it can lead to inconsistent material processing outcomes such as uneven ablation or welding defects. A different beam shape may be more appropriate for applications that require a more homogeneous intensity distribution.

Gaussian distributions are the native beam profile of many lasers, but they can be converted to other beam shapes like flat-top beams, Bessel beams, ring-

shaped beams, or even lines. A flat-top beam – also called a top-hat beam, when the edges of the profile are sharp and very well defined – has a constant intensity distribution across the beam diameter (Fig. 2), meaning the laser energy can be utilized much more efficiently. Flat-top beams are used in laser applications that require uniform markings and even appearance with consistent contrast and depth such as QR codes, bar codes, or intricate logos. This beam profile is also used in applications such as glass or polymer welding, e.g., in medical or microfluidic devices, where the flat-top distribution prevents stress concentrations that could cause cracking. Flat-top beams ensure that the entire irradiated area receives the same amount of energy, providing cleaner and more precise cuts than Gaussian beams. Homogeneous energy delivery is also essential in dermatological treatment where 'hot spots' caused by uneven distribution could damage healthy tissue. However, when planning a laser system, it is important to consider that flat-top beams have a relatively short working distance and do not maintain their shape when passing through optical components.

Bessel beams feature a bright central core surrounded by concentric rings of lower intensity. Bessel beams are unique because of their non-diffracting properties, meaning that they maintain their intensity profile over long distances without spreading like Gaussian beams. Bessel beams are also self-healing; they can reconstruct themselves after encountering obstacles such as microscopic debris or dust present in the beam path, small opaque objects like a thin wire or partial mask, or when passing near or through uneven edges of materials like glass or biological tissue. As long as some of the concentric rings remain unobstructed, the beam can regenerate beyond the blockage. These properties make Bessel beams highly valuable in applications where beam stability and precision are crucial. Bessel beams provide an extended focal depth, enabling deeper and more uniform drilling compared to Gaussian beams, for example in deep laser drilling and cutting where greater penetration depths are required. In material pro-

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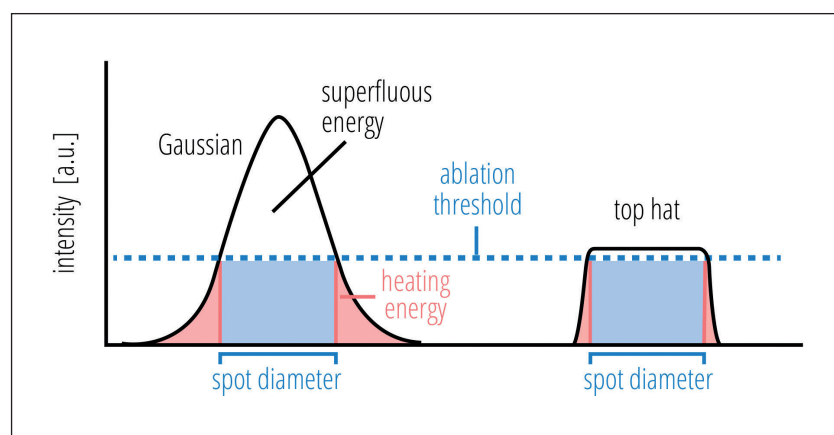


Fig. 2 Comparison of a Gaussian profile and a top-hat profile. In laser ablation processes, beams with Gaussian profiles are less efficient than those with flat-top profiles due to both the large beam area with superfluous energy above the required ablation threshold, and energy below the threshold in the outer regions of the Gaussian profile.

cessing, Bessel beams provide clean cuts and sharp edges and are ideal for cutting glass, sapphire, and other brittle materials without causing cracks. They are also commonly used in medical applications such as tissue removal in the eye where the ring-shaped beam provides an increased ability to smooth and vaporize corneal tissue. However, true Bessel beams are impossible to generate. Instead, approximate Bessel beams – also known as quasi-Bessel beams – can be generated through the interference of plane waves produced by a conical surface such as an axicon (Fig. 3).

Ring-shaped beams – also called donut beams – have little to no intensity in the middle of the laser spot, and all the energy is concentrated in a ring around the central axis of the beam. Ring-shaped beams provide highly uniform temperature distribution, delivering a consistent temperature across the laser-irradiated area, which reduces thermal stress and benefits applications such as ophthalmology, laser welding, and thin-film ablation.

Lastly, laser lines distribute laser energy over a specific length and width, and are ideal for large area processing such as laser cleaning or laser ablation where a certain part of the material is removed by the laser. Laser lines are also frequently used in scanning sys-

tems such as bar code reading and 3D surface profiling where the line shape enables rapid and detailed surface measurements.

Transformation of laser beams

Gaussian beams are sometimes physically truncated by an aperture in cost-sensitive, low-performance systems to create a pseudo flat-top profile. While this approach reduces system complexity and cost, it is inefficient as it wastes energy from the outer regions of the Gaussian profile. In contrast, higher-performance applications that prioritize efficiency typically use either refractive or diffractive laser beam shapers to modify the beam.

When light travels from one medium to another – for example from air to glass – the different refractive indices of the materials cause a change in the light's direction. This is referred to as refraction. Some of the most common refractive beam shaping elements include aspheric lenses – or optical assemblies made of aspheric lenses – that reduce spherical aberrations and improve beam focusing, Powell lenses that convert a laser beam into a uniform line distribution, cylindrical lenses used to shape circular beams into elliptical or line-shaped beams, and optical assemblies called flat-top beam shapers that

combine different optical elements to convert a Gaussian beam into a uniform, flat-top intensity profile. Since this type of beam typically loses its flat-top intensity profile when focused through a lens, field mappers are used to transform the original Gaussian beam into an Airy disc profile. This transformation enables the formation of flat-top spots when the beam is subsequently focused by a diffraction-free lens.

Diffractive optical elements (DOEs) contain nanostructured patterns within their substrate that manipulate the phase of incoming laser light into a different profile and shape. DOEs are beneficial in space-limited set-ups, but they are very sensitive to alignment, beam position, wavelength, and dirt on their surfaces. Some of the most common DOEs include beam homogenizers – also known as top-hat DOEs – that convert Gaussian beams into uniform intensity top-hat profiles, diffractive beam splitters that split a single laser beam into multiple beams with controlled intensity and angular separation, vortex phase plates – also called optical vortex DOEs – that generate optical vortices with phase singularities and often produce doughnut-shaped beams, and computer-generated holograms that use computational designs to shape laser beams into complex intensity distributions.

Challenges in shaping laser beams

Choosing the right beam shaper for your application is crucial and not only depends on your system space and budget but also on the critical parameters of your optical system, such as the wavelength, beam diameter, the beam energy density, and whether you are working on the focal plane or on the

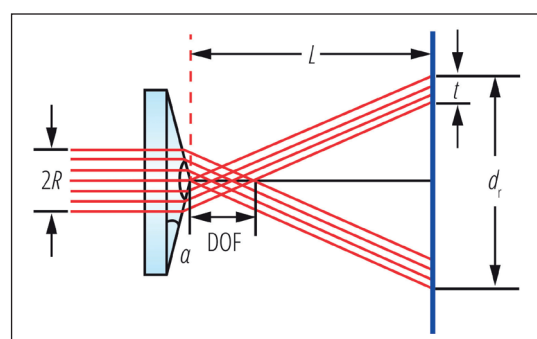


Fig. 3 Schematic of an axicon that is used to create a Bessel beam showing the Bessel beam in the depth of field (DOF) region, and the ring-shaped beam that propagates after the overlap region.

Authors

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started her career at Edmund Optics in 2008 as a sales and applications engineer. She holds a diploma in optical engineering from the University of Applied Sciences in Cologne, Germany. Her diploma thesis was written in cooperation with the Fraunhofer ILT in Aachen, Germany and focused on process monitoring in CO₂ laser welding. Today she works as a technical content specialist at Edmund Optics.



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image plane. Achieving the desired laser beam quality requires high precision optical components with tight tolerances, as well as careful alignment. High energy laser beams can damage the coating on the optical surface, making it essential to use components with high laser-damage thresholds. Also, materials may exhibit nonlinear effects at high intensities, causing unwanted beam distortion and phenomena such as thermal lensing that can degrade the beam quality and must be accounted for. These factors are all critical when designing a beam shaping system for laser applications.

Future outlook

As in many other areas of industry and research, artificial intelligence could have a major impact on laser beam shaping in the future and could transform the way we control laser beams. AI can optimize laser processing by determining the ideal parameters – such as the wavelength, pulse duration, frequency, power, and beam shape – based on the material properties, desired depth, scanning speed, precision requirements, and cost constraints. AI can also be used for adaptive and tailored beam shaping, employing algorithms that leverage machine learning and modify

beam profiles in real-time to enhance efficiency, reduce waste, and improve overall process stability. AI-assisted laser material processing is an active area of current research and, although not yet ready to be implemented at a large scale, it will certainly play a pivotal role in the future [1–2].

In many industrial or medical laser applications, the shape of the laser beam is, and should be, something worth looking at. There are many high-quality optical components on the market today that can help you to shape your laser beam and enhance your laser application. Optical component manufacturers and suppliers, such as Edmund Optics, can help you to find the right beam shaping optics for your needs. No matter which industry you are in, optimizing the laser beam shape is essential to achieve consistent, high-precision results – minimizing the need for post-processing or costly rework. By taking a closer look at beam shaping, you can unlock greater efficiency, reliability, and performance in your laser-based applications.

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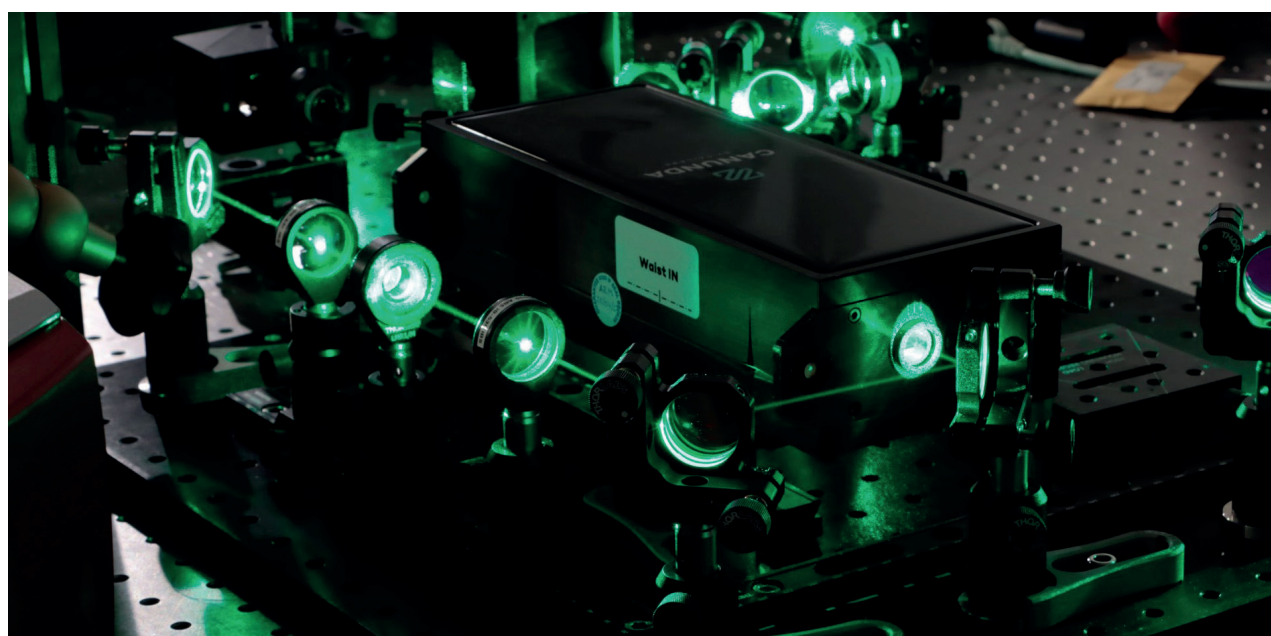
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Beam shaping: a key enabler to upscale industrial laser processes

Case studies highlighting beam shaping as a driver of industrial laser process innovation

Gwenn Pallier & Clémentine Maurier



Source all images: Cailabs

This analysis traces the evolution of laser process upscaling over the years, highlights key milestones and technological improvements and identifies the current challenges faced by existing laser processes, focusing on three critical sectors: microprocessing, laser welding and powder bed fusion – laser beam (PBF-LB). A series of case studies from Cailabs and its industrial partners demonstrates how beam shaping provides a valuable technological advantage, enabling real industrial improvements in laser-based manufacturing processes.

Since the 1960s, lasers have revolutionized the manufacturing industry, enabling the creation and enhancement of everyday objects, from watches to cars and solar panels. The technological advancements have driven significant performance improvements across various sectors. However, the performance of industrial lasers today – commercially available at reasonable cost and typically providing tens of kW cw and 300 W femtosecond power – cannot be used to the full extent as the extra power cannot be applied while maintaining the same quality. Beam shaping has emerged as a promising solution to overcome the scientific challenges associated with cur-

rent technologies, offering a method of optimizing laser processes by altering the thermal profile seen by the parts. This method does enable improved product quality, reduced operational costs, and increased flexibility in industrial applications.

Technological evolution of industrial laser sources

Since their first industrial implementation in the 1960s, lasers have profoundly transformed manufacturing technologies. The introduction of CO₂ lasers marked a pivotal milestone as they were the first to deliver sufficient power to induce localized material

melting, thereby enabling processes such as welding and laser cutting on an industrial scale. Companies such as Coherent were instrumental in democratizing this technology, facilitating its widespread market adoption. Even at that early stage, basic beam shaping techniques such as ring-shaped intensity profiles were tested with CO₂ lasers, and were already employed to enhance energy distribution, offering a cost-effective means of improving processing efficiency and quality. The subsequent emergence of solid-state lasers in the 1980s, characterized by improved beam quality and stability, enabled precision applications such as electronic drill-

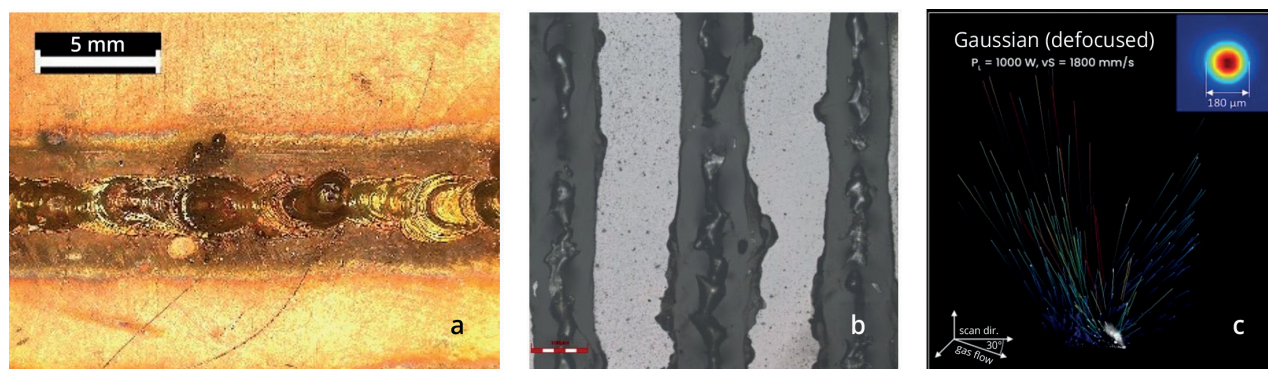


Fig. 1 (a) Unstable welds at too high power, (b) heat-Affected zone during microwelding at too high power, (c) spatters damaging protective window during L-PBF at too high power

ing, thereby expanding the range of viable laser-based processes. Trumpf played an important role in scaling the technology to industrial standards. In the 1990s, fiber lasers revolutionized the market through their compactness, high efficiency, and cost-effective manufacturing, made possible by in-fiber amplification. This advance significantly lowered the entry barrier for various industrial sectors, notably in the automotive and medical domains, with IPG Photonics leading the way in large-scale deployment. The early 2000s saw the emergence of ultrashort pulse lasers, particularly femtosecond sources, pioneered at industrial scales by companies such as Amplitude. These lasers enabled unprecedented micromachining precision by minimizing the heat-affected zone, paving the way for highly controlled and damage-free material processing.

The need for disruptive innovation to address emerging constraints

Despite decades of progress and diversification, critical limitations persist in the context of high-productivity appli-

cations such as laser welding, additive manufacturing and micro-processing. Notably, increasing the laser power – a strategy commonly pursued to accelerate processing rates – often induces process instabilities. These include weld defects (e.g. porosity and lack of fusion, humping) and the deterioration of mechanical properties, both of which compromise part reliability and structural integrity. In PBF-LB, elevated power levels exacerbate spatter formation, which not only reduces part quality but also poses a risk of damage to optical components such as protective windows and introduces safety concerns for operators.

In this context, process optimization increasingly relies on advanced beam shaping techniques that allow finer control over energy distribution on the workpiece surface. These methods reduce the negative thermal effects associated with high irradiance peaks by tailoring the beam profile, improving both the process stability and reproducibility. Beam shaping therefore emerges not merely as an enhancement, but as an essential technological enabler to meet current industrial requirements – particularly where productivity, quality, and operational safety converge as strategic priorities.

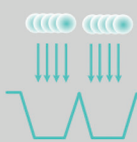
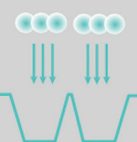
	gaussian beam	square top hat
		
beam size	7 μm	15 μm
number of side passages	13	10
compliance	yes	no
time needed to achieve compliant riblets	0.5 s	0.3 s

Table 1 Comparison of riblet texturing performance with Gaussian vs. square top hat beams

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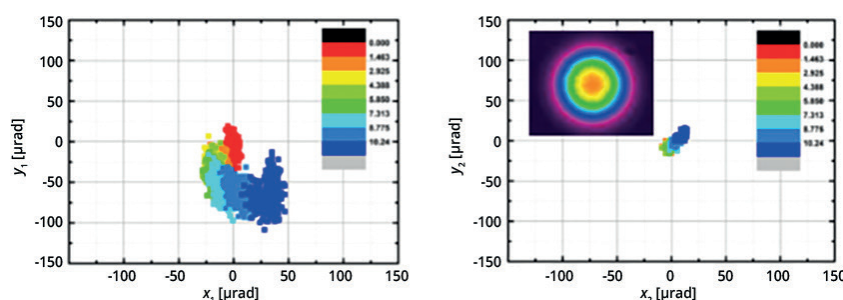


Fig. 2 Less than 100 μrad of input beam pointing jitter over 12 hours, the improved system (with Canunda pulse) demonstrated high robustness, with stable output power and preserved beam quality

Solving microprocessing constraints: from fiber coupling to surface texturing

Microprocessing with ultrashort-pulse lasers enables high-precision surface functionalization, but it is still constrained by limitations in beam stability, fiber delivery, and process throughput. Beam shaping appears as a key enabler to overcome these bottlenecks, particularly when dealing with femtosecond pulses.

Cailabs has developed an innovative passive beam stabilization module that reshapes a fluctuating Gaussian beam into a clean, stabilized Gaussian profile. In collaboration with GLOphotonics, a French company specializing in hollow-core photonic crystal fibers for ultrafast laser delivery, the reliable coupling of femtosecond beams into hollow-core fibers was demonstrated. The stabilized beam achieved a coupling efficiency above 93 % with minimal energy loss and eliminated any fiber damage. This passive mode-cleaning solution also mitigates pointing fluctuations (tilt, shift, ellipticity), and has shown that depointing of the beam can be reduced by a factor of 16. All these benefits open the door to the industrialization of these processes and large-area applications, such as aircraft component surface treatment, through robust beam delivery from robot arms or gantry systems.

Another major industrial challenge lies in increasing the process speed

during surface texturing operations. Cailabs collaborated with Amplitude, the leading French manufacturer of ultrafast laser systems for micromachining, to address this through square top-hat beam shaping. By increasing the laser power and using a sharp square beam perfectly matching the riblet geometry, this approach enabled lateral single-pass processing for laser riblet structuring on aircraft wings, an aerodynamic texture designed to reduce drag. The result was a 17-fold gain in throughput compared to traditional Gaussian beams that provided compliant structures only with multi-lateral passes and therefore less energy/power. This performance leap not only supports the aeronautics sector's requirement for industrial-scale laser texturing at 100 cm^2/min but also contributes to the long-term objective of significantly reducing aircraft kerosene consumption thanks to the drag-reducing properties of riblet structures.

Faster, smarter and more flexible EV laser welding

In the context of relocating electric vehicle manufacturing to Europe, improving manufacturing yield and process efficiency is essential to ensure continued global competitiveness. Consequently, the industry is interested in providing a robust and high-speed alternative to traditional techniques, particularly for cell contacting. At present, wobbling is

conventionally used to manage energy distribution during cell contacting. However, this method limits process speed and increases system complexity. In collaboration with Fraunhofer ILT and Precitec, it has been demonstrated that beam shaping alone can fully replace wobbling while delivering equivalent welding quality. Eliminating beam oscillation has enabled a five-fold increase in welding speed, representing a major gain in productivity and industrial scalability.

Another critical application of beam shaping lies in copper busbar welding (Cu ETP), where melt pool stability is essential – especially when welding copper lap joints at moderate power levels. In collaboration with Institut Maupertuis and Precitec, a ring-dot beam shape was used to stabilize the keyhole and melt pool in 3 mm over 3 mm copper lap welds at 8 kW. While high-power welding of thick copper is feasible, operating at lower speeds and powers often leads to instability. With the same ring-dot shaped beam, it was possible to achieve a 1.5-fold increase in penetration depth without increasing laser power, while simultaneously enhancing process control at lower speeds. This improvement reduces part tolerances, simplifies fixturing, and opens the door to more flexible production. It is worth highlighting that the same laser and the same beam-shaping system can handle a wide variety of welding configurations – a key asset for next-generation EV factories, where production lines must adapt to rapidly evolving vehicle designs.

Company

Cailabs

The company was founded in 2013 and is a French deep-tech enterprise that designs, manufactures, and sells innovative photonics products for telecommunications and industrial lasers. A world leader in complex light shaping, its technology is currently covered by 19 patents. Its innovative components are used in various fields, from aeronautical wiring to factory local area networks, including laser manufacturing. They have contributed to several world records – in particular, the fiber optic throughput record held by the Japanese operator KDDI.

www.cailabs.com

Meet us at Laser World of Photonics (June 2025), Hall A3, Booth 152 –
PLI Conférences (September 2025) – ICALEO (October 2025).

Extending PBF-LB productivity through beam shaping

PBF-LB faces one main challenge that hinders broader industrial adoption: limited productivity in comparison with more standard processes. Cailabs has developed a solution that addresses this issue by leveraging beam shaping to enhance process robustness. Firstly, productivity must be significantly increased to unlock new market opportunities, including high-throughput segments

such as the automotive industry and the fabrication of large-volume parts. To this end, collaborative work with Fraunhofer ILT has focused on assessing the influence of beam shaping profiles during the processing of Nickel 625. A comparative analysis was performed between Gaussian and ring-shaped beams of the same size and power ($\varnothing = 240 \mu\text{m}$), demonstrating that the latter produces a smoother thermal gradient, which modifies spatter behavior (lower angles and lower speeds). As a result, the process can be scaled up to higher power levels (up to 1 kW), demonstrating the industrial feasibility of 3.3 times faster printing compared to a 300 W small Gaussian beam.

Secondly, as industry seeks to expand the range of materials and enable the retrofiting of legacy equipment, beam shaping becomes pivotal. In collaboration with Pres-X, an Italian company specializing in additive manufacturing and post-processing, experiments were conducted on a PBF-LB platform limited to 200 W nominal power. Processing of Inconel 939, a nickel-based superalloy prone to cracking and poros-

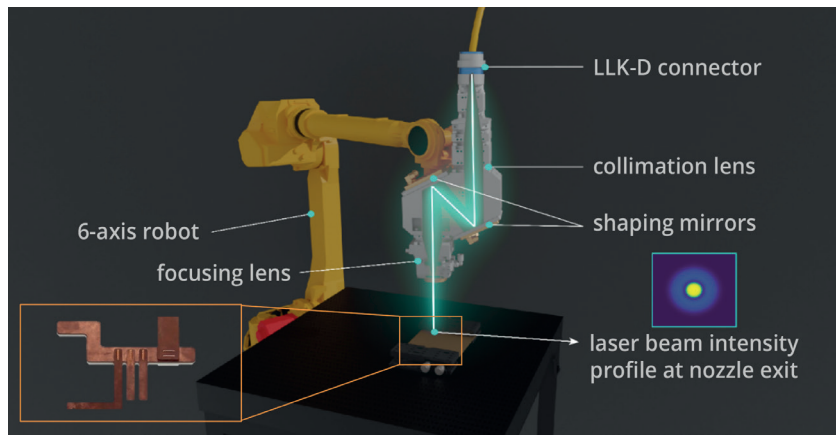


Fig. 3 Copper ETP busbars welded using a ring-dot shape

ity, was found to be infeasible using a Gaussian beam. However, substituting with a circular top-hat profile ($\varnothing = 90 \mu\text{m}$) led to a substantial reduction in thermal gradients, enabling a reduction of hot cracking while maintaining a very low porosity.

Unlocking new industrial capabilities with beam shaping

Beyond those applications, beam shaping technologies show strong potential in other high-precision industrial laser

processes – notably laser cutting, surface treatment, and glass processing.

Generally speaking, laser cutting is not usually regarded as a primary application for beam shaping, given that the sector is strongly driven by cost reduction. Standard laser heads are already widely optimized and inexpensive. However, this context presents an opportunity for innovation in high-value or technically demanding cutting operations where the ability to shape the beam can offer strategic advantages. In the context

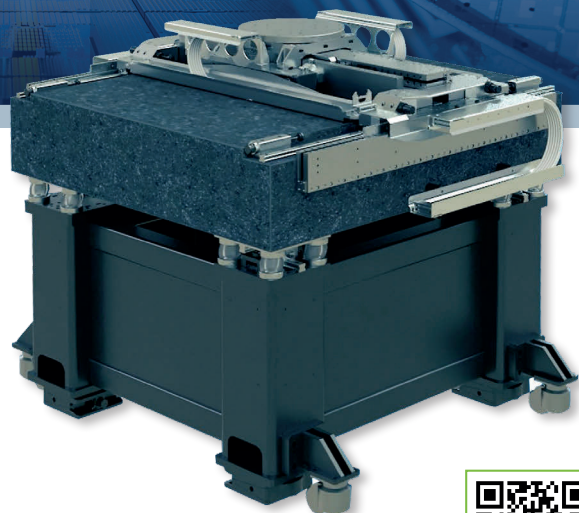
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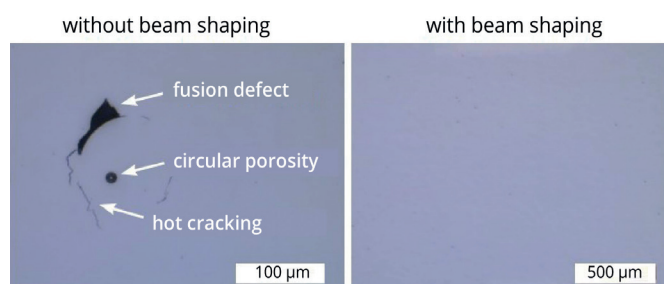


Fig. 4 Significant decrease of defect appearance thanks to beam shaping

of deep laser cutting, a collaborative study involving Cailabs, the Institut für Strahlwerkzeuge (IFSW, Stuttgart University) and Precitec, aimed to demonstrate how beam shaping can overcome a fundamental limitation in thick metal cutting. A C-dot shaped beam profile was designed to address the strong energy gradient between the top and bottom of the kerf when cutting very thick steel. With this tailored beam it was possible to concentrate up to three times more energy into the lower part of the cut, significantly improving cut quality and reducing surface roughness. This had a direct impact on eliminating prewelding preparation steps, which are typically required after deep cuts – especially in shipbuilding and heavy industry applications. By skipping these intermediate steps, this method enables a substantial increase in process yield, confirming the potential of beam shaping to support high-value, time-efficient cutting operations that go beyond standard industrial capabilities.

In collaboration with Amplitude, a roll-to-roll ultrashort-pulse laser process (700 W, 10 ps) was developed to explore laser-based alternatives to chemical surface treatments. The challenge was to combine a high processing speed with robustness on non-flat surfaces. Using a $1 \times 1 \text{ mm}^2$ top-hat beam, it was possible to achieve 60 % useful energy strictly within the ablation threshold, and a 20 mm depth of field, enabling consistent ablation across varying surface profiles. Compared to DOE-based solutions, the beam shaping setup provided a four-fold improvement in the depth of field and 30 % higher efficiency. This approach confirmed the feasibility of replacing chemical processes with cleaner, high-throughput laser solutions, meeting industrial requirements for yield and tolerance.

In the field of micromachining, particularly in the context of ultrathin glass processing, a primary challenge lies in achieving a balance between speed, precision, and process robustness, especially when using femtosecond lasers. In response to this challenge, a collaboration with the Laser Zentrum Hannover (LZH)

has led to the generation of a stable Bessel beam ($20 \mu\text{m} \times 45 \mu\text{m}$) based on a fully reflective, high quality (small tip) axicon for the cutting of $50 \mu\text{m}$ -thick glass sheets. This configuration enabled the processing of $50 \times 50 \text{ mm}^2$ areas in a single pass, with minimal debris and high edge quality. The collaboration has yielded a five-fold increase in cutting speed while maintaining compatibility with galvanometric scanners, underscoring the beam's suitability for high-throughput, precision glass processing in electronics and display manufacturing.

Conclusion and outlook

These examples collectively underscore the broad applicability of beam shaping across industrial laser processes, offering a pathway to higher yields, simplified workflows, and sustainable process transitions. Whether through improved energy control, enhanced depth of field, or increased processing speed and even machine lifespan, beam shaping has consistently delivered measurable gains in yield, quality, and scalability. It has been shown that beam shaping can replace conventional techniques like beam wobbling, enabling a higher throughput in

EV welding, mitigate surface roughness in thick metal cutting, or reduce hot-cracking for low-power additive manufacturing on sensitive materials such as Inconel 939. Similarly, in surface treatment and micro-machining, the ability to adapt the beam profile to material and geometry constraints enables new use cases to scale up to industrial levels. Finally, one of the main challenges of beam shaping is to identify the optimum shape / process combinations for each application. As part of this exploratory approach, we are working with academic partners to develop advanced process simulations that will enable us to better understand these interactions and support innovation in the design of beam shaping shapes.

*

We would like to thank GLOphotonics, Amplitude, Fraunhofer ILT, Precitec, Pres-X, IFSW and LZH for their collaboration and contributions to the work presented. Their support was instrumental in exploring and validating the use of beam shaping across a range of industrial laser applications.

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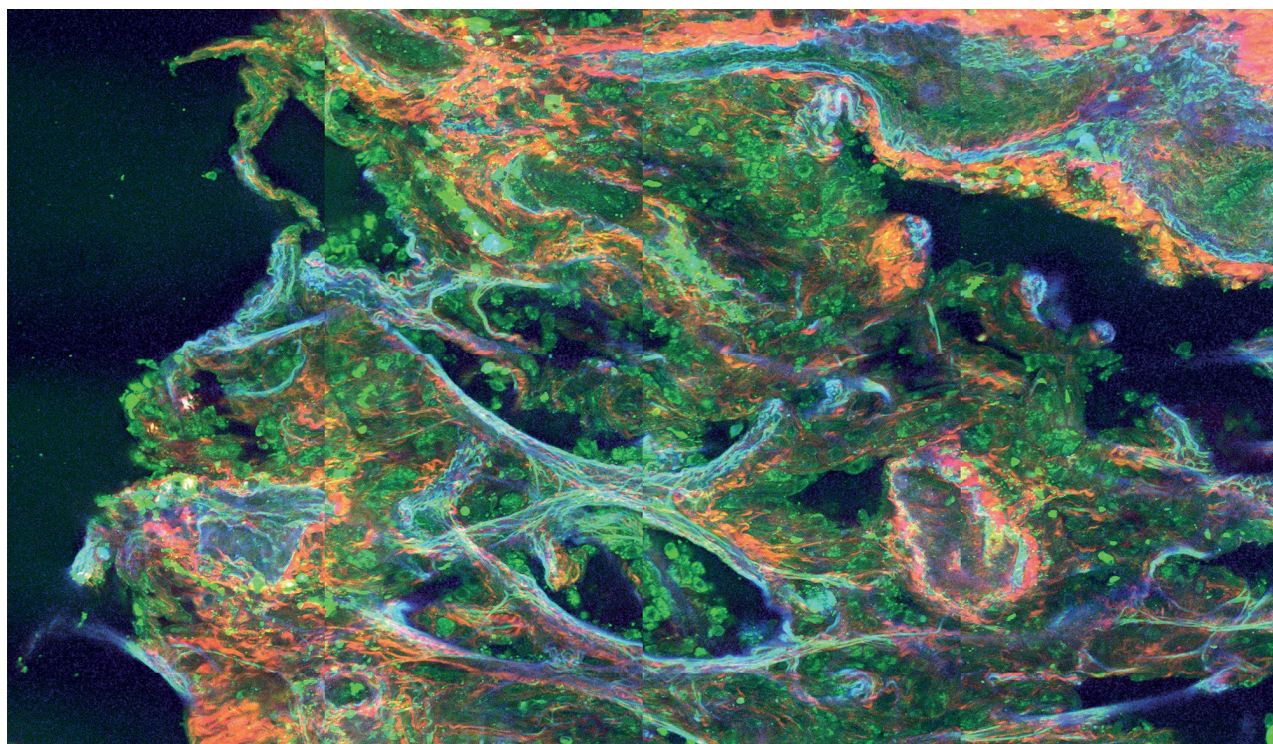


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Unveiling cell secrets with lasers

Ultrafast lasers enable rapid cancer diagnosis with simultaneous two and three-photon imaging

Oliver Prochnow & Laura van Huizen



Source: VU Amsterdam

A new generation of compact ultrafast laser systems capable of simultaneous two and three-photon microscopy – including two-photon fluorescence (2PF), second harmonic generation (SHG), three-photon fluorescence (3PF), and third harmonic generation (THG) imaging – offer exciting potential to accelerate biomedical research and clinical diagnostics.

3D in-depth visualization

Femtosecond lasers are a critical enabler of higher-order harmonic generation (HHG) imaging, commonly referred to as multiphoton microscopy. Unlike conventional single-photon excitation, multiphoton processes require two or more photons to arrive at the exact same location and time to simultaneously excite a molecule – a highly improbable event under normal conditions. This nonlinear interaction becomes feasible only with the extremely high peak intensities of ultrashort laser pulses. As a result, femtosecond lasers make it possible to achieve precise, localized excitation

within biological tissues, with minimal photodamage and improved imaging depth – hallmarks that make multiphoton microscopy uniquely powerful in biomedical imaging. Since the interaction occurs only at the focal point, the excitation volume can be scanned throughout the sample, enabling intrinsic three-dimensional imaging without the need for confocal pinholes or out-of-focus light rejection.

Pulse duration is the key factor to improving imaging quality. Reducing the pulse duration by a factor of five while maintaining constant average power results in roughly a five-fold increase in signal for two-photon

▲ In this lung tissue image, third harmonic generation (green) visualizes cells and other structures, second harmonic generation (red) visualizes collagen fibers, while two-photon excitation (blue) visualizes autofluorescence, mainly from elastin fibers (image width: 800 μm)

absorption. Three-photon excitation is even more dependent on peak intensity, scaling with the cube of the intensity and inversely with the square of the pulse duration. Consequently, the same reduction in pulse duration can produce up to 25 times higher signal for

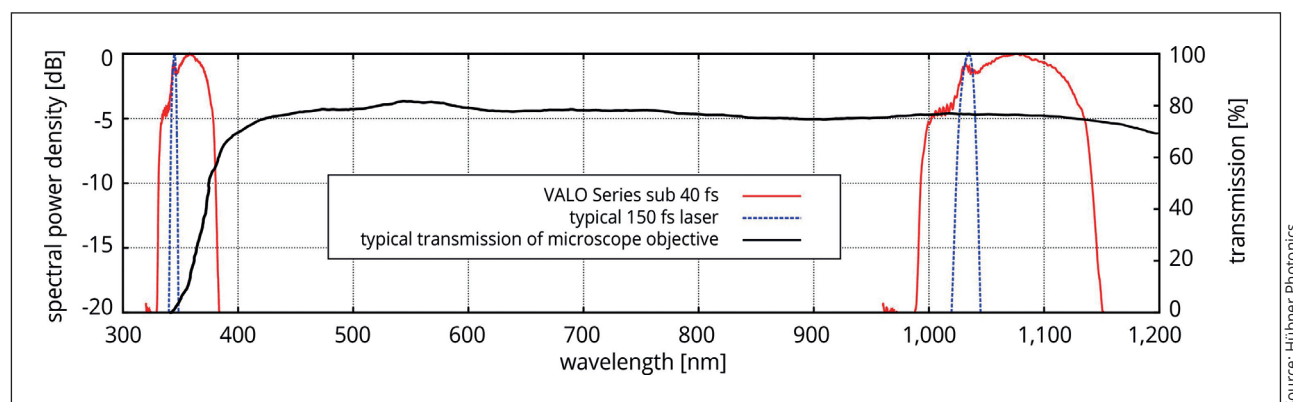


Fig. 1 Fundamental and third-harmonic generation (THG) spectra of a 30 fs broadband fiber laser (red) compared with standard 150 fs lasers. The solid black line shows the typical transmission characteristics of a standard microscopy objective. Only a THG spectrum generated from wavelengths of above 1,080 nm will be transmitted.

three-photon processes. What is more, if peak power is held constant, shorter pulse durations allow for a proportional reduction in average power compared to systems with longer pulses. This reduction in average power significantly limits sample heating and photobleaching, enabling long-term imaging of live cells with minimal damage – an essential benefit for sensitive biological applications.

In general, shorter pulse durations are accompanied by broadband optical spectra. To achieve pulse durations as short as thirty femtoseconds, the spectrum typically spans the range of approximately 990 – 1,140 nm. This broad spectral range introduces a previously unattainable capability: the portion of the spectrum above 1,080 nm can efficiently generate three-photon signals that are transmitted through standard microscope objectives. In contrast, three photon signals generated from wavelengths below 1,080 nm are blocked due to UV absorption in stan-

dard objective lens material, limiting their transmission (Fig. 1). This makes the use of broader spectra not only beneficial for pulse compression but also essential for unlocking advanced three-photon imaging through conventional optics.

The VALO Femtosecond Series represents a new class of ultrafast fiber lasers, delivering exceptionally short pulse durations and an ultrabroadband optical spectrum, all in a compact easy-to-use form factor, making them suitable for simultaneous two and three-photon excitation.

Thanks to a distinctive design, these lasers produce temporally clean sub-40 femtosecond pulses (Fig. 2 left) with an exceptionally broad spectrum (Fig. 2 right). Compared to conventional systems, their shorter pulse durations yield significantly higher peak power, resulting in unmatched imaging contrast.

Engineered for reliability and ease of integration, these robust fiber lasers

feature a built-in dispersion precompensation unit, ensuring the shortest pulses reach the sample after passing through a microscope objective. They also operate without the need for water cooling, simplifying the setup and operation.

Fast and accurate cancer diagnosis with higher harmonic generation imaging

Higher-order harmonic generation (HHG) microscopy systems can ultimately be used in many biomedical research or clinical diagnosis applications as they provide high-resolution and high-contrast imaging capabilities. This technique is a nonlinear optical microscopic technique that enables label-free imaging of fresh unprocessed biological specimens.

Imaging biological samples with traditional microscopy requires sample slicing and staining to create contrast in the tissue. The nonlinear mechanisms generated by femtosecond laser pulses, however, eliminate the need for labeling or sample preparation, revealing molecular and structural details within tissue and cells while leaving the sample intact.

One key application is cancer diagnosis, for example during bronchoscopy procedures; it can be challenging to obtain adequate material for diagnosis. The standard histopathological analysis can take several days to provide diagnostic results and, in cases where no diagnosis can be made, the patient might have to come back for a repeated procedure. This indicates the clinical need for rapid intraoperative feedback on biopsies.

Higher-order harmonic generation imaging, on the other hand, can rap-

Companies

Flash Pathology

Flash Pathology is a Netherlands-based start-up, originally spun out of the Vrije University. The company is developing a compact, affordable higher harmonic generation microscope that will enable real-time visualization of unprocessed tissue in a clinical setting.

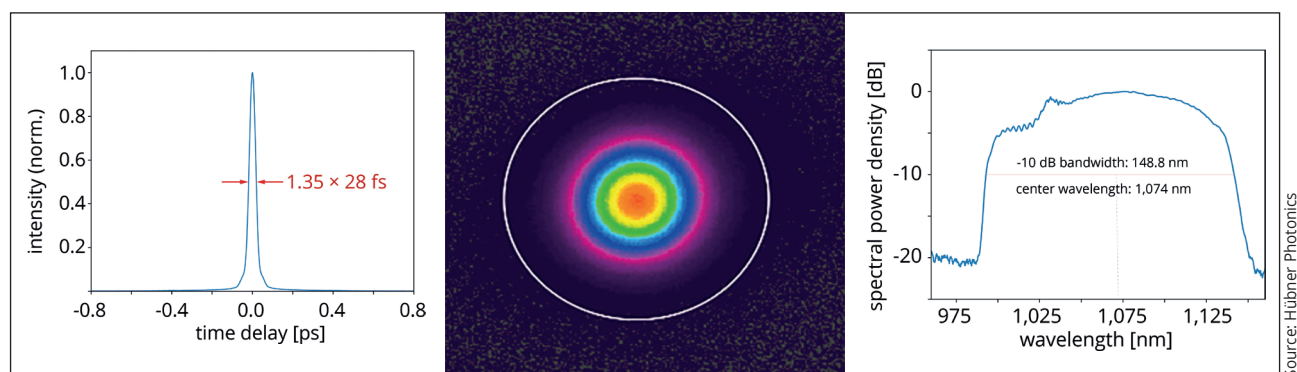
<https://flashpathology.com>

Hübner Photonics

Hübner Photonics is an international organization with offices in Sweden, Germany and the US. The company supplies high performance lasers to leading instrumentation manufacturers, innovative start-ups, universities, and research labs around the world. Fiber laser manufacturer Valo Innovations became a part of Hübner Photonics in 2021.

<https://hubner-photonics.com>

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Source: Hübner Photonics

Fig. 2 Left: typical temporal pulse profile of a 28 fs pulse with very low pulse pedestal. Middle: typical beam profile. Right: typical optical spectrum of Hübner Photonics' VALO Femtosecond Series lasers.

idly visualize unprocessed tissue samples, enabling diagnosis in situ. A recent study demonstrated that it could image a biopsy sample and provide feedback just six minutes after excision, with an accuracy of 87 % – enabling immediate decisions as to whether a further biopsy is required [1].

The typical HHG microscopy system's impressive diagnostic performance is partly due to its ability to generate four nonlinear signals simultaneously using a single ultrafast femtosecond laser: second and third-harmonic generation plus two and three-photon fluorescence. The system then uses filters to spectrally separate these signals, which provide complementary diagnostic information. SHG, a coherent nonlinear process, arises in noncentrosymmetric structures such as collagen fibers, microtubules, and other ordered biological assemblies. This makes it particularly useful for imaging connective tissues, cytoskeletal structures, and fibrillar proteins with high contrast and specificity. On the other hand, THG occurs at interfaces with refractive index mismatches or in regions of material inhomogeneity, providing detailed imaging of cell membranes, lipid-rich structures, and organelle boundaries. Two and three-photon fluorescent signals are generated by autofluorescent molecules, such as FAD and NADH, visualizing elastin and cell cytoplasm.

Towards future clinical applications

Once fully realized in the clinic, a higher-order harmonic generation imaging system will provide an invaluable tool for rapid in situ tissue analysis during bronchoscopy procedures or other procedures where tissue is excised. The unique combination of four nonlinear imaging modalities, made possible with a single compact femtosecond

laser, delivers complementary diagnostic information and is poised to revolutionize rapid medical diagnostics.

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- [1] L.M.G. van Huizen, et al.: Rapid on-site histology of lung and pleural biopsies using higher harmonic generation microscopy and artificial intelligence analysis. *Modern Pathology* (2025).

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The new green revolution

Photonics for smart farming

Jérémy Picot-Clément

Source: Digifoods



Photonics is revolutionizing agriculture, playing a pivotal role in the rise of smart farming as a sustainable solution to global food security challenges. By harnessing advanced light-based technologies such as tunable LED systems, hyperspectral imaging, and smart optical sensors, smart farms can optimize plant growth, monitor plant health, and minimize resource consumption.

◀ In-line assessment of sweetness in cherry tomatoes by NIR spectroscopy developed by Nofima

In 2009, the United Nations estimated that by 2050, global food production would need to increase by 70 % to meet the demands of a growing world population predicted to reach 9.7 billion by then. Furthermore, to achieve this target, smart farming techniques would need to be employed to make agriculture production more efficient and productive, more sustainable, more adaptable to changing climate conditions, and with a greater focus on reducing food waste throughout the supply chain.

Key technologies in smart farming – also called precision agriculture – include drones and satellites equipped with sensors to monitor crop health, soil conditions, and overall field mapping, AI and machine learning to help farmers make better decisions – like when to plant, irrigate, or harvest – and automa-

tion and robotics such as machines that can plant, weed, and harvest with little or no human help. However, central to all these technologies is photonics in the form of optical sensors and imaging systems that can provide non-invasive, precise, and real-time monitoring of crops, livestock, and the environment.

This article delves into how photonics is enabling precise control over light spectra, enhancing photosynthesis, and automating crop monitoring in both open fields and controlled environments. These innovations are not only increasing yields but also reducing energy and water usage, positioning photonics as a driving force behind the new green revolution in agriculture.

Hyperspectral imaging

Hyperspectral imaging (HSI) captures and analyzes a wide range of light wave-

lengths beyond the visible spectrum. Unlike standard cameras that capture only red, green, and blue (RGB) light, HSI cameras collect data across hundreds of spectral bands in the visible (VIS), ultraviolet (UV), infrared (IR), near-infrared (NIR), and shortwave-infrared (SWIR) regions. As each material has a unique spectral signature across a wide range of wavelengths, HSI enables noninvasive, highly detailed material identification and analysis which is used for crop health monitoring, weed and pest detection, soil analysis, yield prediction, water management, and harvest optimization.

HSI was first used in airborne and satellite-based agricultural monitoring in the early 2000s. At that time, HSI sensors were large and required heavy, complex setups. Since then, considerable advances in sensor technology have

led to smaller and lighter designs, making them suitable for drones, handheld devices, and even smartphones. Additionally, onboard AI, edge computing, and machine learning models now allow real-time spectral analysis directly on the device, reducing the need for external computing. At the same time, new fabrication techniques such as the 3D printing of optical components and mass production of MEMS-based filters (micro-electromechanical systems) have significantly reduced costs.

An example of a company at the forefront of integrating cutting-edge HSI systems is the Norwegian research company **HySpex**. Their range of hyperspectral cameras incorporates machine learning, and they are designed as turnkey solutions for the rapid and efficient automated analysis of heterogeneous biological samples in smart farming.

HySpex's turnkey solutions not only reveal chemical composition and spatial distribution but also provide deeper insights into physiological status, nutrients deficiency, damage, pathogen infections, and responses to both abiotic and biotic factors in agricultural and food products.

Their automated HSI systems are also used for contactless, nondestructive, real-time grading, inspection, processing, and quality control across a range of crops including lettuce, tomatoes, berries, and cocoa beans.

Also active in the development of smart sensors for food quality assessment is **SFI DigiFoods**, a research center in Norway. Within DigiFoods, the research institutes Nofima and SINTEF are developing non-contact NIR spectroscopic sensors that probe deep into foods, for example enabling the determination of sugar and dry matter in fruit and vegetables.

The technology can be used directly in the field, handheld, on field robots, or on packing lines, ensuring high quality to the consumers and reducing food waste. The technology has been demonstrated for the measurement of sugar and sweetness in strawberries in the field and in cherry tomatoes on packing lines. The emerging opportunities with these novel sensors also make them highly interesting for quality management in the fish and seafood industry. In DigiFoods, new technologies for rapid food quality assessment are also based on IR, Raman and hyperspectral imaging.



HySpex automated HSI system for contactless, real-time grading, processing, and quality control of strawberries

Source: HySpex

Multispectral imaging

Whereas hyperspectral cameras capture hundreds of narrow, contiguous spectral bands often less than 10 nm wide, multispectral cameras only capture between three and ten spectral bands that are relatively broad (e.g. red, green, blue, near-infrared) between 400 nm and 1 μm . An advantage of multispectral systems over HSI is that they can collect data more quickly, which is crucial for real-time or near-real-time applications – like drones or satellites in motion, because they capture fewer bands. As the data volume is much smaller, multispectral cameras and sensors require less computational power and simpler algorithms, they can be made smaller and lighter and are generally cheaper and more commercially available. Finally, multispectral imaging is good enough for many applications such as normalized difference vegeta-

tion index (NDVI) crop health, water body monitoring, or land use classification, which does not require hyperspectral-level detail.

CSEM, a Swiss technology innovation center, develops multispectral imaging systems leveraging photonics for precision agriculture. Their 16-band multispectral camera (350 – 1,000 nm), integrated into Agreenculture's robotic platform, identifies vineyard diseases such as downy mildew and flavesence dorée. The company also collaborates with Smart Greenery on multispectral vision systems for vertical farming, utilizing spectral demultiplexing techniques with RGB sensors and four-band spectral illumination panels. These systems enable the early detection of pests (thrips, spider mites) and plant growth anomalies, facilitating timely interventions. Their technology enhances agricultural productivity through smart system designs and precise spectral analysis, and supports effective crop health monitoring in diverse farming environments.

Laser-based sensing

Laser-based sensing relies on laser reflection and absorption properties. Lasers are directed onto plants or soil, and their reflected light is analyzed. Different materials – e.g. healthy vs. diseased crops, wet vs. dry soil – absorb and reflect light differently. Near-infrared (NIR) and mid-infrared (MIR) lasers are used to determine the moisture content of soil because water absorbs strongly in these regions.

Similarly, laser-induced fluorescence can be used to measure a plant's health. In this process, when laser light at a specific wavelength is directed onto a plant – e.g. UV, blue, or red – the plant's pigments such as chlorophyll, carotenoids, flavonoids, absorb the high-

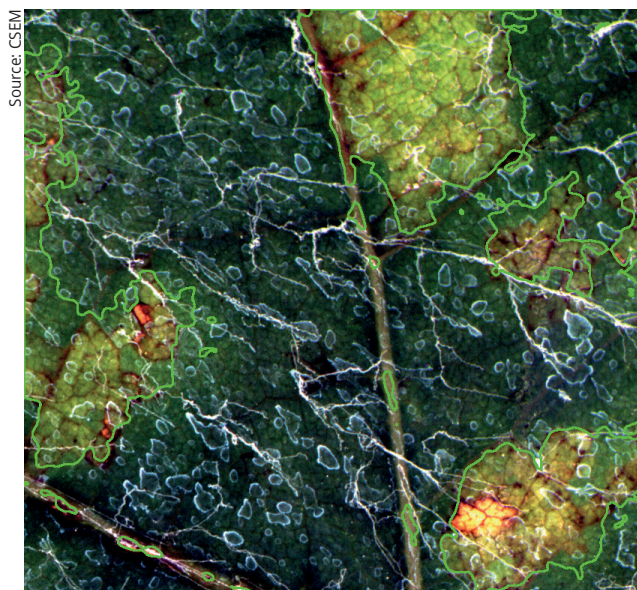
Organization

EPIC – European Photonics Industry Consortium

EPIC is the world-leading photonics industry association representing more than 800 members across 35 countries. EPIC promotes the sustainable development of organizations working in the field of photonics. EPIC fosters a vibrant photonics ecosystem by maintaining a strong network and acting as a catalyst and facilitator for technological and commercial advancement. EPIC publishes market and technology reports, organizes technical workshops and B2B roundtables, supports EU funding proposals, advocacy and lobbying, education and training activities, standards and roadmaps, and pavilions at exhibitions.

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sRGB reconstruction of the leaves using CSEM's handheld SpectroX device, with automatic segmentation of the downy mildew areas.

energy photons and a portion of this energy is dissipated as fluorescence. The fluorescence signal can be measured to assess plant health and stress conditions. In the case of chlorophyll fluorescence, low fluorescence indicates a healthy plant as the energy is mostly used in photosynthesis, not re-emitted as light. In the same way, high carotenoid fluorescence is indicative of a stress response to drought, nutrient deficiency, or disease, while elevated flavonoid fluorescence can indicate UV stress, drought, a pathogen attack, or oxidative stress.

The Dutch company **Avantes**, part of the Nynomic group, manufactures high-performance spectrometers which, in conjunction with pulsed laser sources, can be used to study chlorophyll fluorescence. Their spectrometers cover UV, VIS, and NIR ranges (190 – 2,500 nm) and empower farmers with

real-time, data-driven insights from assessing chlorophyll levels for plant health to analyzing soil nutrients for precision fertilization and sorting produce by ripeness. Their systems can be deployed in the field, integrated seamlessly into existing systems, or deployed in-line to enable precise crop monitoring, optimized resource use, and improved yield quality.

Lidar – light detection and ranging

With lidar, emitted laser pulses bounce off surfaces and return to the sensor, and the time taken for the laser to return is used to calculate distances and to create a 3D model. 3D maps of farmland can then be created for smart irrigation and crop planting, as well as 3D images of plant height, density, and biomass for yield estimation. Lidar can

also be adapted for gas detection in a process known as differential absorption lidar (DIAL). In this process, two laser wavelengths are used: one is absorbed by the target gas (on-line) and the other not (off-line). The gas concentration along the laser path can be estimated by comparing the return signal strength between these two.

Photonics Bretagne, located in Brittany, France, is a photonics innovation hub that develops novel photonics solutions to meet the needs of farming, marine resources, and agrifood. They are involved at local and European levels through engineering services and collaborative projects involving proof of concept and demonstrators that integrate multiple photonics technologies, including lidar, to quantify gas content from fertilizer spreading and in livestock buildings. Other projects focus on spectroscopy to study abiotic stresses in plants, bright-field imaging combined with an AI analysis for early detection of plant pests, and spectral imaging to automate harvests.

Advanced lighting solutions

LED lighting systems play a crucial role in smart agriculture, particularly in controlled environment agriculture (CEA) such as greenhouses and vertical farms. Their efficiency, spectrum tunability, and low energy consumption make them ideal to optimize plant growth.

Tuning LED light spectra allows the precise control of light wavelengths – for example, blue for vegetative growth or red for flowering – while UV and far-red LEDs can enhance plant defense mechanisms and improve nutritional quality. Additionally, pulse lighting (intermittent LED flashes) improves photosynthetic efficiency, and certain LED wavelengths can deter pests and reduce fungal growth.

Since 2015, the Korean company **Seoul Semiconductor** has been at the forefront of horticulture LED innovation, investing significantly in advanced lighting solutions for boosting efficacy, developing spectra targeted for specific agricultural outcomes such as pest control or enhanced metabolite production as well as testing genetically modified crops under realistic lighting conditions before they reach the field.

In collaboration with Crocus Labs from Berlin, Seoul Semiconductor has developed a 4-channel LED luminaire specifically designed for smart agriculture applications. The four adjustable



Probing the nitrogen amount in cauliflower using a reflectance signal developed by Photonics Bretagne



Source: Seoul Semiconductor

Seoul Semiconductor's 4 channel luminaire

channels typically cover key wavelengths such as blue for promoting vegetative growth and strong root development, red to enhance photosynthesis and encourage flowering and fruiting, far-red which influences seed germination and regulates flowering cycles, and white to provide a balanced spectrum that supports overall plant health and allows for visual inspection.

Adjusting the spectrum for each stage of the plant's growth enables big energy savings to be made and, with the considerable drop in price of LEDs over the last ten years, more LEDs have been added, increasing efficacy by 500 %.

Future outlook

The future for photonics in agriculture is exceptionally promising, poised to drive significant advancements in smart farming. Market reports project substantial growth in the global smart agriculture sector, expected to rise from

14.4 billion US dollars in 2024 to 23.4 billion by 2029, exhibiting a compound annual growth rate of 10.2 %. While growth is anticipated predominantly in the US and Asia, the European intelligent agriculture market is also forecast to expand considerably from 2.2 billion dollars in 2024 to 4.1 billion in 2029 [2].

Beyond the critical need for efficient, sustainable methods to increase food production with limited resources, key market drivers include the escalating demand for IoT and AI-based systems in agriculture. A significant factor is the ongoing development of cost-effective and portable photonic sensors and devices, including advancements in integrated photonics and photonic integrated circuits (PICs), which are making these technologies more accessible to a wider range of farmers. These integrated solutions enable miniaturization, improve accuracy, and allow for detailed in-field analysis using techniques like

near-infrared (NIR) and Raman spectroscopy. The increasing use of lidar for 3D mapping and analysis also plays a vital role.

Crucially, government initiatives are acting as major market drivers by actively addressing challenges that have previously hindered the widespread adoption of photonic technologies in agriculture. High initial investment and maintenance costs for photonic equipment and data processing software remain a challenge, particularly for small and medium-scale farmers. However, initiatives such as the EU's 3 billion euro investment in sustainable farming, offering extended repayment periods and specialized financing, are designed to alleviate this financial burden. Other significant challenges involve the necessity to train farmers in data interpretation, calibration, and maintenance, alongside issues of inadequate Internet connectivity and infrastructure in remote agricultural areas. Collaborative efforts, such as the Agriculture Innovation Missions for Climate, which has mobilized significant funding from global partners, are also supporting the transition to climate-smart agriculture and food systems.

Coupled with continuous technological advancements in areas like tunable LED systems, hyperspectral imaging, smart optical sensors, and integrated photonics, these government funding initiatives are positioning photonics to play a crucial role in creating more sustainable and resource-efficient farming practices. This will lead to increased resilience to environmental challenges and ultimately enhance global food security. The future will likely see further integration of these technologies, with intelligent imaging systems becoming more adept at early disease and stress detection, and controlled environment agriculture leveraging advanced lighting for optimized growth conditions. The development of versatile photonic solutions that can adapt to the unique characteristics of diverse crop varieties will be key to their broader adoption.

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- [1] Markets and Markets: Smart Agriculture Market Size, Share & Trends, December 2024
- [2] Market Data Forecast Europe Intelligent Agriculture Market

Investment in Photonics

Three experts share their advice on how to increase your chances of finding the right investors for your enterprise

Carlos Lee

Source: EPIC



Carlos Lee (left) at Photonics Investors TechTour Event

To find out more about how photonics companies, particularly start-ups, can increase their chances of a successful pitch, three people with extensive experience in photonics investment talk to EPIC director general Carlos Lee for an investee perspective: two investors, Ewit Roos at PhotonVentures and Marek Kotelnicki from Vigo Ventures, and Ronny Timmreck, serial entrepreneur and currently CEO at Vitrealab, a provider of light engines for AR glasses.

What is your experience in photonics investment?

Ewit Roos: I started in photonics as a director at Brightmove, where I navigated early-stage equity funding for high-tech startups. I then became managing director of PhotonDelta, a founder and funder of deep-tech photonics startups. Since 2023 I have been a general partner at PhotonVentures, a deep-tech venture capital firm providing funding for companies working in integrated photonics.

Marek Kotelnicki: I have spent half my working life in the high-tech sector helping engineers to secure capital, advising them how to pitch to investors, and how to market their products. I have advised hundreds of technology companies from more than forty countries. Since 2018, I have been a managing partner at Vigo Ventures, an early-stage deep tech VC firm with a focus on photonics, investing globally.

Ronny Timmreck: I started my first company even before my PhD in photonics and later co-founded or led five startups, both operationally and from the board, three of them in photonics. The most recent is Vitrealab, which focuses on the augmented reality industry with groundbreaking light engine technology. I have given more than a hundred pitches and got to know hundreds of investors during my career in photonics.

Firstly, for the investors, what is the scope of your investments?

Ewit Roos: We provide Series A funding for European companies, i.e., 500,000 to 5 million euros, and we have a reserve for follow-on funding of 7 to 10 million if needed. We look for at least three to four times the return on our invested capital, depending on the sector.

Marek Kotelnicki: We focus on the early stage, meaning pre-seed and seed-stage photonics companies with tickets up to 1.5 million euros, typically from 200,000 to 1 million of initial investments and around 500,000 in follow-on capacity. We invest across the whole of Europe, but since 2023 we have started expanding more towards the US and Canada. We aim to invest in companies that are in the B2B space and have platform technologies enabling multi-scenario exits, bringing double or triple multiples on exit.

Why did you become involved with photonics?

Ewit Roos: Having a background in photonics through Photon Delta, we have seen rapid growth in integrated photonics because of its advantages of bandwidth, speed, and reduced energy consumption, among other benefits. We know the technology, the markets,



Source: PhotonVentures

Ewit Roos



Source: Vigo Ventures

Marek Kotelnicki



Source: Vitrealab

Ronny Timmreck

and the applications pretty well, and we started this investment fund because we were convinced we were going to make money.

Marek Kotelnicki: Back in 2017 we saw the global spread of photonics. The market is going to hit around 2 trillion US dollars in 2030 and we see opportunities in areas such as optical communications and information, healthcare and well-being, advanced manufacturing and quality control, autonomous vehicles and smart mobility, next generation computing, and security and defense.

Ronny Timmreck: I have always had a passion for physics. My PhD was on solar energy and I have been hooked on photonics ever since.

How many investment pitches for investors do you see per year and what criteria do you use to select the successful ones?

Ewit Roos: We received around two hundred start-up pitches in 2024, and invested in three. As regards criteria, we do not consider pitches heavily dependent on healthcare because, with the protocol and legal hurdles, it takes longer to get to market. To be successful, products have to be for relatively high-volume markets. What is also important for us is its integration capability, i.e., the solution has to be integrable in existing architectures or systems. The other points are manufacturability, and the need to have partners who have a name in the market. The same applies

to development partners because with respected names behind you, you are immediately credible and get a lot of positive feedback on your product and your technology development path.

Marek Kotelnicki: We receive around two hundred photonics projects per year, and on average, we invest in two. For simplicity, our criteria could be described as the five Ts. The first is team: is the team aligned with the strategy and will it be there for you for the ups and downs? The second is timing, in relation to the adoption readiness level of the market toward their solution – how well the founders understand the market they want to enter and how to navigate it. The third is technology: is it usable? Is it implementable? Is it defensible? Is it explainable? Is there a need or will there be a need for the technology to solve a defined problem? The fourth is transparency: in short, you are consciously self-critical and can be open about the things that need to be addressed. This creates trust and credibility. The last T is your awareness of the time it will take to raise funds, and your commitment to the process both now and in the future. The process can be swift, but only if you are well prepared and have done your homework.

The funding process usually starts with a PowerPoint presentation. In general, are they acceptable?

Ewit Roos: We never judge a start-up on their first pitch, however unsatisfac-

tory their slide deck presentation may be – that is why they are a start-up. In the first instance, all we are interested in is the technology: if it will be required in the next three to five years, we see potential.

Marek Kotelnicki: There is no perfect pitch; the truth is in the conversation, although based on our practical experience, we help and provide a process document to show what is needed. We see both good and poor decks.

Ronny Timmreck: My advice to people fresh out of academia is to forget everything you have learned about PowerPoint presentations from the academic world. Approaching investors with an academic presentation doesn't make any sense, because academia and industry are completely different. Accept the fact that you know nothing about the investment world and take advice from experienced founders on what investors want and how to approach them.

What can companies do to improve their chances of a successful pitch?

Ewit Roos: We are not interested in current solutions, we are interested in solutions that will be on the market in five years' time. So aside from the team and the technology, to be accepted by us, companies have to think ahead and the business case has to be a convincing long-term one of at least five years.

Marek Kotelnicki: From our experiences, more emphasis should be put

on organizational maturity – understanding exactly the skills and people that you have at hand, who is responsible for what, how you will be able to deliver with the resources that you have, and how to grow. You need to take into account the hiring process, how long it takes, the onboarding process, and limit the situations when you hire the wrong person.

The other thing is market sizing and choosing your beachhead. I would like to see less of a general approach and a greater focus on a bottom-up approach. So if you have a product, you need to figure out how many of these products are being sold today [by your competitors] and how do you fit in. If your product can be cheaper than the competition, what is your pricing strategy?

Finally, there is a need for a collaborative mindset: we want to work with collaborative, bold, and forward-thinking people who are looking to build a long-term relationship through defined milestones.

Ronny Timmreck: First of all, it is important to understand that fundraising is not an end in itself – it is like filling up your car: you are not doing it to drive in circles and show off the tank, but to actually get somewhere. And to stretch the metaphor a bit further: the location of gas or charging stations may shape your route, but they should not define your destination.

To support what Marek said: to be successful with fundraising, you need to build a personal network into the investor scene because, at the end of the day, investment is a people's business and you need the personal connections. Fundraising is a long-term game. It is not just a case of getting the money: you have to be connected to the investors

all the time. Let them know what you are doing early on and let them be part of the overall journey of your company.

I would also add that one of the big challenges for founders coming from academia, where most photonic start-ups originate, is the need for a complete change in mindset. You need to pitch from a business perspective, not from an academic one. You need to think about scaling, milestones, recruitment, marketing etc. Investors are not investing just in the technology, they are investing in solutions that really fulfill the needs of customers and this is what needs to be in the center of the pitch. How can you fulfill the needs of customers? How big is the market, and what is the narrative behind it?

Founders from academia who do not make this mind shift may be successful in creating a small to medium sized company, but they will be unable to scale the company and attract the big investors because they want to see the potential for business growth.

From your perspective Ronny, what could be improved on the investors side?

Ronny Timmreck: Life would be much easier for both sides if investors communicated their investment criteria clearly on their websites, which many fail to do. For this reason, it is difficult to build an investor list when you are in the research phase because you are not sure what they are looking for, and you end up wasting a lot of time by approaching a lot of investors who are not relevant.

Some investors also lack professionalism. For example, I went to an investor event last week in the Silicon Valley where there was a matchmaking app for startups to contact investors. In my case,

many investors did not respond to my messages, so it was difficult to understand why they were there.

How welcomed have you felt by investors?

Ronny Timmreck: Investors need a deal flow, so they need to welcome you because they need to invest their money. It is important to be aware that investors are under a lot of pressure because they need to invest their clients' money wisely. Of course, they have their priorities, and you won't be welcome if your technology is not aligned with those priorities. It is therefore important to know an investor's portfolio of companies before you approach them.

What is the one piece of advice you would give to a company going to their first investor event?

Ewit Roos: Know and be able to validate why your solution and approach are feasible and sustainable, not now, but within three to five years on the roadmap of the domain that you are covering.

Marek Kotelnicki: Do your homework on who you want to be your investor. It is not only a case of being able to answer the investor's questions. What I value most is when companies can tell me what is valuable for them, what they want to achieve, and how I can help them do that. My role is not to drive innovation, it is rather to help companies take the necessary risks to change the status quo.

Ronny Timmreck: Yes, doing your homework is key to success, but it takes a lot of work and time. To select the right investors, you have to search through the different kinds of networks on the internet like Crunchbase or PitchBook. You have to look at which similar startups to yours have been funded by which investors, who the lead investors and the people behind them were, and how can you connect with them.



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Infobox

EPIC investment support activities

Finding quality investors i.e., those who can add value to a company through their understanding and interest in the technology, is of critical importance for photonics companies. This is why the European Photonics Industrial Consortium (EPIC) regularly organizes in-person investor meetings and puts its members in contact with potential investors through e-mail introductions during the whole year. The next photonics investors dedicated events that EPIC supports are the TechTour investors event on 9 – 10 October 2025 in Berlin, and on 4 – 5 November 2025 in Eindhoven, The Netherlands.

<https://epic-photonics.com/members/membership-benefits/>

Meet us at Laser World of Photonics, Hall X Booth Y



Are you looking
for investors?

EPIC is here
to support you!

40 years of the Fraunhofer Institute for Laser Technology ILT

The laser is a success story and some chapters of it were written in Aachen



Source: Fraunhofer ILT

Lasers form the backbone of modern communications technology, but they also weld together batteries for electric cars. Lasers measure the atmosphere and correct our vision, but they also produce tiny computer chips. They are currently paving the way for quantum computers and fusion power plants of the future. From developing 20 kW cutting lasers to AI-controlled production systems, the teams at the Fraunhofer Institute for Laser Technology ILT have been contributing to the success story of lasers for forty years, always aiming to effectively transfer ideas from research into practice.

The laser – one solution and many questions

After the first ruby laser emitted its bright red light in May 1960, the idea of this “light amplification by stimulated emission of radiation” quickly became popular: the fascination was so great that a laser appeared in the James Bond film *Goldfinger* in 1965, seen cutting metal. In the real world back then, the

laser was seen more as a research topic; inventor Theodore Maiman even called it “a solution in search of a problem”. In material processing, the first real applications came in the 1970s: springs in watches were welded with lasers as were the cathodes of picture tubes in TV sets later on. Although these were still pioneering solutions, they confirmed that lasers had great potential.

▲ At the corner of the Fraunhofer ILT building, a light installation by artist Annette Sauermann symbolizes laser beams in action

These lasers only partially met the expectations of the users; rather, they showed how much research and development was actually still needed. Measure-

Pioneers from the very beginning (from left to right): Dr Falk Rühl, then deputy director of Fraunhofer ILT, Prof Gerd Herziger, director of Fraunhofer ILT from 1985 to 1996, Prof Peter Loosen, later deputy director, and Prof Eckhard Beyer, who started at Fraunhofer ILT and later headed Fraunhofer IWS in Dresden



Source: Fraunhofer ILT

ment technology and process knowledge were also still in their infancy. However, industry and politics had clearly recognized the potential and so several laser institutes were founded in Germany in the mid-1980s, including the Fraunhofer Institute for Laser Technology ILT. Their task was clear: these institutes were to act as a link between research and industry, helping to effectively transfer the abundant knowledge available in academics to industry. Politicians supported this with a series of funding programs.

From research to implementation

The working groups at various universities had accumulated a great deal of knowledge about lasers by the early 1980s. At the Technical University of Darmstadt, for example, around twenty-five researchers were working on lasers, especially on the associated

plasma physics. Gerd Herziger, head of the Institute of Applied Physics, came up with the vision of a national laser institute. Politicians saw this with great interest, and several state prime ministers made contact to inquire whether an institute should be founded in their state.

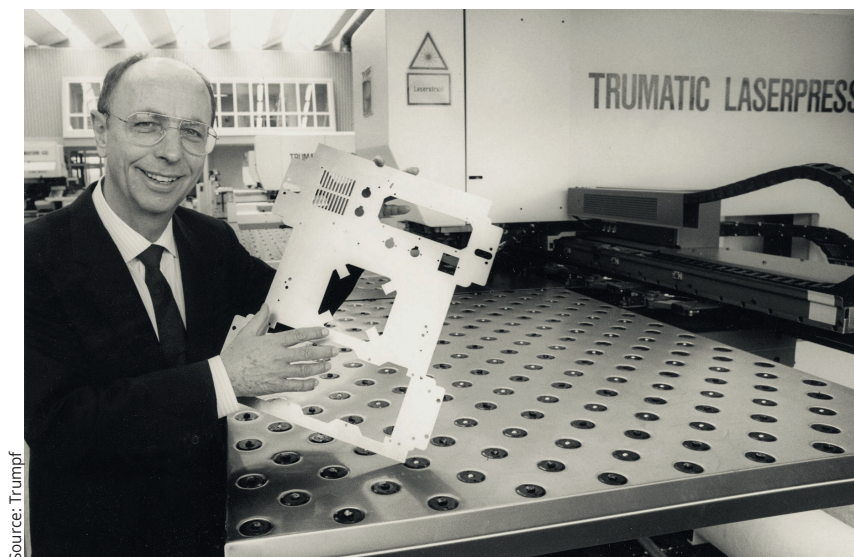
“We wanted to develop industrial applications, such as material processing with lasers,” recalls Reinhart Poprawe, a doctoral student at the time and later head of the institute. “We finally found the right partner in the Fraunhofer-Gesellschaft. Then Fraunhofer ILT came to Aachen because the production technology at RWTH Aachen University was so well suited to the vision of industrial laser technology.”

New beam sources for industry

Herziger’s vision also met with great interest from industry and it was not long before the founder and his first

three department heads – Eckhard Beyer, Peter Loosen and Reinhart Poprawe – sat down with engineer and entrepreneur Berthold Leibinger in Ditzingen, near Stuttgart, Germany. Leibinger, then managing director of the Swabian machine tool company Trumpf, had already gained experience with American CO₂ lasers. He still saw a need for development, but any improvement would have been available to his competitors worldwide. For this reason, he had been building up a laser development department at Trumpf since the early 1980s.

The team at Fraunhofer ILT joined as a partner to support Trumpf in developing the technology for fast-flow CO₂ lasers. With up to 20 kW, these lasers became a milestone in material processing. CO₂ lasers with an output of 40 kW were even built directly at the Fraunhofer ILT application center together with Trumpf. In cooperation with the



Source: Trumpf

Dr Berthold Leibinger presents the Trumatic laser press

Past and present – managing directors of Fraunhofer ILT



Prof Gerd Herziger



Prof Reinhart Poprawe



Prof Constantin Haefner



Dr Jochen Stollenwerk

Source all images: Fraunhofer ILT

partner institutes, Trumpf was able to build up a solid patent portfolio and position itself worldwide as a technology leader in laser machine tools. Today, the world's most powerful CO₂ lasers are produced in series at its headquarters in Ditzingen. The Dutch ASML Group, one of world's largest suppliers of tools to the semiconductor industry, uses them in lithography systems for chip production.

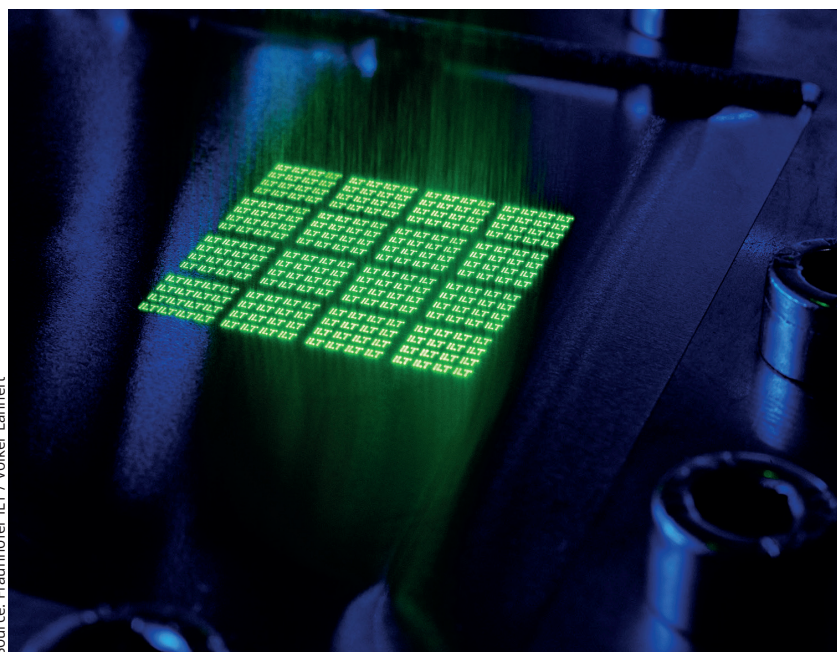
Innovative collaboration models secure competitive advantage

The close and long-term cooperation with local companies led to the expansion of the laser user center. Companies were able to rent their own laboratory space and premises there. This was new and unusual for a research institute, but for the cooperation between the teams from the institute and the companies, it created the foundation for an extremely successful collaboration that attracted worldwide attention. This meant that the unique technical infra-

structure could be used effectively and the partners could exchange information fast and efficiently. Not only did established laser manufacturers such as Trumpf and Rofin-Sinar as well as innovative laser users such as Thyssen and Philips work closely together, but spin-offs from the Fraunhofer ILT – in the fields of special plant engineering, laser production technology and laser measurement technology – also found a suitable environment to implement their ideas on an industrial scale. They have all set standards, both in Germany and internationally. The VAT alone that is generated by the jobs and turnover of these now forty spin-offs could pay for the basic funding of Fraunhofer ILT four times a year.

Twenty years later, RWTH Aachen University adopted the new business model of spin-ins – i.e. local companies and industrial working groups – and initiated the campus model, a systematic platform for cooperation between the

university, industry and affiliated institutes. This close collaboration gave rise to a new, structurally anchored form of cooperation: a structural measure entitled the Digital Photonic Production DPP Research Campus initiated by the Federal Ministry of Education and Research BMBF in order to accelerate technology transfer in photonics. For example, the chair of laser technology at RWTH Aachen University coordinates the photonics cluster on the RWTH Aachen Campus together with Fraunhofer ILT, one of seven current clusters. Two buildings have already been constructed by private and public investors in the photonics cluster. Shortly after this opened in 2016, more than twenty companies set up shop in a 7,000 m² building specially designed for industrial research. Premises such as laboratories and offices can be used as required. Interdisciplinary teams from industry and science interact in co-working structures.



Source: Fraunhofer ILT / Volker Lannert

Multibeam optics convert a laser beam into a matrix of multiple beam segments that can be used on the workpiece in parallel and controlled individually – a significant increase in productivity

Fiber, disc or slab?

At the end of the 1980s, the institute's first projects placed the development of powerful laser sources in its DNA. Early on it was clear that the future belonged to solid-state lasers. They are more energy-efficient and much easier to service than CO₂ lasers. The boom in diode lasers for telecommunications in the 1990s was decisive for this new laser class. Although the diodes were still relatively weak, the Aachen institute developed both diode-pumped solid-state lasers and the first pure diode lasers in the kilowatt range.

The core of a solid-state laser is the active medium where the radiation from the diodes is converted into laser radiation. It can be very long (fiber) or extremely short (disk). Both have their advantages and disadvantages. Fraunhofer ILT has found a solution in between – the Innoslab laser. This multi-award-winning concept uses a plate-shaped crystal ('slab') in which the laser beam can propagate freely, a decisive difference to earlier slab laser concepts.

The idea came from Keming Du, who worked on the concept together with Peter Loosen and applied for a basic patent in 1996. The result is a solid-state laser platform with high average power and excellent beam quality, ideal for applications such as micro-machining, satellite-based lidar and ultrashort-pulse lasers.

Du successfully transferred the technology to the start-up Edgewave in 2001. One prominent application of the first Edgewave lasers was the popular internal glass engraving process, which can be used to create three-dimensional images in a glass body. Development at Fraunhofer ILT continued following this success. As Peter Loosen's successor, Hans-Dieter Hoffmann is driving development toward short and ultrashort pulse generation and amplification. This was followed by further spin-offs in the high-power laser sector, such as the Amphos company, which was later integrated into the Trumpf group.

It's the optics that count

As high-power diode lasers were being developed for material processing, an elementary question arose early on: how can the beams from many different laser diodes be combined into one beam? The answer came in 1995 with a staircase mirror that combines the beams of an entire sequence of diode lasers. Such



The inventors of the LPBF process, (from left to right) Dr Wilhelm Meiners, Dr Kurt Wisenbach, and Dr Andres Gasser, stand in front of a small transport trolley carrying the first LPBF machine

projects show that sustainable laser development requires much more than just a powerful laser source. All the parts in a laser system – mechanics, control, beam shaping – must be optimized together. The optical system modifies the radiation from the laser source so that it matches the machining process. The strategic change in laser technology can be seen in beam shaping: in the early days of the laser, the pioneers in the industry looked at which processes were possible with the device; the optics were little more than a lens. Today, the laser generates 'tailored light', a beam that is optimized in every detail for the specific application, making it the gold standard in many areas. From the wavelength and pulse shape to the beam profiles, focus position and depth of field, nothing is left unnoticed.

Fraunhofer ILT developed simulation, production and test procedures for laser optics for this purpose. The engineers set their sights on developing optics that shape the laser beam in such a way that the process runs as efficiently as possible and delivers the highest possible quality. Since then, many special cutting and welding optics have been designed in Aachen, but also special optics such as multi-beam optics that convert one high-energy laser beam into a matrix of multiple beamlets and can be used on the workpiece in parallel – a significant increase in productivity. A team of scientists founded Pulsar Photonics in 2013 based on this technology. Today, the company successfully builds and sells industrial laser machines with multibeam optics and a wide range of other optical systems. Developments in this area also continued at Fraun-

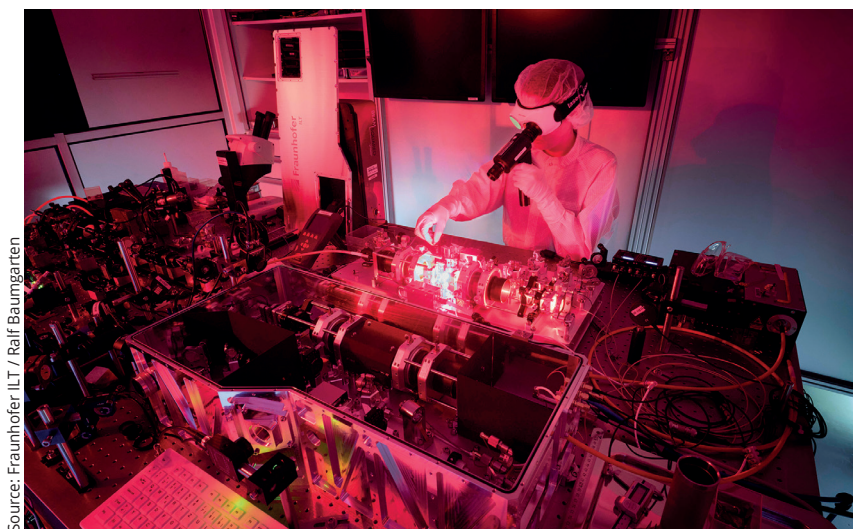
hofer ILT: in 2020, a team of researchers and industry partners was awarded the Science Prize of the Stifterverband for Collaborative Research for the development of multibeam technology for the production of functional surfaces.

Process knowledge is the key

What happens in the material when a laser beam hits it? Or what exactly does a laser beam have to look like to cut a 100 mm steel beam? A deep understanding of the processes that take place on and in the material is one of the institute's core competencies. In order to build up and expand this knowledge, it not only uses a wide variety of measurement methods, but is also constantly carrying out new simulations. Process knowledge is created through the interplay of theory, simulation and measurements. For particularly high-resolution measurements, a team from Fraunhofer ILT used X-ray pulses from the PETRA synchrotron in Hamburg to film laser welding processes. Hundreds of films were recorded. Alexander Olowinsky, the head of the department responsible, explained it quite simply: "We use the X-ray beam to look at the laser focus through the molten metal. This is the only way we can really understand what is happening during the process."

Thanks to such in-depth insights, Fraunhofer ILT has been able to establish a competitive edge for the industry. This know-how has also formed the basis for several special laboratories at Fraunhofer ILT and the cooperating RWTH institutes. Today, one part of the RWTH focuses on hydrogen technology, while another covers all steps in the production of batteries for e-mobility.

Source: Fraunhofer ILT



Source: Fraunhofer ILT / Ralf Baumgarten

The alexandrite lasers are being optimized at Fraunhofer ILT as part of the EULIAA project so that they can operate in lidar systems for climate research for several months without maintenance or adjustment

Building up material with the laser

In 1996, another revolution in material processing started at Fraunhofer ILT: Wilhelm Meiners, Kurt Wissenbach and Andres Gasser registered a basic patent for metallic 3D printing, now called laser powder bed fusion LPBF. Wilhelm Meiners later recalled: “Nobody believed – except us – that our development could turn into something useful!” For example, Fraunhofer ILT produced the world’s first generatively manufactured hip cup implanted in a patient and the first generatively manufactured dental implant made from a cobalt-chrome alloy.

The LPBF process represents a decisive advantage of laser technology: the production costs are less dependent on a component’s geometrical complexity, but mainly on its volume. Complex and individualized shapes such as implants can be produced at almost no extra cost. Today, the LPBF process is widely used in industrial applications in turbomachinery and automotive engineering, aerospace, and medical technology. The market for additive processes with metals is worth several billion euros, with LPBF being the dominant technology.

Fast, faster, EHLA

Additive processes have been continuously developed over the forty years of the institute’s history. In laser material deposition (LMD), for example, a laser is used to melt a metal powder onto a workpiece surface. This means that even the hardest metal can be applied with high precision to almost any metallic base material. One problem with many additive processes is the speed; the process simply takes time. Researchers at

Fraunhofer ILT and the digital additive production division at RWTH Aachen University have therefore developed EHLA, extremely high-speed laser material deposition.

EHLA makes laser material deposition several orders of magnitude faster. The metal powder is applied to a surface with a nozzle and melted with the laser while still in flight. This allows rotationally symmetrical surfaces to be coated at speeds of up to 500 meters per second. The process is extremely efficient and completely dispenses with the use of environmentally harmful chemicals or noise emissions, making it a cost-effective replacement for electrochemical or thermal spraying processes. EHLA has now also made it into the additive manufacturing of complex components. For example, it can be used to quickly print difficult-to-weld materials such as tool steels, titanium, aluminum, and nickel-based alloys as well as multi-material composites or graded components. The researchers from Fraunhofer ILT and RWTH Aachen University were honored for exactly this innovation with the Berthold Leibinger Innovationspreis in 2018.

Lasers for climate research

Lasers have many amazing capabilities beyond material processing. Adapted laser beams interact with atoms and scientists can obtain information about the atmosphere from the reflected signal. This works just as well in the atmosphere as in the laboratory. Various lasers have been built at Fraunhofer ILT for this type of measurement. In the European Space Agency’s Merlin mission, for example, a satellite will record the methane concentration in the Earth’s atmosphere from an altitude of

around 500 kilometers at high temporal and spatial resolution. A laser amplifier from Fraunhofer ILT will be on board for this purpose. It is based on the Fulas platform for which the experts have not only developed components suitable for space travel, but also their own assembly technology. The optomechanical components are assembled and adjusted with manually guided robots using the pick-and-align method.

However, the atmosphere can also be observed from Earth. Josef Höffner at the Leibniz Institute of Atmospheric Physics IAP in Kühlungsborn is a pioneer of measurements at high altitudes of over 100 km: he measures the scattering of laser beams on individual atoms at this altitude with a mobile lidar system. His data is crucial to understand processes in the middle and upper atmosphere and incorporate them into weather and climate models. The laser for this is a diode-pumped alexandrite laser, a development from Aachen. It has now been produced in small series to enable such measurements to be taken anywhere in Europe in the near future.

Lasers in medicine

Skull surgery on an awake patient is considered an exceptional situation, even among the doctors performing it. Sometimes it is unavoidable, for example when the patient has to give the surgeon feedback on where certain functionalities are affected during the operation. Researchers at Fraunhofer ILT have developed a system to open the skull during such operations that removes bone without vibration and simultaneously measures the remaining bone thickness with micrometer precision. For those affected, this could be just as

much of a game changer as a comparable system for risky spinal surgery.

The potential of lasers in the life sciences is extremely diverse: the spectrum ranges from use in operations and spectroscopic applications in the laboratory to the construction of prostheses. And the potential continues to grow.

The close connection between the laser and digital technology is particularly advantageous for applications in personalized medicine: data for implants can be fed directly from the computer into the 3D printer. They are precisely adapted to the patient and the surfaces can be designed so that they grow in particularly well. The modular system of technologies at Fraunhofer ILT includes everything from image processing and process planning to post-processing.

How to digitize production in an integrated manner

A lot has changed since Maiman's ruby laser: today, laser beams are generated completely electronically and shaped in such a way that they process material optimally without human intervention. This makes lasers predestined as instruments to digitize production.

The concept of 'digital photonic production' describes digitally controlled laser production. Products are planned on the computer and manufactured in laser machine tools using light as a tool. CAD design data is converted directly into CAM production data, while inline measurement data helps to optimize the process during machining. Such processes require an integrated approach: in addition to using complex machine tools, a powerful modeling and a simulation platform, users need extensive process knowledge. This vision has been put into practice at Fraunhofer ILT over the decades.

This digitized production (computer integrated manufacturing, CIM) is fueled by increasingly powerful computer technology. Today, complete production lines are digitally simulated, machines given a 'digital twin' and components and processes simulated. Indus-

trial users have access to data along the entire process chain at all times.

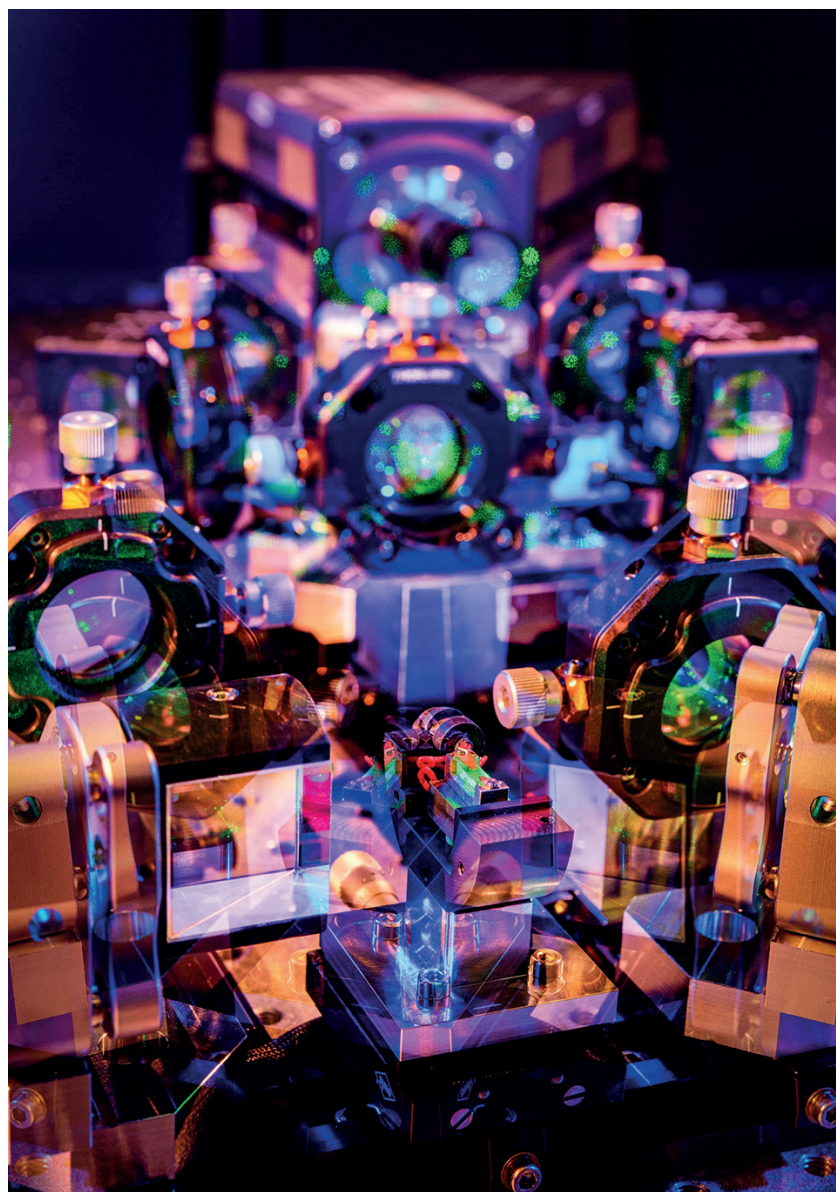
This means that production processes can be tested digitally during the planning stage. However, digitization also enables new functions during operation. For example, sensors continuously supply data on the condition of the workpieces and tools to local computers (edge computers). Individual data is sent to a control center, for example at the laser manufacturer. This enables them to predict when a machine needs to be serviced.

This predictive maintenance saves costs and increases system availability. Data from production lines around the world can also be compared: for example, a material problem in Brazil can be analyzed in Bavaria, which leads to adjustment of the settings at the plant in Spain. The technology for this has been researched in Aachen for years and is

used in automotive production, among other things.

From Aachen to the world

The choice of where to locate Fraunhofer ILT was made forty years ago in Aachen. There were already established partnerships between research and mechanical engineering there, which have been massively expanded since then. Several competencies were established at RWTH Aachen University and Aachen University of Applied Sciences, and partnerships with other universities and Fraunhofer institutes were established and expanded. Users from a wide range of industrial sectors, from turbine construction and automotive production to medical technology, also came to develop innovative products and processes with Fraunhofer ILT from elsewhere in Germany, Europe, and all over the world.



Source: Fraunhofer ILT / Volker Lammert

Lasers are ubiquitous in quantum technology: for cooling atoms, as optical tweezers, or for manipulating and measuring the quantum mechanical states of atoms, molecules, ions, or photons. Here in the picture: Interferometric quantum imaging setup

Surgical opening of the vertebral body is highly risky due to the spinal cord located in the spinal canal. The robot-assisted laser surgery system developed at Fraunhofer ILT is designed to replace high-speed mechanical milling and minimize surgical risks



Source: Fraunhofer ILT / Ralf Baumgarten

The exchange of ideas is particularly intensive at the various conferences that Fraunhofer ILT has organized. Whether it is about ultrashort pulsed lasers or turbomachinery, battery or hydrogen technology, Fraunhofer ILT has set high standards for specialist conferences and done so with great commitment. The highlight every two years is the AKL – International Laser Technology Congress with more than five hundred participants from all over the world. The presentation of the Innovation Award Laser Technology in the Coronation Hall of Aachen City Hall creates lasting memories for everyone involved.

The future belongs to photons

The innovative potential of laser technology is far from exhausted. The laser, once just an instrument of research, has matured into a universal tool of the modern age. And yet the photonic revolution is only just beginning. “There is huge untapped market potential in cyberphotonics, fusion, quantum technology, secondary sources, and the megatrends of sustainability and Industry 4.0,” says Constantin Haefner, ILT director from 2019 to 2025.

Artificial intelligence and digital photonic production are increasingly

merging into highly productive first-time-right manufacturing; closed control loops are within reach. At the same time, the use of AI shortens development cycles, minimizes the number of real-world tests and trials, and assists in the design of optics and the layout of beam paths. Integrated photonics also minimizes the energy consumption of AI data centers. Fraunhofer ILT adopted AI early and is consistently advancing its use in cooperation with the technology of optical systems division at RWTH and industry partners. This is because the potential that cyberphotonics can unleash in the application markets of photonics is already becoming clear.

Lasers are also ubiquitous in quantum technology: to cool atoms, as optical tweezers, or to manipulate and measure the quantum mechanical states of atoms, molecules, ions, or photons – or even in the manufacture of complex optics, ion traps, and other hardware for quantum computing, quantum communication, and quantum sensor technology. While lasers make use of large photon collectives, quantum technologies sometimes use individual photons and phenomena such as their pairwise entanglement and superposition. Fraunhofer ILT is currently developing many

important building blocks for high-performance quantum computing, secure quantum networks, and quantum sensor technology and imaging.

Fusion power plants represent another potentially huge future market for laser technology. Research has been on the rise worldwide since a plasma ignition was successfully achieved at the National Ignition Facility of the Lawrence Livermore National Laboratory in California in December 2022, which released more energy from the world's most powerful laser than was supplied for ignition. Today, Fraunhofer ILT is working with partners from industry and research to develop basic technologies for fusion power plants of the future. These include robust optical components and high-power diode lasers that can be produced fully automatically. The institute's research focuses on fusion power plants, but also produces secondary sources as valuable by-products. These convert intense laser pulses into electron, proton, X-ray, or even neutron beams, which enable completely new applications. Fraunhofer ILT is currently involved in a consortium that is developing a compact neutron beam source that should enable it to analyze and image materials through the walls of sealed barrels and containers.

More than five hundred employees, who register an average of one patent per month, now look back with pride four decades after Fraunhofer ILT was founded on what they have achieved, and remain full of boundless energy. The institute is ideally positioned to continue shaping the development of photonic technology and to write new chapters in laser history because one thing is certain: the future belongs to photons.

Institute

Fraunhofer-Institut für Lasertechnik ILT

With more than 550 employees and more than forty spin-offs, the Fraunhofer Institute for Laser Technology ILT in Aachen is one of the leading contract research and development institutes in its field. For forty years, the Fraunhofer ILT experts have been developing and optimizing laser beam sources and laser processes for production and metrology, energy and mobility, medical and environmental technology, as well as quantum technology. www.ilt.fraunhofer.de

Meet us at Laser World of Photonics 2025, Fraunhofer-Gemeinschaftsstand A3.431

Edmund Optics – offering two specialized solutions!

With over eighty years of experience, Edmund Optics has built a reputation as a trusted provider of high-quality optical components and solutions, serving a variety of markets including Life Sciences, Biomedical, Industrial Inspection, Semiconductor, and R&D since 1942. The company employs over 1,300 people across 19 global locations and continues to expand.

As a leading optics and photonics company, Edmund Optics continues to innovate and expand to meet the evolving needs of its customers, offering two specialized solutions: a robust Marketplace for the best brands in optics and an Advanced Manufacturing service specializing in custom and volume production of precision optical and imaging components.

Edmund Optics' **Marketplace** offers over 34,000 off-the-shelf products from in-house manufacturing and global sourcing. A focus on continually expanding inventory ensures that

customers find the right components for their applications. Edmund Optics serves as a one-stop shop for customers' entire beam path, granting access to 40+ top-tier brands alongside its own high-quality optical components. With over three million items in stock, Edmund Optics ensures fast, reliable delivery. Its 24/7 online chat connects customers with engineers for real-time support across industries, enhancing the customer experience anytime, anywhere.

Edmund Optics' **Advanced Manufacturing** services include custom design, first article production, and volume manufacturing of high-quality optical and imaging components and systems. From initial concept validation to full-scale production, Edmund Optics manufactures over two million optical components and 175,000+ optical assemblies annually. With in-house design, manufacturing, and metrology expertise across four design centers and nine specialized factories worldwide, we sup-



port both high-volume and specialized manufacturing needs. Our expert team of optical and optomechanical designers, project managers, and manufacturing engineers will guide you seamlessly through every stage of your project.

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Laser World of Photonics B1.416

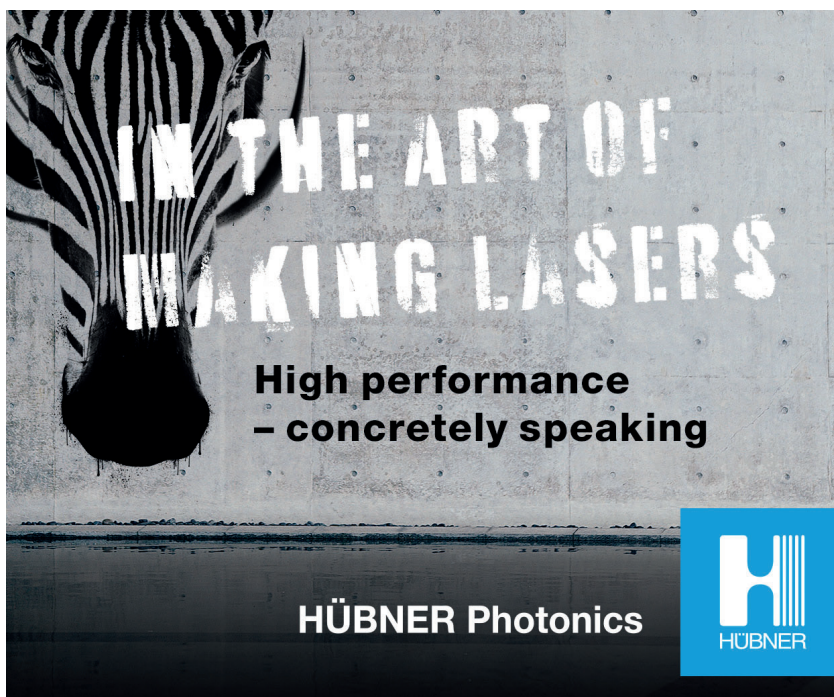
THE FUTURE DEPENDS ON OPTICS



Hübner Photonics

Hübner Photonics is committed to supplying high performance and innovative lasers that meet or exceed the market's expectations concerning quality, reliability and robustness. Hübner Photonics offers the full range of:

- Single and multiline lasers by Cobolt
- cw tunable lasers
- Laser combiners
- Femtosecond lasers
- Terahertz imagers & spectrometers



Through continuous technology development, customer orientation and an ISO certified quality management system, Hübner Photonics has become a preferred supplier of lasers to major instrument manufacturers and leading research labs for cutting-edge applications in the areas of fluorescence microscopy, flow cytometry, Raman spectroscopy, metrology, holography, nanophotonics and quantum research. Hübner Photonics has manufacturing sites in Kassel, Germany and Stockholm, Sweden with direct sales and service offices in USA.

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Laser World of Photonics B2.217

JPT Opto-Electronics

Registered in 2006, Shenzhen JPT Opto-Electronics Co., Ltd. (Stock Code: 688025) is a national high-tech enterprise specializing in the R&D, production, and sales of lasers, laser/optical intelligent equipment, and fiber optic components. Adhering to the “Laser +” strategic positioning, the company is dedicated to advancing core laser technologies, deeply integrating AI to build intelligent driving engines, and focusing on laser core modules and future optical connectivity solutions, aiming to create an “Optics + AI” integrated innovation ecosystem.



Leading manufacturer of MOPA pulsed fiber lasers

In the past years, JPT has continuously innovated and is always seeking breakthroughs in technology with the mission of “Leading Optical Technologies for People” while keeping improving of the excellent consultant, management, R&D and sales team, where the key team members consist of several PhDs and masters from global famous universities and research institutes. JPT MOPA pulsed fiber lasers have been the first ones to be mass-produced in China which bridged the long-term technical gap in this field. With the excellent precipitation and accumulation of laser technology, JPT has harvested lots of honors and been widely recognized as:

- Top 1 of MOPA pulsed fiber laser in global
- Top 3 of fiber lasers manufacturers in China

Laser technology promotes industrial application

JPT provides multi category of laser source including ultrafast lasers, cw fiber lasers, DPSS lasers and ultrafast

JPT

lasers. These products are widely used in many kinds of manufacturing processes, such as black marking on anodized aluminum, color marking on stainless steel, deep engraving, welding of dissimilar metal sheets, paint removal of plastic product, laser cleaning, glass drilling, lithium battery processing, electrode tab and photovoltaic silicon wafer cutting, etc. JPT laser technology is being used in an increased number of industries, including 3C, PV, lithium battery, PCB, semiconductor, communications, detection, machinery, transportation, medical industry and etc.

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Laser World of Photonics A3.331

Laserline – The Driving Force for Tailored Laser Innovation

Laserline GmbH, with its headquarters in Mülheim-Kärlich near Koblenz, was founded in 1997. The company is a world leader in the development and manufacture of highly efficient, modular diode laser systems with blue and infrared wavelengths. Laserline's high-power

diode lasers, delivering output powers of up to 60 kW and wall-plug efficiencies exceeding 50 %, are recognized for their reliability, energy efficiency, and quality. Based on decades of experience, Laserline develops customized laser solutions for industrial applications – including



high-quality beam shaping optics for the realization of variable spot geometries – and has established itself internationally as a reliable partner. Today, more than 7,500 Laserline high-power diode lasers are in use around the world, demonstrating their performance in a wide variety of processes and applications. The laser technology specialist currently employs around 400 people and has international subsidiaries in the USA, Mexico, Brazil, Japan, China, South Korea, and India.



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Laser World of Photonics B3.311

Laseroptik – home of high power optics and coatings

Laseroptik is a manufacturer of high LIDT laser optics and coatings from VUV to IR and employs more than forty coating machines using six different coating methods. They include e-beam evaporation, ion assisted deposition (IAD), magnetron sputtering, ion beam sputtering (IBS) and atomic layer deposition (ALD).

Laseroptik offers an express coating service starting with a 24 hour option

for rapid prototyping. Coatings and optics can be configured in the online app "LOOP", a database with more than 1,200 coatings plus substrates and coated components.

Typical products are high LIDT mirror and AR coatings, thin-film polarizers, gradient filters, dispersive coatings like GTI mirrors, chirped mirrors and mirror pairs, attenuators, customized filters, metal-enhanced coatings, coat-



ings on crystals, fibers, viewports and space optics.

Laseroptik offers special capabilities in their Ion Beam Sputtering section. Two IBS coaters have been built up for coatings on large substrates of up to two meters in length or 550 mm in diameter.

With a team of more than a hundred people, Laseroptik produces 180,000 coated optics per year on average for laser applications in industry, medicine and scientific research.



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Laser World of Photonics B1.120

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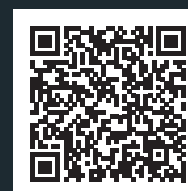
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Thank you
and kind regards,
Dr. Birgit Foltas
Editor-in-chief



<https://analyticalscience.wiley.com/publication/microscopy-and-analysis>

Microscopy and Analysis

Enabling technologies that transform our world

MKS Instruments helps businesses solve their hardest technology challenges. A trusted partner of the world's largest electronics and industrial companies, we leverage leading-edge science and engineering capabilities to offer solutions that improve process performance and productivity for our customers.

Spectra-Physics, Ophir and Newport are brands within the MKS Photonics Solutions Division. Spectra-Physics combines groundbreaking laser technologies with deep application expertise to

deliver industry leading lasers for precision industrial and scientific research applications. Ophir specializes in laser and LED measurement products, including laser power and energy meters and laser beam profilers. Ophir also provides high-performance IR thermal imaging lenses and optical elements as well as optics for CO₂ and high-power fiber laser material processing. Newport provides a full range of solutions including precision motion control, optical tables and vibration isolation systems, photonic



Spectra-Physics

Newport

Ophir

instruments, temperature sensing, optical and optomechanical components.

MKS' Surround the Workpiece strategy delivers end-to-end photonics solutions, from innovative product design and integration to expert maintenance and calibration, ensuring excellence in laser-based manufacturing.

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Laser World of Photonics A3.314

Competence in Laser Beam Diagnostics

Primes offers innovative and process-optimized measurement devices for focus characterization and performance assessment of laser beams. Our comprehensive range of high-precision, durable products is essential in numerous industrial applications to realize the full potential of laser technology. Primes systems are highly regarded by researchers and developers in both industry and academia. With all hardware and soft-

ware developed in-house, we deliver tailored solutions for a wide variety of laser measurement tasks, system characterization and failure analysis. Standardized interfaces ensure seamless integration of our instruments into production processes.

Choose the optimal solution for your laser measurement needs:

- Power meters – from compact portable devices to OEM systems for

PRIMES

- continuous production monitoring
- Beam profiling devices – for focus characterization, beam distribution, and direct fiber measurement
- System integration solutions – robust, versatile, and proven in industrial production
- Focus shift detection – to optimize your optical setup or processes
- Raw beam measurement devices – easy to adjust, individually expandable

Since its founding in 1992, Primes has installed more than 35,000 systems worldwide, earning its reputation as a global pioneer in laser beam diagnostics.

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Laser World of Photonics A3.219



Schäfter+Kirchhoff – Optics, Metrology and Photonics

Schäfter + Kirchhoff



Schäfter + Kirchhoff GmbH in Hamburg is 70 years old! The company started in 1955 with classic lens design and customized optical solutions. Gradually, the focus shifted to today's product lines, which are still manufactured in the heart of Hamburg and distributed worldwide: polarization-maintaining fiber optics, lasers for machine vision, line scan cameras as well as scanner and inspection systems.

Throughout our 70 years, our key focus has always been on combining high optical precision with high mechanical precision. This focus ensures the high quality, stability and longevity of our products.

It is reflected for example in the 60SMF laser beam couplers, which are used for coupling into polarization-maintaining fibers (PM fibers) and due to their outstanding precision and quality achieve very high coupling efficiencies with long-term stability.

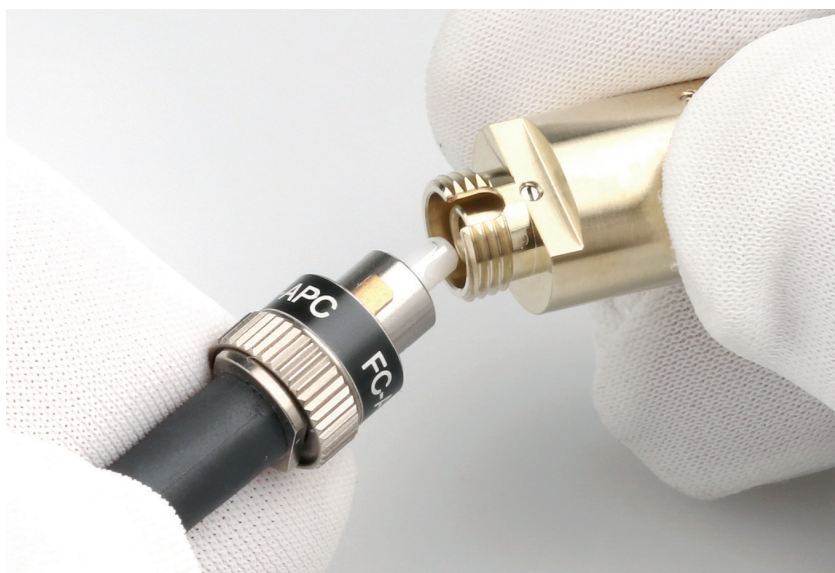
Our fiber optic products have been part of quantum experiments for over two decades. The current portfolio enables light transport in PM fiber cables and light distribution in our fiber port clusters, which have recently been extended to include acousto-optic modulators (AOMs) for frequency and power modulation (e.g. in an integrated double-pass AOM). In addition, we offer

beam launchers that enable illumination with multicolor beams of customized size, as used for laser cooling or atom manipulation.

Another example of our successful optomechanics can be found in the field of machine vision. The latest member of this product family, the AdheScan system, is based on a specially developed image acquisition system combined with a trainable machine learning algorithm. It provides a quantifiable, reproducible, and highly efficient evaluation of adhesive failure surfaces according to the DIN standard. The AdheScan is just one example of our industrial and research-grade system solutions.

Our customers are manifold and use our products, for example, for basic research on the International Space Station ISS, for the search for dark matter, for work on quantum computers, for sending probes to Mars, for climate research in polar ice or for the investigation of corrosion phenomena. Our customers include nanotechnology leaders, Nobel Prize winners, semiconductor manufacturers, solar cell testers, manufacturing process optimizers, and more.

We serve major industries worldwide, including the automotive, solar, aerospace, and semiconductor industries. Our components are integral to key technologies that drive the global economy. We are often at the cutting edge of these developments and are in constant exchange with scientists and experts in the field. Our R&D, manufacturing and sales operations are closely linked, enabling us to respond quickly and efficiently to our customers' needs.



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Laser World of Photonics B2.315
World of Quantum A1.531

Topag Lasertechnik – Laser Experts for Science and Industry

Topag Lasertechnik offers high-end laser technology for demanding applications in research and industry.

The company operates in two core areas:

- Consulting, sales, commissioning, and technical support for pulsed laser systems, optical metrology, and precision optics. Topag serves customers from laboratories, research, and industry and represents leading international manufacturers in Germany and Austria.
- In-house development and production of beam-shaping optics, including top-hat generators, diffractive beam splitters, and attenuators. Topag supports users in integrating them into existing optical setups and develops customized optical systems based on wave-optical simulations.

What sets Topag apart:

- A team of physicists and engineers with experience in research and industrial development – consulting on an equal footing.

- Honest recommendations specific to the application – with the goal of long-term customer satisfaction.
- Long-term operational reliability with support and spare parts supply for up to ten years – including fast response times.

Topag – Optimizing Your Laser Setup



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Laser World of Photonics A2.400



Toptica Photonics

Toptica has been developing and manufacturing high-end laser systems for scientific and industrial applications for more than 25 years. Our portfolio includes diode lasers, ultrafast fiber lasers, terahertz systems and frequency combs. The systems are used for demanding applications in biophotonics, industrial metrology and quantum technology. Toptica is renowned for providing the widest wavelength coverage

of diode lasers on the market, providing high-power lasers even at exotic wavelengths.

Toptica develops and manufactures high-end laser systems for scientific and industrial applications. OEM customers, scientists, and over a dozen Nobel laureates all acknowledge the world-class exceptional specifications of Toptica's lasers, as well as their reliability and longevity.

Founded in 1998 near Munich (Germany), Toptica became one of the leading laser photonics companies by aiming for, and consistently delivering high-end specifications. Toptica's diode lasers are appreciated for excellent coherence, wide tuning range and ideal beam profiles.

Toptica's 600 employees take pride in developing customized systems. In close collaboration with several universities and institutes, latest scientific discoveries are frequently incorporated into commercial products. With a global



distribution network, Toptica provides exceptional service worldwide.

Short profile Toptica Photonics

Founded: 1998
Employees: 600 (2025)
Revenues: 140 Mio. €
Legal form: Aktiengesellschaft (AG), private ownership
Presidents: Dr Wilhelm Kaenders, Dr Thomas Renner
Chairman: Dr Dieter Schenk

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Laser World of Photonics A1.502 + B2.103





Source: MackBrooks



Source: Mesago / M. Kutt

June 24 – 27, 2025

LASER World of PHOTONICS

Exhibition

Munich, Germany

<https://world-of-photonics.com>



September 15 – 18, 2025

SPIE Sensors + Imaging

Madrid, Spain

<https://spie.org/conferences-and-exhibitions/sensors-and-imaging>

June 24 – 27, 2025

World of Quantum

Munich, Germany

<https://world-of-quantum.com>

September 17 – 19, 2025

LASER World of PHOTONICS INDIA

Bangalore, India

<https://world-of-photonics-india.com/en/>

June 24 – 27, 2025

automatica

Munich, Germany

<https://automatica-munich.com>

September 24 – 25, 2025

W3+ Fair Jena

Jena, Germany

<https://w3-fair.com/jena>

August 03 – 07, 2025

SPIE Optics + Photonics

San Diego, California, USA

<https://spie.org/conferences-and-exhibitions/optics-and-photonics>

September 29 – October 01, 2025

ECOC Exhibition

Kopenhagen, Denmark

www.ecocexhibition.com

August 24 – 28, 2025

European Optical Society

Annual Meeting

Delft, The Netherlands

www.europtics.org/events/eos/eosam2025.html



October 07 – 08, 2025

LaserEMobility Workshop

Bologna, Italy

www.laseremobility.org



October 07 – 08, 2025

Quantum Effects

Stuttgart, Germany

www.quantum-effects.com



September 10 – 12, 2025

CIOE

Shenzhen, China

www.cioe.cn/en/



October 21 – 24, 2025

Schweisstec/Blechexpo

Stuttgart, Germany

www.blechexpo-messe.de, www.schweisstec-messe.de



Read event previews and reviews on www.wileyindustrynews.com/en/

Connecting trade visitors and companies in Wetzlar

Review: W3+ Fair, 19 – 20 March 2025, Wetzlar, Germany



W3+ Fair Wetzlar 2025

The W3+ high-tech trade fair and conference in the German town of Wetzlar in central Hesse has again attracted

experts in optical and related technologies. Despite the tense global situation, the mood was upbeat. Many idea-generating lectures and accompanying events, new contacts thanks to the national and international exhibitors, and the great commitment of the participating partners altogether created a good atmosphere.

With around 200 exhibitors, partners and speakers, including Opto-Tech, Hensoldt, Jenoptik, Märzhäuser, IMT as well as Meopta from the Czech Republic, TNO from the Netherlands and Universal Photonics from the USA, the exhibition hall was well filled. Of

the exhibiting companies, 35 % were from the region, 45 % from other German states and 20 % from nine other countries were represented at the event. The supraregional exhibitors once again benefited from the easy networking with the economically strong industrial region. More than 2,000 trade visitors found their way to the Buderus Arena Wetzlar this year – an increase of around 5 % on the previous year.

In Jena, the W3+ Fair will open its doors on 24 – 25 September, 2025. The next W3+ Fair in Wetzlar will take place on 18 – 19 March, 2026.

<https://w3-fair.com/jena>

Five days of unmatched industry impact

Review: OFC Exposition, 30 March – 03 April, 2025, San Francisco, California, USA

OFC 2025 was uniting the optical communications community for a successful week of groundbreaking technical presentations, demonstrations and industry discussions in San Francisco.

The Optical Fiber Communication Conference and Exposition is the industry's most comprehensive gathering – featuring forward-looking research, dynamic exhibition programming and vital industry networking that bridges

innovation from the lab to real-world applications and commercial deployments.

The 50th anniversary event saw 16,700 attendees from 83 countries (pre-audit), 685 exhibitors and 170,000 net square footage, the largest OFC since 2003. 118 technical sessions and poster sessions were held, including 816 technical talks and posters, with 1,300 paper submissions.

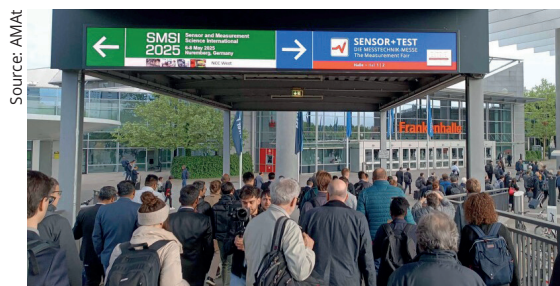
The OFC Exhibition featured a vibrant showcase of innovations spanning the entire optical communications supply chain. From global industry leaders to cutting-edge startups and pioneering research institutions, 685 companies highlighted breakthrough technologies across multiple domains.

OFC 2026 is scheduled from 15 – 19 March 2026, in Los Angeles, California.

www.ofcconference.org

Strong impulses for sensor, measurement and testing

Review: Sensor+Test, 06 – 08 May 2025, Nuremberg, Germany



Many visitors at the SMSI and Sensor+Test entrance

The international sensor and measurement technology industry met at Sensor+Test 2025 under the motto 'Welcome to the Innovation Dialog'. Three days full of innovations, technical discussions and ideas for future developments – exhibitors, trade vis-

itors and the organizers drew a thoroughly positive conclusion. 348 exhibitors presented their latest developments and solutions in sensor, measurement and testing technology. Sensor+Test welcomed around 5,000 visitors, 348 exhibitors from 24 countries, who showcased their innovations on around 5,200 m² of exhibition space, as well as 546 participants at SMSI 2025 – the Sensor and Measurement Science International conference.

The focus was not only on personal exchanges with customers and business partners from all over the world, but also on future-oriented topics such as energy efficiency, climate protection, sustainability and artificial intelli-

gence. Hot topics were 'condition monitoring' and 'innovative calibration'. Live demonstrations, lecture series and practical examples impressively illustrated how AI, digital calibration strategies and predictive maintenance are already helping to make industrial processes more sustainable, safer and more efficient. Sustainability, digitalization and artificial intelligence played an important role in this – whether in energy-efficient sensor systems, intelligent diagnostic tools or cloud-based calibration solutions.

Next year, Sensor+Test will take place in Nuremberg from 9 – 11 June 2026.

www.sensor-test.de

Growing Importance of QA in production

Review: Control, 06 – 09 May 2025, Stuttgart, Germany

High levels of visitor interest, in-depth expert discussions and ground-breaking technological innovations for greater cost-effectiveness and efficiency in product manufacturing: the 37th Control international trade fair for quality assurance logged 500 exhibitors, including 180 from outside of Germany. They presented state-of-the-art measuring and test technology innovations to 20,166 expert visitors from a total of 70 countries in four exhibition halls. The newly launched “Control Quality Talks” stood out as a highlight on the first day of the trade fair.

Product manufacturing is focused on efficiency, productivity, the conservation of resources, and sustainability. Modern measuring systems with higher levels of performance and precision provide significant support for the optimization of processes and the prevention of waste, which is why quality assurance (QA) is playing an increasingly important role in production. The growing significance of contactless measuring procedures was demonstrated by the great interest in the special show for “Contactless Measuring Technology” organized by Fraunhofer Vision.



Source: Schall

“Control Quality Talks” as highlight and crowd puller

The fair switches to a two-year cycle, so the 38th Control will take place in an expanded format from 27 – 30 April 2027.

<https://www.control-messe.de>

“The right visitors are coming”

Review: Rapid.Tech 3D, 13 – 15 May 2024, Jena, Germany



Source: Messe Erfurt / Christian Seeling

Rapid.Tech 3D exhibition 2025

Visitors were pleased with the 21st Rapid.Tech 3D thanks to its proven high quality and a new level of networking. Around 170 exhibitors and speakers

from Germany and abroad presented the latest developments and applications in additive manufacturing (AM) to an interested audience.

Formats such as the Technical Deep Dives tours and the expert tables made a particular contribution to this networking. During the Technical Deep Dives, participants were given brief and in-depth insights into new technologies and applications directly at the exhibitor stands. At the expert tables, the role of 3D printing in the dental trade, additive manufacturing in implantology, tool and mold making, the challenges of large-format PBF/LB-M printing and

issues of standardization were discussed in small groups.

The 3D Pioneers Challenge international design competition selected the Pioneer of the Decade to mark the anniversary of the show in Erfurt. The award went to the team from the Dvirs Lab at Tel Aviv University for a 3D-printed, beating heart made from stem cells.

Dr Dieter Schwarze and Dr Matthias Fockele also received awards. The physicists, pioneers of metal 3D printing, received the Big Five Award 2024 for outstanding achievements in AM.

www.rapidtech-3d.de

A successful premiere

Review: Quantum Photonics, 13 – 14 May 2024, Jena, Germany

The new Quantum Photonics trade fair brought together many companies, institutions and experts from research, development and application. As a congress trade fair, there was not only a trade exhibition, but also a high-level congress program with experts from the active field of quantum photonics. A total of around five hundred trade visitors attended the event, ensuring excellent discussions at the booths.

The new trade fair aimed to bring together the key players in the field of quantum photonics over the two days

of the trade fair and get them talking to each other.

Well-known companies presented their innovative products at the trade exhibition in order to engage in discussions with their users as well as with representatives of the other exhibitors. By the end of the first day of the trade fair, the exhibitors were already very satisfied with the discussions. On site were Lasos Lasertechnik, Fraunhofer Institute for Applied Optics and Precision Engineering IOF, Hamamatsu Photonics, Fiberware, AIM Micro



Source: Messe Erfurt / Wissel

Impression of the Quantum Photonics trade fair

Systems, Nanoplus, the Abbe Center of Photonics, the QuNET initiative, the CiS Research Institute for Microsensor Technology, SmarAct, X-Fab, Quantum Optics Jena, Layertec and others.

www.quantum-photonics.de

Preview: ECOC 2025

29 September – 01 October 2025, Copenhagen, Denmark



The ECOC Exhibition is a meeting place for everyone in the fiber optic communication technology industry, attracting over 6,500 decision-makers from across the industry. In 2025, the event takes place at the Bella Center, Copenhagen.

The European Conference on Optical Communication stands as Europe's premier gathering for optical communications, holding a prominent position as one of the globe's most signif-

icant events in this field. This conference unites pioneers and professionals from academia, research, and industry, fostering the exchange of cutting-edge discoveries and future-oriented perspectives.

The ECOC Exhibition, in existence for nearly three decades, has evolved into Europe's largest optical communications exhibition. It serves as a pivotal hub where industry leaders convene, making it a cornerstone for

decision-makers in the fiber optic communications technology sector.

The Market Focus theatre offers three days of unrivaled content with 50+ presentations from innovative optics companies discussing key market issues. Check the timetable for details.

The Product Focus theatre showcases innovative product presentations and live demonstrations. Stay up-to-date with the latest products.

www.ecocexhibition.com

Preview: LaserEMobility Workshop

07 – 08 October 2025, Bologna, Italy



The LaserEMobility section of the Italian Association of Manufacturing (AITeM) invites you to the fourth workshop at the BI-REX and Opificio Golinelli venues in Bologna. The event is organized by the Laser Group of the Department of Industrial Engineering of Università di Bologna in collaboration with Politecnico di Milano, the Technical University of Munich and the Friedrich Alexander University Erlangen-Nuremberg. Attendees fundamental research, laser component manufac-

turing, system integration, and users as well as laser application developers will have the opportunity to present their latest innovations in electric vehicle manufacturing.

In addition to technical presentations for an international audience, the exhibition zone will showcase cutting-edge technologies. Following the success of the 2022, 2023 and 2024 editions, the LaserEMobility Workshop 2025 will continue to be a place of discussion for an international audience

from industry and academia working on laser-based processing. Thanks to the sponsors, the two-day event is free of charge for all participants.

As media partner of the event, PhotonicsViews published a special digital issue on the featured topics on 1 April 2025.

www.wileyindustrynews.com/en/photonicviews/photonicviews-digital-special-issue-d1-2025

www.laseremobility.org

Preview: Blechexpo/Schweisstec 2025

21 – 24 October 2025, Stuttgart, Germany



The industry sector will meet in Stuttgart for the 17th Blechexpo international trade fair for sheet metal working, together with the 10th Schweisstec international trade fair for joining technology. Careers, category winners, AI, congress – trade fair promoters and exhibitors are once again putting together a trade fair with high levels of internationality, which is attracting attention from around the world.

Attention will be focused entirely on sheet metal working in nine jam-packed halls at the Stuttgart Exhibition Center. Topics range from thermal and mechanical sheet metal processing, along with system peripherals including controllers and software, as well as solutions for handling and feeding, right on up to quality assurance. Blech-

expo/Schweisstec is a highly acclaimed technical event where suppliers and users can gather information about the latest developments and exchange ideas in a direct dialogue with experts. The layout of the exhibition halls ensures a concise overview and an efficient trade fair visit: sheet metal, pipe and profile processing will be located in Halls 1, 3, 5 and 7. Halls 4 and 6 are reserved for stamping technologies. Cutting, joining and fastening technologies will be presented in Hall 9. Hall 8 will focus on pressing and forming technologies. Finally, the topics of steel and metal services, as well as surface finishing technology, will be addressed in Hall 10. The trade fair duo unites two key production technologies. The clear thematic structure makes it possible

for all trade fair visitors to discover new systems and solutions throughout the entire value chain at a single location.

Roughly 45 % of the exhibitors come from outside Germany. Georg Knauer, project manager at trade fair promoters P. E. Schall, expects nine full exhibition halls and lots of lively interaction. Seven months before the fair, he is already promising a world-class supplementary programme on all trade fair days. In addition to the "best Award" ceremony on the first day of the event, the career campaign on Friday and the daily presentation forum, the "best Congress" will also attract a large audience of experts.

www.blechexpo-messe.de
www.schweisstec-messe.de

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