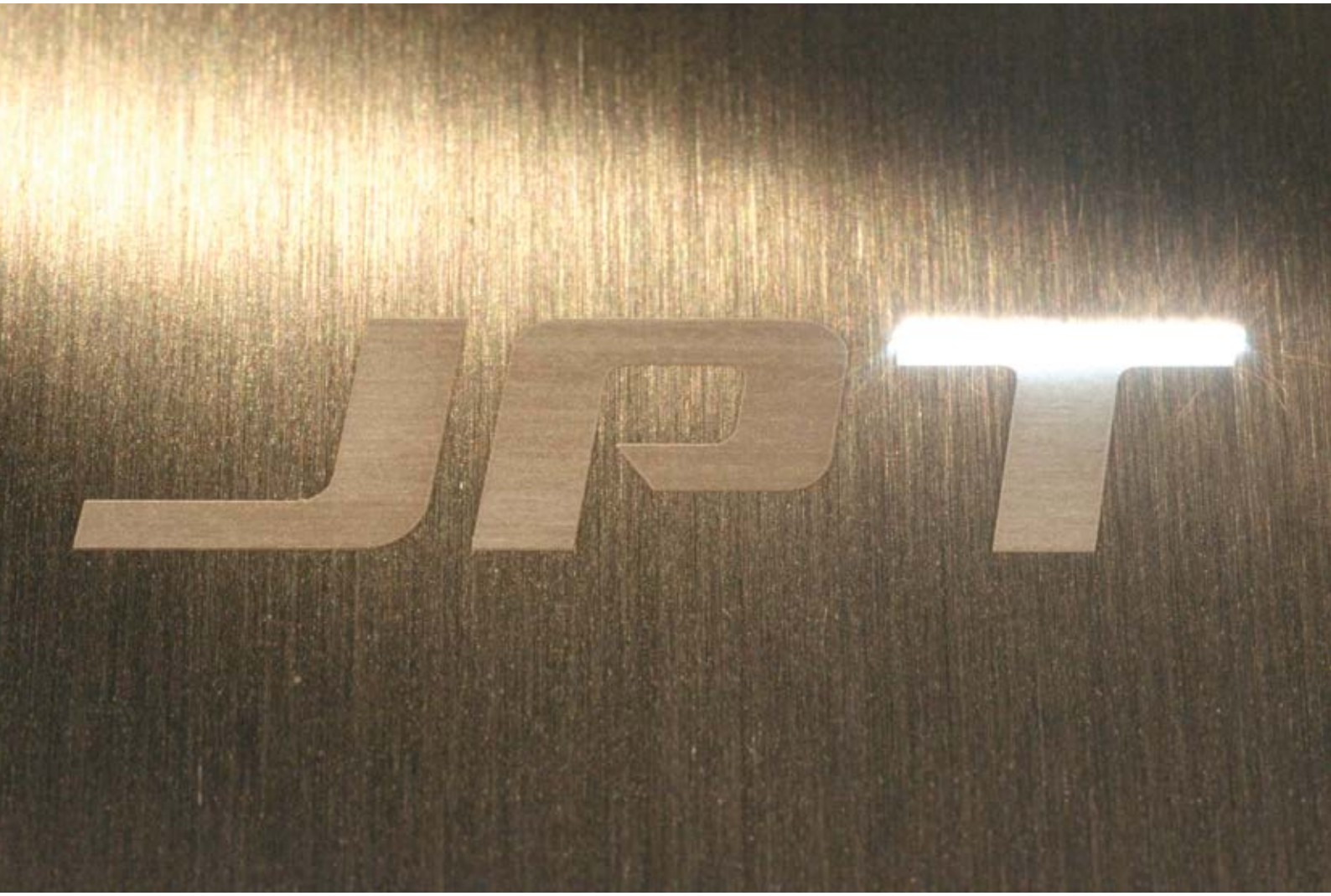
Volume 21 April / May 2024

2

PhotonicsViews

OPTICS • PHOTONICS • LASER TECHNOLOGY



AKL '24

SPECIAL SECTION

International Laser Technology Congress

MARKET REPORT
Laser sources: global market and trends

LASER WELDING
High precision laser welding for the electric vehicles of tomorrow

ADDITIVE MANUFACTURING
Innovative measurement tool optimizes development

WILEY

published in media partnership with EPIC EOS

publishing medium of PHOTONICS GERMANY DGaO

YOUR FAST TRACK TO SUSTAINABLE LASER PROCESSES

AKL'24
INTERNATIONAL LASER TECHNOLOGY CONGRESS

SEE US AT BOOTH 59

MKS technology drives sustainable industrial processes. Using Spectra-Physics lasers, resource-efficient micromachining can be achieved which leads to reliable and uninterrupted production for years to come. Ophir laser measurement devices and optics provide game-changing innovations that help to streamline processes, saving valuable material and energy. Newport advanced motion and inspection equipment guarantees superior quality and optimal manufacturing efficiency.

For more information visit **www.mks.com/sustainable-laser-processes**

www.mks.com

mks | Newport | Ophir | Spectra-Physics

Closing the loop

AI has the potential to disrupt – and photonics needs to take advantage of this

In the forefront of digital photonic production, lasers are not only tools but keystones, representing a manufacturing renaissance where products are customized to the individual, not the masses. This edition examines how the combination of laser technology and artificial intelligence (AI) is helping to create this environment. Experts hail AI as a revolutionary force on a par with the internet and smartphones. AI's advanced language models can accurately interpret human speech while foundation models generate meaningful text or images with unprecedented quality. The advent of new AI models is having significant implications on our industry.

As we explore optical system advancements, we encounter the transformative power of deep neural networks. An AI-based optical system design allows tailoring of the laser beam for the specific application, enhancing its efficiency, productivity, and quality. The result is a harmonious dance between laser, optical system, and material, choreographed by the high-performance algorithms of AI. AI's influence goes beyond design optimization: it fundamentally reshapes our approach to process monitoring, quality control, and parameter finding. AI in combination with numerical modeling and the intelligent design of experiments guides us towards targeted experimental endeavors. This accelerates innovation while minimizing trial and error.

This evolution is steering us towards a manufacturing utopia of autonomous optimization of process parameters bolstered by AI, enabling 'first-time-right' production with enhancements in process accuracy and a reduction of exhaustive quality verifications. Whether augmenting human capability or governing closed-loop systems, AI is poised to trigger a productivity renaissance. Those who resist change risk obsolescence.

Self-learning laser machinery and AI-optimized processes beckon a promising future for highly adaptable Industry 4.0 production landscapes. Photonics, with its arsenal of advanced laser sources, optical systems, and sensors, is set to make significant strides in manufacturing. Yet, we must weigh the gains in productivity and quality against the investment in digitalization.

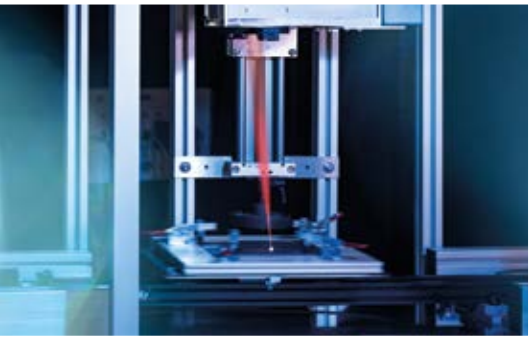
Photonics stands at a crossroads. The AKL'24 event in Aachen this April presents an apt moment to envision and navigate impending transformations with industry experts. This edition of PhotonicsViews features insights from various AKL'24 speakers and serves as a primer for this crucial dialogue. We look forward to delving deeper into these discussions with you.

Source: Fh. ILT

Prof. Constantin Häfner
Director,
Fraunhofer Institute for Laser Technology ILT,
Aachen, Germany

AKL'24
INTERNATIONAL LASER TECHNOLOGY CONGRESS

PhotonicsViews
OPTICS • PHOTONICS • LASER TECHNOLOGY



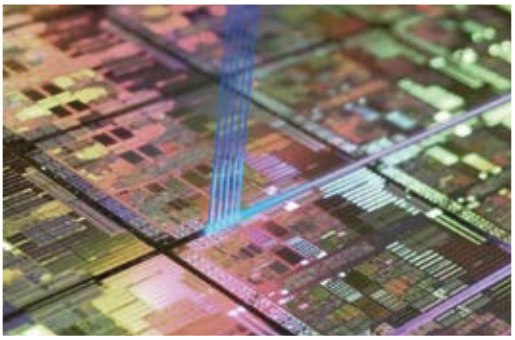
28 High precision laser welding for the electric vehicles of tomorrow

32 Accelerating into production

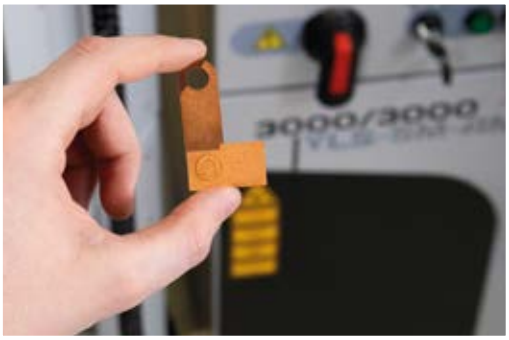
44 High-energy UV lasers for display and green energy applications

Contents

2/2024



48 **High speed wafer grooving with UV-USP lasers**



52 **Dual-beam lasers meet challenges of automotive industry**

64 **Lasers – smart tools with a bright future**

Cover:

Marking brass with a pulsed fiber laser. For more information, please visit:

https://en.jptoe.com

AMS Technologies takes over Neolase

As an accquisition to broaden the existing customized photonic solutions portfolio, AMS Technologies, a provider of photonics and thermal solutions, has bought Neolase, a manufacturer of high brilliance, diode pumped, solid-state lasers. The strategic partnership expands AMS Technologies' engineering expertise and customization capabilities for DPSS lasers, electronics and cooling solutions, enabling them to offer all-in-one photonic system solutions.

Source: AMS Technologies

L–r: Philipp Weber, Maik Frede, Jan Meise

The acquisition of Neolase significantly amplifies AMS Technologies' capabilities to engineer and deliver photonic solutions, providing tailored high-power laser systems that are not available on the market. The laser systems are meticulously built to exact customer specifications, offering selectable pulse duration, repetition rate and output power while ensuring excellent beam quality.

"At AMS Technologies, we are more than just laser providers, we are 'photon jugglers' dedicated to crafting precision solutions tailored to each customer's specific needs," says Jan Meise, CEO at AMS Technologies. "Whenever your laser runs out of steam, Neolase holds a high degree of qualification and competence to enhance it. The modular concept of amplifier kits allows a variety of different laser parameters and therefore a lot of different industrial, medical, and scientific applications."

AMS Technologies has broad knowledge of lasers, with a dedicated design center for pulsed DPSS lasers, complemented by an extensive portfolio through manufacturing partners from the distribution business. Neolase, located in Hanover's photonics cluster, has long-term expertise in DPSS laser amplification for a lot of different seeders and offers MOPA systems with nano to femtosecond pulse durations. Neolase's solid-state lasers are designed for 1064 / 1030 / 1940, and 2050 nanometer applications along with higher harmonics, and have compact and rugged system designs.

Maik Frede, the founder and managing director of Neolase, joins CEO Jan Meise and Philipp Weber, CFO and COO of AMS Technologies, as vice president of engineering, reflects on the importance of this acquisition: "Our mission is to extend beyond just providing products. We aim to develop lasting partnerships and establish ourselves as the primary source for specialized, customizable photonic solutions from a dedicated, singular provider."

https://amstechnologies.com
https://neolase.com

100 % acquisition of Art Photonics

Art Photonics, an established company in the fiber optic technologies market segment, has been sold to Nynomic. The sale marks a significant step in the development of the company and opens up far-reaching perspectives for the future.

Nynomic also acquired a 31.25 % share in the capital stock of NLIR ApS, Copenhagen, Denmark, in October as part of a capital increase.

For more than 25 years, Art Photonics has been continuously setting new standards in the development and production of specialty fibers for various applications in the broadest spectral range 0.3 – 16 µm and is one of the technology leaders in this segment.

The leading expertise within the technology of polycrystalline mid-infrared (MIR) and metal-coated silica fibers is used for the assembly of various spectroscopy probes for industrial process control, environment monitoring, and medical diagnostics. There are also a wide range of applications in the field of medical and industrial lasers.

Art Photonics has around thirty employees in Germany. Annual sales grew to around four million euros in the 2023 financial year. After the sale, the company will continue to operate as an independent brand.

https://artphotonics.com
www.nynomic.com

Oxford Instruments acquires First Light Imaging

The provider of high technology products and services to industry and scientific research communities, Oxford Instruments has acquired First Light Imaging SAS, a scientific camera producer.

Based in France near Aix-en-Provence and founded in 2011, First Light specializes in the design and manufacture of high-speed, low-noise scientific cameras for infrared and visible imaging, with applications in astronomy and life sciences. It will become part of Oxford Instruments Andor ("Andor"), with a common global customer base spanning leading academic institutions and commercial companies. Its cameras are highly complementary to Andor's existing scientific camera portfolio, with the acquisition providing opportunities to enhance both companies' offerings and to expand into adjacent markets.

Under the terms of the acquisition, Oxford Instruments is paying an initial cash consideration of 15.7 million euros, on a cash-free, debt-free basis, with a further 3 million euros cash consideration conditional on First Light's trading performance over a 12-month period following completion. First Light's estimated revenue for the 12 months to 31 December 2023 is 8 million euros, with return on sales below the average for the group.

www.oxinst.com
www.first-light-imaging.com

Synopsys to acquire Ansys

Source: Synopsys / Ansys

The companies from Sunnyvale, CA, and Pittsburgh, PA, have entered into a definitive agreement under which Synopsys will acquire Ansys. Under the terms of the agreement, Ansys shareholders will receive 197.00 dollars in cash and 0.345 shares of Synopsys common stock for each Ansys share, representing an enterprise value of around 35 billion dollars.

"The megatrends of AI, silicon proliferation, and software-defined systems are requiring more compute performance and efficiency in the face of growing, systemic complexity. Bringing together Synopsys' industry-leading EDA solutions with Ansys' world-class simulation and analysis capabilities … is the logical next step for our successful, seven-year partnership," said Sassine Ghazi, president and CEO of Synopsys.

"Since inception 37 years ago, Synopsys has been an innovation pioneer, central to world-changing semiconductor advances in computation, networking, and mobility, and now enabling the new era of 'pervasive intelligence,'" said Aart de Geus, executive chair and founder of Synopsys. "For more than fifty years, Ansys has enabled customers to design, develop and deliver cutting-edge products that are limited only by imagination. By joining forces with Synopsys, we will amplify our joint efforts to drive new levels of customer innovation," said Ajei Gopal, president and CEO of Ansys.

Ansys Zemax's industry-leading optical product design and simulation software, OpticStudio, OpticStudio STAR Module, OpticsBuilder, and OpticsViewer, helps optical, mechanical, and manufacturing engineering teams to design their systems. Standardizing on Ansys Zemax software reduces design iterations and repeated prototypes, speeding time to market and reducing development costs.

The transaction is anticipated to close in the first half of 2025, subject to approval by Ansys shareholders, the receipt of required regulatory approvals and other customary closing conditions.

www.synopsys.com
www.ansys.com

Focuslight completes the acquisition of Suss MicroOptics

Süss MicroTec successfully completed the sale of its Swiss subsidiary Suss MicroOptics SA in January 2024. With the closing of the transaction, the micro-optics division is now part of Focuslight (HK) Investment Management, a subsidiary of the Shanghai-listed company Focuslight Technologies. Süss MicroTec and Focuslight had agreed on the sale in November 2023. This strategic move marks a significant step forward in Focuslight's goal to be an industry leader in photon generation, photon control and photonics application solutions.

Suss MicroOptics will undergo full integration immediately, becoming a new Focuslight entity with all businesses and functions under the management of Focuslight's current business units, operations and functional departments. Suss MicroOptics' fiber and semiconductor micro-optics business will be part of Focuslight's laser optics business unit, while its automotive lighting business will be merged into Focuslight's automotive business unit. This transition will also entail the adoption of the new entity name Focuslight Switzerland SA and the consolidation of its entire product portfolio under the unified Focuslight brand.

It is a commitment from Focuslight to grow with Suss MicroOptics' existing facility and capacity, and make further investment significantly in R&D and manufacturing capital in Switzerland. There are also additional plans from Focuslight for further cost-reduction initiatives with measures focusing on manufacturing excellence, operation digitalization, and in-house process capability build-up.

www.focuslight.com
www.suss.com

Siemens buys Inspekto

Siemens Aktiengesellschaft has acquired the AI-supported image processing software company Inspekto, headquartered in Heilbronn, Germany.

Inspekto becomes part of Digital Industries, Siemens' factory automation division headquartered in Nuremberg. Factory automation is an industrial automation provider that drives digital transformation together with its customers. Siemens wants to use the AI-supported image processing potential of Inspekto and ensure technological advantages for all of its customers. Inspekto is to be continued as a company for the time being.

Inspekto's AI technology and capabilities are intended to complement Siemens' industrial AI software portfolio. The main use case is easy-to-use automated visual quality inspection based on image processing.

www.siemens.com


Source: Inspekto

The S70 AI-controlled image processing system

Toptica takes over sales and service for France from Opton Laser

Source: Toptica

Toptica Photonics SAS employees in front of their premises located in Pessac, Bordeaux, together with Drs Thomas Renner (1st row left) and Wilhelm Kaenders (1st row right) of the group management board

As of January 1, 2024, Toptica's French subsidiary took over the sales of Toptica and HighFinesse products in France. This will strengthen the collaboration between French scientific or industrial customers and Toptica by offering a direct link between the partners.

The decision to directly perform sales and service operations in France reflects the company's strategy to foster close relationships with this local market and to ensure the highest level of service for its innovative quantum technology, biophotonics, and industrial metrology solutions.

Vincent Aubertin, formerly sales director at the previous partner Opton Laser International, has joined Toptica Photonics SAS. In his new position as sales director for France, his role is to keep and foster the relationship with French customers and be responsible for the excellence of the product consultations. Customers will profit from his excellent expertise in the Toptica and HighFinesse product portfolios and his technical education as an optics engineer.

During a half year transition phase, Opton Laser will continue to follow-up ongoing sales projects.

www.toptica.com

Expanded accreditation for laser power and energy measurement

MKS Instruments has received ISO/IEC 17025 certification for its Ophir Photonics calibration laboratory in Darmstadt, Germany.

The scope of the accreditation covers MKS Ophir's photodiode, pyroelectric, and thermopile laser power and energy sensors, as well as its power and energy displays and virtual meters. ISO/IEC 17025 is given to calibration laboratories that have achieved the highest standards of quality, administration, and technical operations, thereby ensuring the highest accuracy, as measured by the National Institute of Standards and Technology (NIST).

All of MKS Ophir's calibration laboratories are now ISO/IEC 17025 accredited: Jerusalem, Israel, North Logan, Utah, Omiya-ku, Japan, and Darmstadt, Germany.

Markus Schmiedt, manager of the European Calibration Lab in Darmstadt, Germany, stated, "European customers that are required to have the re-calibration done by a lab with ISO/IEC 17025 accreditation benefit from shorter lead times as their equipment does not need to be shipped to international labs. Calibration certificates issued in our European lab will now automatically carry the ISO/IEC 17025 accreditation."

ISO/IEC 17025 accreditation ensures that Ophir's calibration laboratories operate under controlled and approved working procedures, the equipment and calibration standards used are regularly calibrated by other ISO/IEC 17025 certified, and NIST traceable laboratories and the uncertainty values communicated to customers have a solid foundation based on rigorous experimental and statistical analysis.

www.mks.com

Tailored solutions for the e-mobility market

The cornerstone of a new collaboration is the integration of Cailabs' beam shaping modules into Precitec's laser beam welding heads.

The partnership between the two companies started in 2018 as part of the Horizon 2020 Custodian project. They have seamlessly combined their expertise, leading now to the integration of the companies' beam shaping modules and welding heads to improve precision and efficiency in laser welding.

Source: Cailabs

Collaboration partners (l–r): Alexandre Severin, Pu Jian, Daniel Richert, Markus Kogel-Hollacher, Thibaut Atché, Gwenn Pallier

The challenges of laser welding in e-mobility, particularly with reflective and thermally conductive materials such as copper and aluminum, have been specifically addressed in recent months by Cailabs' beam shaping technology. This improves the interaction of the laser with these materials, ensures energy absorption, and improved welding quality. Integration with Precitec's laser welding heads not only overcomes traditional welding limitations, but also opens up new possibilities for advanced manufacturing techniques in the growing e-mobility sector.

This partnership is poised to make a significant impact on the e-mobility market. "The collaboration is a testament to our commitment to driving innovation in laser technology", says Cailabs CEO Jean-François Morizur. Precitec managing director Klaus Löffler adds, "The integration of Cailabs' beam shaping expertise into our welding systems opens up new possibilities for e-mobility manufacturers worldwide in terms of precision and efficiency in laser welding."

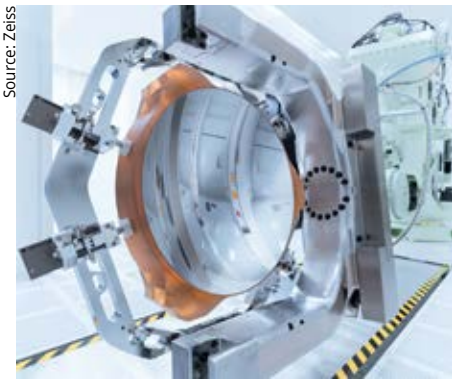
www.cailabs.com
www.precitec.com

High-NA-EUV for global microchip production

The first machine for the new lithography technology includes an optical system from Zeiss and was recently delivered by ASML.

Together with its strategic partner ASML, the Dutch manufacturer of lithography systems, the Zeiss Semiconductor Manufacturing Technology (SMT) segment has created the basic prerequisites for the production of integrated circuits at a new level. With so-called High-NA-EUV lithography, significantly smaller structures can be realized on the microchips wafers and even more powerful, energy-efficient and cost-effective chips can be produced. The first series production using the new technology is set to begin in 2025.

Source: Zeiss



The highly precise mirror is installed in the optical system for High-NA-EUV lithography

Zeiss has invested around ten million man-hours in research and development for High-NA-EUV lithography. Strategic partner ASML and many other European partners are also involved in the development of the technology. "We are always working on pushing the boundaries of what is technically feasible," states Andreas Pecher, member of the Zeiss executive board as president and CEO of the SMT segment.

"Thanks to the larger numerical aperture and the new mirrors for the High-NA-EUV lithography, we can capture more light and expose it with even greater detail and precision. Experience has shown that the smaller the chip structures have to be, the larger the projection optics and illumination system will be," says Dr Peter Kürz, head of the High-NA-EUV lithography business at Zeiss SMT. The illumination system for that technology consists of around 25,000 parts and weighs more than six tons. With more than 40,000 parts, the projection optics weigh around twelve tons and ensure high-precision focusing of the light in the wafer scanner.

www.zeiss.com

Lithography system for high-tech fab

Jenoptik is investing a low double-digit million euro amount in its Dresden site, and purchasing a machine from Vistec Electron Beam, the Jena based e-beam technology specialist. The system will be delivered at the beginning of 2025. This type of electron-beam lithography system can 'write' structures with a precision in the ten-nanometer range on substrates up to 300 mm in diameter.

Source: studiobrand.3dvisuals

Concept image of the new high-tech fab

The Vistec SB3050-2 electron-beam lithography system is based on the so-called variable shaped beam principle, with which even large areas can be structured accurately and effectively. The high degree of automation, combined with flexibility in the usable substrates, are further features of the Vistec SB3050-2 that enable it to be used in an industrial environment. The system is equipped with cell projection functionality, opening up further possibilities for applications in micro-optics.

The company is consolidating its production at the new high-tech fab at Airportpark Dresden that is currently spread across several small external sites, while at the same time expanding its capacity. The clean room production in the new fab will cover 2,000 square meters with clean room areas of classes ISO 5 and 3 and meet the highest requirements for freedom from vibration and temperature stability.

According to the company, high environmental standards are taken into account for the entire fab: Jenoptik is striving to fulfill the currently most comprehensive and stringent building sustainability criteria with the KfW 40 Standard and the LEED Gold Standard Certification.

www.vistec-semi.com
www.jenoptik.de

ALSO OF INTEREST

Sensopart is expanding

Photoelectric sensors and image processing company has founded a new subsidiary in Portugal

PI with new head of global sales

Laurent Melin became senior vice president global sales of Physik Instrumente

Aeva to provide advanced 4D lidar

Daimler and Torc Robotics select technology supplier for series-production autonomous trucks

Ametek inaugurates new facility

Opening of new Customer Center of Excellence in Weiterstadt, Germany

Atlas Copco introduces new CEO

Vagner Rego takes over the position of president and CEO at Atlas Copco, succeeding Mats Rahmström

Pixargus becomes part of the Citex Group

The measurement technology manufacturer Pixargus is moving under the umbrella of Citex Holding and together they are targeting the US and Asian markets

Process Sensing Technologies acquires three companies

PST expands its portfolio with three strategic acquisitions

ITIS Holding buys Vitronic

The Vitronic Group is to be taken over by ITIS Holding. ITIS is a company of the PPF Group, an international investment company

Zeiss launches "Quality Innovation Days"

Company takes part in Control fair every two years only, starts own event series in 2024

Winning products, companies, and startup challenge contestants

On the evening of January 31st, SPIE recognized the most innovative new optics and photonics products with the industry-focused Prism Awards. The gala night, held during Photonics West, also marked the awards' 16th anniversary.

Source: SPIE

SPIE Startup Challenge 2024: Jenoptik's Ralf Kuschnereit, Traqc's Benjamin Dringoli, and 2024 SPIE President Jennifer Barton

Each year, the SPIE Prism Awards reflect the rapidly growing trajectory of photonics products and photonics-enabled solutions. This year, the annual ceremony honored a range of established and emerging companies applying groundbreaking and creative solutions to critical problems in areas such as augmented and virtual reality, sensors, lasers, quantum technology, and biomedical optics solutions.

The winners in their respective categories are:

- AR VR MR: **Porotech**, DPT (DynamicPixel-Tuning)
- Autonomy: **Anello Photonics**, SiPhOG (Silicon Photonics Optical Gyroscope)
- Biomedical: **JenLab GmbH**, MPTcompact: Multiphoton Tomograph with Femtosecond Fiber Laser
- Cameras and Imaging: **Thorlabs, Inc.**, Prelude Functional Imaging Microscope
- Lasers: **Ekspla**, FemtoLux 30
- Quantum Tech: **Qunnect**, QU-APC: Auto Polarization Compensator
- Sensors: **Scantinel Photonics GmbH**, Scantinel X-One
- Software: **Frenel Imaging**, TPiCore
- Test and Measurement: **Persistence Data Mining, Inc.**, Soilytics

This year, in addition to the regular slate of application-focused awards, the society was showcasing the inaugural SPIE Catalyst Award. This new recognition honors for-profit companies with specific social or environmentally-focused programs that have had significant positive impact, either within their workplace, on society at large, or on the environment. The winner of the first-ever SPIE Catalyst Award is **Intel** with their innovative and inclusive semiconductor workforce development programs: Quick Start, the semiconductor-technician-training program, and the Returnships career-returning program.

A day before, **Traqc** was announced the winner of the 10,000-dollar top prize at the 14th annual SPIE Startup Challenge. Their real-time inspection solution for the printed electronics industry utilizes THz radiation and metamaterial technology to ensure quality while reducing waste.

ClearVision, with a non-invasive alternative to permanent vision-correction surgeries based on corneal sculpting with femtosecond laser technology, received 5,000 dollars for second place. **UriMetrics** came in third, winning 2,500 dollars, with their lens-free imaging solution for reducing the incidence of catheter-associated urinary tract infections. All cash prizes are provided by SPIE Startup Challenge founding partner Jenoptik.

The annual SPIE Startup Challenge showcases new businesses, products, and technologies that address critical needs by utilizing photonics in the areas of healthcare and deep tech. This year's six finalists included innovations in medical applications, industry supply-chain solutions, and optical manufacturing.

https://spie.org

Edmund Optics presents 2023 Educational Award and Norman Edmund Award

More than 30,000 euros worth of Edmund Optics products will be awarded to the Gold, Silver, and Bronze winners in the Americas and EMEA to support their research.

Source: Edmund Optics

Danilo Almeida Machado of the Instituto Nacional de Pesquisas Espaciais earned the Gold Award

In the Americas, the Gold Award was awarded to Danilo Almeida Machado at Instituto Nacional de Pesquisas Espaciais, Brazil, for a telecentric optical system developed for rocket injector spray analysis that enables a thorough characterization of cold tests of combustion injectors.

In EMEA, the Gold Award was awarded to Jelle Schoppink at the University of Twente, Netherlands for laser-induced cavitation in a microfluidic channel for fast jet generation. The thin jet is fast enough to penetrate the skin and, therefore, deliver medication without a needle.

The Norman Edmund Inspiration Award was awarded to Dilara Long at the University of Arizona, USA, for aiming to compare structural and functional features of the uterotubal junction in women with and without endometriosis using optical coherence tomography imaging, and for developing a miniature minimally invasive endoscope for endometriosis diagnosis.

This research project has the potential to bridge the gap between unmet clinical needs and state-of-the art, non-invasive optical technology, particularly in women's health applications. In the setting of endometriosis, minimally invasive optical technologies have the potential to reduce costs and complications, inform diagnosis and staging, monitor disease progression, and facilitate personalized treatment, ultimately reducing chronic pain, infertility, and even the risk of some cancers. It is the intent to show young students that their aptitude or interest in optical sciences can be harnessed toward improving health and wellness, particularly for marginalized populations.

www.edmundoptics.com

Stéphane Bussa joins Lasea as CCO

With a 25-year career in commerce and an impressive seven-year tenure as chief commercial officer at Physik Instrumente, Bussa brings a wealth of expertise and experience to the Belgium-based laser solutions company. He takes over global sales and marketing.

"We are confident that with Stéphane's leadership, our commercial strategies will reach new heights, furthering our commitment to innovation and excellence in the field of high precision laser machines," says Axel Kupisiewicz, CEO of the Lasea group.

"I am really excited to join such a dynamic and fast-growing company. Lasea is continuously developing impressive differentiators in laser machining, addressing fascinating applications.

Source: Lasea

Stéphane Bussa

I look forward to working with our teams to develop the applications and markets that will ensure the group's international expansion," comments Bussa.

As his successor at Physik Instrumente, Laurent Melin became senior vice president global sales as of January 1, 2024. Melin was previously responsible for the PI group's sales activities in the EMEA region, excluding GAS.

www.lasea.eu

www.physikinstrumente.com

Coherent CEO Mattera retires

Dr Vincent "Chuck" D Mattera, Jr, CEO of the materials, networking, and lasers provider Coherent, has informed the company's board of directors of his intent to retire as CEO following the commencement of employment of his successor.

Dr Mattera, 68, has served with Coherent for twenty years, the last eight of which have been as CEO. He is the company's third CEO since its founding in 1971 as II-VI Incorporated. He has also served as chair of the company's board of directors since November 2021. During his tenure, Dr Mattera led the transformation of II-VI, into Coherent Corp, a global, diversified company enabling multiple irreversible megatrends in the industrial, communications, electronics, and instrumentation markets.

Source: Coherent

Dr Vincent 'Chuck' D Mattera, Jr

Over his twenty years, the company's annual revenue grew from 150 million dollars in fiscal 2004 to more than 5 billion in fiscal 2023.

"Leading this 53-year-old company through its multidecade growth transformation has been an incredible privilege," said Dr Mattera. "I want to acknowledge and deeply thank our employees, investors, customers, partners, and especially our leadership team."

www.coherent.com

SVS-Vistek gets a new managing director

The founder and CEO of SVS-Vistek, Walter Denk, retired at the end of 2023. The leadership of the camera manufacturer SVS-Vistek will now be taken over by Robert Franz, who has already taken on the role of CEO for the German 2D vision companies within the TKH Group. It is intended to improve the existing collaboration between the TKH 2D vision companies, which include Allied Vision, Chromasens, Euresys, NET and SVS-Vistek. As components of the TKH vision, they have already cooperated under the same roof in various areas in the past. For example, the sales activities led by Björn Krasemann (CSO) and the marketing activities led by Johannes Zurin (Director Business Development & Marketing) for SVS-Vistek and Allied Vision were merged.

The areas of product management, led by Thorsten Schmidt (CPO) and research

Source: TKH

Robert Franz

and development, led by Gerd Reichle (CTO), will continue to be managed in their previous functions in order to maintain existing competitive advantages. However, there will be closer exchange and increased cooperation between the two companies in these activities in order to act in a coordinated manner and exploit synergies. In addition to his previous tasks, Thorsten Schmidt will take on the role of site manager SVS-Vistek for the Gilching site.

www.svs-vistek.com

www.tkhgroup.com

Lynred with new executive president, CEO

The provider of high-quality infrared detectors for the global aerospace, defense, and commercial markets, Lynred, has appointed Hervé Bouaziz as executive president and Xavier Caillouet as CEO. Their objective is to leverage together the company's technological skills and the 85 million euros Campus industrial project to increase the offering in state-of-the-art infrared detectors, while strengthening its global market competitiveness.

Hervé Bouaziz has thirty years' aerospace, defense, and security experience. He joins Lynred from Europrop International, where he served as CEO for four years. Previously, he held several roles in electronics and defense, including his appointment in 2013 as EVP for strategy and M&A at Safran Electronics and Defense, and in 2016 as VP for military engines programs at Safran Aircraft Engines. Prior to that, Bouaziz had a twenty-year career at the French defense procurement agency DGA, where he first started as a test engineer in 1994.

Xavier Caillouet joins Lynred after a thirty-year career in international roles within various Thales divisions. Recently, he was VP of radiology and CEO of Trixell, a position he held

Source: ALA / Roland Grail / Lynred

Xavier Caillouet (l), Hervé Bouaziz

for five years. Until 2018, he served as VP of operations in airlines support for Thales Avionics. He holds a degree in engineering (1983) from Sup'Aero, a leading French institution for aerospace.

www.lynred.com

Waser retires from Bystronic, Iacovelli takes over


Source: Bystronic

Alex Waser (l), Domenico Iacovelli

Domenico Iacovelli, formerly at Schuler, takes over effective July 1, 2024, from the long-time CEO who has decided to step down. Under Alex Waser, Bystronic more than doubled its revenues in the last ten years. It grew organically and through strategic acquisitions, including China-based machine producer DNE and Spanish software company Kurago. Under his leadership, the company evolved from a manufacturer of sheet metal machines to a global full-solution provider.

Iacovelli brings extensive management and leadership experience, having spent 13 of his 20 years in the sheet metal industry in CEO roles. In 2018 he was named CEO of Schuler and prior to that, CEO of Andritz Soutec. In April 2022, he was given additional responsibilities and named a member of the executive committee for Andritz, as well as head of business area metals and group head of IT and automation and digitalization.

The Andritz supervisory board and Iacovelli had mutually agreed upon amicable terms on his departure as of December 31, 2023. Within the Andritz group, the president and CEO of Andritz, Dr Joachim Schönbeck, has assumed responsibility for the metals business area.

www.bystronic.com

www.andritz.com

Patrick Scheele succeeds Günther Tränkle at FBH


Source: FBH

Prof Dr-Ing Patrick Scheele

In January 2024, Prof Dr-Ing Patrick Scheele (48) was appointed the new scientific managing director of the Ferdinand-Braun-Institut, Leibniz-Institut für Höchstfrequenztechnik (FBH). This management function is linked to the W3 professorship Microwave and Optoelectronics at the Technische Universität Berlin. Together with administrative managing director Dr Karin-Irene Eiermann, Scheele will form the joint executive management of the institute.

Scheele follows in the footsteps of long-standing scientific managing director Prof Dr Günther Tränkle, who retired at the end of 2023.

Scheele previously worked at Hensoldt Sensors GmbH in Ulm and has known the institute for many years. As vice president and head of radar engineering at Hensoldt, he most recently led several large research and development teams with 950 employees.

www.fbh-berlin.de

Excelitas Technologies expands leadership team

Dan Brailer and Ariel Kuperminc serve as vice president of communications and investor relations, and as vice president, corporate treasurer for the industrial technology manufacturer based in Waltham, Massachusetts.

Brailer brings a wealth of over forty years of business experience to the team having served the past six years leading the investor relations role with Evoqua Water Technologies (Xylem) beginning with its 2017 IPO. He previously held multiple roles at Wesco International including treasurer and investors relations for its 1999 IPO.

Mr Kuperminc served eight years as vice president, corporate treasurer at Evoqua Water Technologies Corporation (Xylem). He will oversee treasury functions, banking relationships and other corporate financial initiatives.

"The addition of Dan and Ariel to the Excelitas team brings a diverse and deep set of disciplines including investor relations, capital markets, corporate governance, and treasury as well as deep stakeholder relationships with investors and analysts. These experiences will be important to drive long-term value, growth and profitability," stated Ben Stas, executive vice president and chief financial officer.

www.excelitas.com

New general manager for Menlo USA

The US subsidiary of Menlo Systems has a new general manager. Jens Schumacher brings more than twenty years' experience in the photonics industry with him, including long stretches at global photonics giants Coherent and Thorlabs. With previous roles covering sales, program and product line management, and customer service, he is well-placed to support Menlo's business in North America, as well as to manage the US-based team of sales and service experts.

Schumacher and his team will provide sales and service support to customers, coordinated from Colorado, and will explore emerging application fields with the establishment of new facilities. This expanding presence showcases the company's commitment to its customers and partners in North America. "I am excited to take on this new challenge as general manager of Menlo Inc, working with the team to move the US site to the next level," he says of his new role.

"We are delighted to have Jens on board. Our team and customers will benefit from Jens' longstanding expertise in photonics, as well as his strong leadership skills," says Michael Mei, Menlo co-founder and managing director. Menlo Systems, pioneers of the optical frequency comb, provides precision enabling technologies.


Source: Menlo Systems

Jens Schumacher

www.menlosystems.com

Redesigned voltage amplifiers with improved sensitivity

Manufacturer: Femto Messtechnik
Product: New 'DLPVA-101-B', '-F' and '-BLN' sensitive voltage amplifier models for the precise measurement of small voltage signals. The amplifiers replace the corresponding 'DLPVA-100' variants and are characterized by significantly lower noise, in some cases by an order of magnitude lower, while the range of functions and operation remain identical.
Features: Models with different input stages cover an amplification range from 20 dB (×10) to 100 dB (×10^5). As usual, four amplification levels are available for different signal levels. There is a choice of bipolar input stages with an impedance of 1 MΩ for low-impedance sources and FET input stages with an impedance of 1 TΩ for high-impedance sources. Models with a symmetrical (true differential) input allow the measurement of differential signals. All models have switchable AC coupling and a bandwidth of 100 kHz, switchable to 1 kHz. Thanks to their high-quality construction, the robust amplifiers can work easily even in areas with strong electromagnetic interference. They are easy to use and can be controlled completely manually or via a digital interface (USB optional).
Applications: The 'DLPVA-101' models are excellently suited as universal low-frequency amplifiers in a wide range of applications. They are ideal as detector preamplifiers, for signal acquisition of industrial sensors, and as an assembly of integrated measuring systems.

Femto Messtechnik GmbH
Klosterstr. 64
10179 Berlin
Germany
phone: +49 30 2804 7110
e-mail: info@femto.de
Web: www.femto.de

All-in-one tristimulus-filtered imaging spectral colorimeter

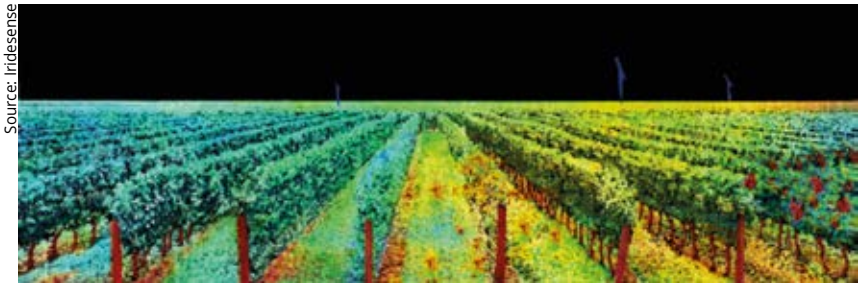
Manufacturer: Westboro Photonics
Distribution: SphereOptics
Product: Cutting-edge 'WP525' imaging spectral colorimeter, an all-in-one solution for superior color measurements of displays, graphics, and lighting in research, development, and production.
Features: The innovative instrument integrates a high resolution 24.6 MP tristimulus-filtered imaging colorimeter with a high-accuracy reference spot spectroradiometer. Designed to streamline color and luminance measurements, the device eliminates the need for multiple discrete instruments. Its unique design, coupled with precision mechanics, ensures swift and automatic color corrections, offering high performance and unmatched flexibility in R&D or production testing of displays, graphics, and lighting. At the heart of the device lies a high speed linear translation stage, enabling rapid and precise switching between optical paths. This component facilitates seamless transition between spectroradiometer measurements and tristimulus-filtered imaging for automated corrections of color measurements. In addition, this feature conveniently enables fully automated shuttering and dark measurements to correct detector noise, without affecting the measurement time. With thirteen interchangeable lenses, including specialized options like a conoscopic lens for viewing-angle testing and a near-to-eye-display lens for AR/VR analysis, the device offers high adaptability to various applications. The intuitive 'Photometrica' software and optional application-specific add-ons provide comprehensive and fully automatable analysis tools.

SphereOptics GmbH
Gewerbestr. 13
82211 Herrsching
Germany
phone: +49 8152 983 7890
e-mail: info@sphereoptics.de
Web: www.sphereoptics.de
analytica, Booth A2.541

A lidar sensor for remote monitoring of crops

Precise, immediate, and comprehensive feedback applied to a global agricultural and ecological context

Source: Iridesense



Reconstruction of multispectral lidar point cloud with healthy (l) and unhealthy (r) vine plants

At CES Las Vegas, Iridesense has unveiled the first 3D multispectral light detection and ranging (lidar) sensor capable of analyzing plant health and soil humidity levels remotely in real time. This new application aims to improve crop yields and resource management by optimizing irrigation, water and pesticide consumption. Other applications include industrial quality control, non-destructive monitoring of infrastructures, and forest management.

Being the first such device in the world according to the company, it is the first sensor to potentially enable such remote measurement, allowing outdoor usage in all types of weather or lighting conditions. Its 3D imagery also allows plant growth to be monitored.

This will enable the company to offer farmers a robust perception solution for optimizing water and pesticide supply, monitoring tree growth and health in orchards, and other agricultural operations. In the long-term, it will potentially save millions of liters of water and pesticides annually in the US alone by improving water allocation between different actors, all while providing farmers with the means to monitor and steer their operations in an objective manner.

In collaboration with GeoCue, a leading US-based actor in 3D lidar mapping, Iridesense will soon deploy this technology in Brazil, where the sensors will be used to monitor plantation health. The device will identify dead or weak plants, enabling farmers to replace them quickly. According to Frank Darmayan, CEO of GeoCue, Iridesense's ability to add multispectral information to the point cloud allows users to get an entire new range of intelligence out of their 3D maps.

Prior to this sensor, no technology could measure plants health or soil moisture levels in outdoor conditions without resorting to sampling. Alternative technologies can only detect these factors at a distance of 1.5 meters, and fail to work outdoors or in environments where lighting cannot be controlled.

https://iridesense.tech

An advanced thermal push-broom hyperspectral camera

Specim's latest innovation provides detailed and accurate imaging for the full LWIR range

The Specim FX120 LWIR hyperspectral camera mounted on the 100 × 50 Lab Scanner in the Specim demo lab measuring mineral samples. (Source: Specim)

The new Specim FX120 is an advanced long-wave infrared hyperspectral camera with a full LWIR spectral range of 7.7 to 12.3 µm. This fast push-broom thermal hyperspectral camera is set to redefine chemical imaging capabilities in challenging environments, day and night. With its excellent spectral and spatial imaging performance, it allows for the simultaneous capture of all 160 swath-width spectral bands at a high image speed of 240 frames per second.

Operating in the LWIR spectral range combined with unparalleled sensitivity, the Specim FX120 opens new possibilities in mineralogical research, environmental analysis, and defense and surveillance applications. It can perform accurate mineral mapping, landmine, and ordnance detection and is sensitive to detect thermal anomalies and classify even gases. Its compact, transferable, and robust design enables easy integration into existing systems, facilitating seamless adoption for various operating environments.

Jere Hartikainen, CTO at Specim: "Compared to its predecessor, the Specim OWL, the new Specim FX120 boasts more spatial and spectral pixels, increased imaging speed, GigE Vision compliant interface, and modern detector technology. This translates into improved uniformity and a greater full well capacity, allowing you to capture more detailed and accurate information."

One of the highlights of the Specim FX120 is its ability to capture minerals undetectable by other wavelengths. In conjunction with the SisuRock workstation, the Specim FX120 revolutionizes drill-core scanning. Its speed and accuracy in capturing all sizes of core drive exceptional productivity and significantly advance drill-core analysis, providing vital information for informed decision-making.

www.specim.fi

A new level of real-time 3D fluorescence information

Evolved ARveo 8 surgical microscope leads to clinical value creation for 3D brain-tumor visualization

Leica Microsystems has launched an evolved version of its ARveo 8 digital visualization microscope for neurosurgery, enhancing surgical visualization through the application of a 3D view and augmented reality (AR) fluorescence. For brain-tumor surgery, the new Glow400 3D AR fluorescence helps surgeons to achieve a new level of clinical value creation with clear visualization of both anatomical structures and a wide range of fluorescence information. In vascular surgery, they can now visualize fluorescent vascular flow in 3D with the Glow800 AR fluorescence.

The advanced MyVeo headset for the ARveo 8 ecosystem (Source: Leica Microsystems)

The wide range of surgical information offered by the ARveo 8 is now also accessible with the new MyVeo all-in-one surgical visualization headset. The headset frees surgeons and assistants from having to stay in front of oculars or external monitors, giving them more ergonomic comfort and a new level of surgical workflow efficiency.

"The continuously evolving ARveo 8 is once again pushing the boundaries of neurosurgery," said Walid Beylouni, vice president medical division at Leica Microsystems. "It opens up a new level of continuous access to clinical applications and digital capabilities. Surgeons will see more information that leads to clinical value creation while performing critical procedures. The result is more confident, real-time surgical decisions."

The new Glow400 AR fluorescence for brain-tumor surgery takes visualization of suspected grade III and IV glioma to another level. Anatomical details are shown more clearly thanks to the multispectral imaging technology of the Glow400 Anatomy View. Even details, such as vessels and bleeding, that were previously hidden under a veil of blue light can be seen.

Additionally, surgeons can observe a wider range of fluorescence intensities with the Glow400 Highlighted Fluorescence View. During tumor resection, they can repeatedly check for traces of remaining visible fluorescence, particularly lower-intensity fluorescence signals of the marked tumor.

Digital real-time fluorescence images are visualized with high resolution in 2D or 3D on a large 55-inch monitor which is available with the evolved ARveo 8.

The all-in-one surgical visualization headset, MyVeo, unlocks surgeons and their team from the microscope, overcoming the challenges surgeons face spending long hours in uncomfortable positions. The headset's displays provide surgeons with a wide range of real-time information in 3D depth perception, including all Glow400 views, the Glow800 digital AR-application, and the white light view of the surgical field.

This is accompanied by 2D views from compatible navigation systems and endoscopes. At the same time, it makes the teaching and learning experience more impactful by the simultaneous use of three headsets. The surgeons and assistants are no longer stuck in front of oculars or fixed screen positions.

www.leica-microsystems.com

ALSO OF INTEREST

Two-photon lidar overcomes range limitations

The findings have the potential to lead to the development of novel sensing technologies.

360-degree head-up display provides real time warning for drivers

New system see through objects to project holographic representations of road obstacles.

Laser scarecrows make birds see red

Lasers could deliver a sustainable answer to the expensive problem of bird damage to crops.

Optimized 3D-printing of optically active nanostructures

The shape, size and optical properties of three-dimensional nanostructures can now be simulated in advance before they are produced directly with high precision on a wide variety of surfaces.

Detecting smallest material defects at an early stage

In aerospace technology or the automotive industry, quantum magnetometers can increase the resilience and safety of systems and materials, researchers from the recently completed Fraunhofer lighthouse project QMag find.

Environmentally friendly quantum dots for fast photodetectors

A novel method for synthesizing InSb/InP colloidal quantum dots stable under ambient conditions.

Laser system for producing high purity crystals

Researchers from Japan and Germany have now developed a method to produce semiconductor crystals for power electronics using a laser-based process.

New lasers for digital holography

MultiLambdaChip project gets underway with Hübner Photonics, Carl Zeiss, Cybertechnologies, University of Freiburg, and the Fraunhofer IPM.

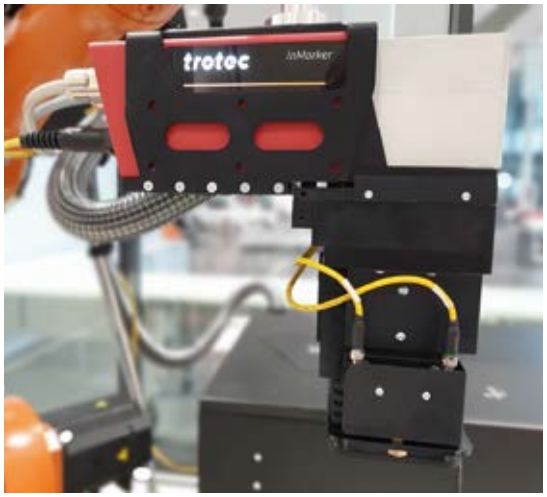
Improving cancer treatment with fast lasers

New approach for more effective use of radiation therapy in oncology.

Inline marking laser with patented safety solution

Trotec launches a lightweight and compact integration laser with a safety solution for operation without a protective housing

Following the market launch of the VIN Marker 2023 as an automotive industry solution, Trotec is now presenting another integration laser, the InMarker. This powerful industrial laser engraver is optionally equipped with a pulsed Yb fiber laser source with 20, 30 or 50 watts or a MOPA laser source with 20 or 100 watts. At just 4.6 kg and with a small footprint, the InMarker is one of the smallest and lightest integration lasers on the market. This enables versatile use on production lines, robot cells or production systems in numerous industrial sectors. Designed to meet the requirements of Industry 4.0, the InMarkers are ideally equipped for standard-compliant marking in short cycle times with full communication connections (fieldbus interfaces), pilot lasers for easy set-up, various lenses, towable connection cable and much more.



InMarker – flexible across all industries (Source: Trotec)

The 'Safetycone' laser safety funnel developed by Trotec saves the effort and expense of a laser safety enclosure and meets all occupational safety requirements. Depending on the selected version, the overall system meets the requirements for laser class 1 or, with a pilot laser, laser class 2.

Protected by several sensors, the Safetycone isolates the laser beam during marking or engraving on the component. Attention was paid to a very compact design to enable installations in narrow and confined areas. Thanks to its modular design, the Safetycone can be mounted on all integration lasers in the InMarker series and can be easily integrated into existing or new production lines. The marking area with the Safetycone is optionally 50 × 40 or 90 × 70 mm or individually adapted to customer requirements. The standard versions are designed for flat surfaces; customizing is possible for curved or bent surfaces.

The compact InMarker marking lasers with the Safetycone solution eliminate the need for clamping and high lateral forces associated with other technologies.

www.troteclaser.com

VCSEL-based illumination module platform for short and mid-range automotive and industrial lidar

Coherent has introduced of an illumination module platform for short and mid-range light detection and ranging (lidar) in automotive safety and robotic vision in industrial applications

The growing adoption of advanced driver assistance systems (ADAS) in vehicles and of depth sensing in industrial robots is accelerating the demand for compact and flexible lidar systems that perform efficiently and reliably, even in the most extreme environments.


Lidar demonstrator with several selectively addressable horizontal slices of the field of illumination (Source: Coherent)

Using eight 940 nm vertical-cavity surface-emitting laser (VCSEL) modules, Coherent has demonstrated a solution with several selectively addressable horizontal slices of the field of illumination (FOI). In addition to offering a compact form factor and excellent power conversion efficiency, the module is a much lower-cost alternative than using large addressable VCSEL arrays. Coherent has a demonstrator available for its customers to explore multiple VCSEL module positioning configurations and scanning algorithms for various depth sensing modalities and types of scenery.

"A powerful aspect of the module platform is the ability to customize an optimized solution for use cases requiring up to thirty meters of depth sensing in bright daylight. Our illuminators exceed thirty percent total power conversion efficiency and have a compact footprint, only about a third of the size of a credit card," said Dr David Ahmari, vice president and general manager, optoelectronic devices and modules business. "To achieve this breakthrough in efficiency and size, we are leveraging our state-of-the-art five-junction VCSEL technology that enables each illuminator module to achieve up to 200 W of output power. Our demonstrator is available for customers to evaluate and better envision the expanded universe of applications enabled."

Customers of Coherent will be able to adjust the duration of the driving pulses to achieve both short and mid-range lidar sensing. The FOI slices are dynamically selectable depending on the number of VCSEL modules and the order in which they are scanned. A voltage supply of only 21 V is required, which is much lower, and therefore more efficient, than existing lidar technology.

www.coherent.com

Brazing and 3D printing without oxidation

The LZH is investigating how an oxygen-free production concept can be applied in laser beam brazing and additive manufacturing

Oxygen is a disruptive factor in many production processes within the metal-working industry: oxide layers formed during metal processing in the presence of oxygen can hinder the joining of workpieces and accelerate the wear of components and tools. An innovative method has been developed in the collaborative Oxygen-Free Production research center to address the oxidation problem.They introduce argon protective gas with a small amount of silane during production. Silane reacts with the surrounding oxygen, creating an atmosphere equivalent to an extreme high vacuum (XHV) environment. This atmosphere has an extremely low oxygen content similar to that in a vacuum below 10^{-9} Pa. This oxygen exclusion approach is significantly more cost-effective than implementing a technical vacuum. At LZH, scientists are researching this method for powder bed-based laser beam melting and laser beam brazing.

In CRC 1368, LZH investigates the processability of metal powders in selective laser beam melting in an oxygen-free atmosphere using a self-developed system (Source: LZH)

In a subproject, a group has developed a novel brazing process that eliminates the need for flux. Fluxes, which are partly environmentally and health-hazardous, are typically used to break up the oxide layer on the material surface, allowing metal and filler material to react. In the newly developed process, LZH researchers break the oxide layer with a nanosecond-pulsed laser beam source instead. Subsequently, the brazing process occurs under a continuous-wave laser beam in a silane atmosphere. The oxygen-free atmosphere prevents re-oxidation of the surface between process steps.

Researchers have demonstrated the ability to permanently remove the oxide layer on aluminum alloys in an oxygen-free atmosphere. It was then possible to wet the surface with a compatible solder material. In the second funding period, researchers will transfer the process to the challenging mixed joining of aluminum and copper and explore the process limits.

Another group is investigating how metal powders can be processed in an oxygen-free atmosphere using laser-based powder bed fusion of metals. The process was developed using the titanium alloy Ti-6Al-4V on a system specially developed for the process and monitored using high-speed cameras.

The subproject's goal is to gain a fundamental understanding of the process in an oxygen-free atmosphere and the influence of oxygen. Researchers expected the absence of oxygen to result in a more stable process, fewer splatters, and improved component properties. They demonstrated that not only did the number of splatters decrease, but they also oxidized less, reducing powder degradation. However, to further improve the process and component quality, eliminating moisture in the atmosphere and powder will be thoroughly investigated in the second funding period.

The Oxygen-free Production research center is funded by the German Research Foundation, with the second funding period supported with aroound 10.5 million euros until the end of 2027.

www.sfb1368.uni-hannover.de
www.lzh.de

Lightning-fast photonic coupling

Improving speed by an order of magnitude, Physik Instrumente introduced an AI-based real-time first light search method at this year's Photonics West

Source: Physik Instrumente

Solving the 'first light problem' with the new PILightning algorithm

To enable the rapid manufacturing scaling of photonics, the new autonomous and virtually instantaneous process eliminates the need for time-consuming searches or manual intervention during photonic coupling. This drives down test and assembly costs in all industrial photonics alignment applications, from wafer probing to final packaging. The PILightning algorithm is available for PI's ultraclean air bearing stages, Nanocube and fast steering mirror mechanisms and leverages the power of ACS controls.

PILightning is based on a new search method with an integrated AI-based real-time executive function. It also replaces fine pitch scanning by high frequency data sampling, raising acquisition speeds. It reduces the time required to acquire first light in single and double-sided couplings and in loopback (omega) waveguide configurations.

Tests have shown improvements of one order of magnitude and more in single-sided alignment applications. Gains are achieved in double-sided first light detection applications. The larger the search area and the more complex the alignment, the more significant the gain.

The PILightning algorithm is available on PI's ultraclean air bearing-based F-142 and F-143 multiaxis photonics alignment system as well as ACS-based Nanocube and steering-mirror controllers.

www.physikinstrumente.com

To space – with 3D printing

BLT enabled Land Space's ZQ-3 to ace first-ever major vertical takeoff and landing recovery test of their reusable rocket

VTVL-1 in flight (Source: Land Space / BLT)

The first private carrier rocket company in China, Land Space, has achieved a flawless debut of their ZQ-3 VTVL-1 reusable vertical takeoff and landing (VTVL) recovery test rocket in January. Integral to the success of this mission was the comprehensive support provided by BLT, contributing their expertise in metal additive manufacturing technology. The collaboration ensured the acquisition of crucial experimental data, solidifying Land Space's position for reusable liquid oxygen-methane rockets.

The successful recovery test affirmed the correctness of the wide-ranging variable-thrust liquid oxygen-methane propulsion system scheme, the compatibility of the rocket control system with engine thrust adjustment characteristics, the accuracy of the guidance and control scheme during the landing phase, and the reliable performance of the rocket's soft landing cushioning mechanism.

The collaboration traces its roots back to 2019 when Land Space foresaw the inherent advantages of metal 3D printing technology in the fabrication and production of liquid oxygen-methane rocket components. BLT proved instrumental in expediting component production, cutting production costs, hastening product iterations, and ultimately elevating the overall development efficiency for Land Space. This partnership has evolved, reflecting the deepening and broadening synergy between the two entities committed to pushing the boundaries of 3D printing in aerospace innovation.

The VTVL-1 recovery test arrow utilizes BLT's metal 3D printing technology for intricate components within the engine, such as joint elements, igniter mounts, and the intricate free-body section, which has a complex internal cooling structure. These components posed challenges in traditional metal fabrication methods such as prolonged production cycles, difficulties in mold manufacturing, and escalated costs.

Leveraging metal 3D printing during the production of the free-body section allowed for the seamless integration of its cooling structure, ensuring superior component performance and effectively preventing erosion of the combustion chamber casing.

www.xa-blt.com

New nanocavities pave the way for enhanced tiny lasers and LEDs

Sub-wavelength confinement of light demonstrated in indium phosphide nanocavities could enable faster data transmission

As industry transitions to a new era in computing, there is a need for new devices that integrate electronic and photonic functionalities at the nanoscale while enhancing the interaction between photons and electrons. In an important step toward fulfilling this need, researchers have developed a new III-V semiconductor nanocavity that confines light at levels below the diffraction limit.

"Nanocavities with ultrasmall mode volumes hold great promise for improving a wide range of photonic devices and technologies, from lasers and LEDs to quantum communication and sensing, while also opening up possibilities in emerging fields such as quantum computing," said Meng Xiong from the Technical University of Denmark DTU.

Source: DTU

Meng Xiong and Frederik Schröder of the research team

The new nanocavity exhibits a mode volume an order of magnitude smaller than previously demonstrated in III-V materials. The strong spatial confinement of light demonstrated in this work helps to enhance light-matter interaction, which allows higher LED powers, smaller laser thresholds, and higher single-photon efficiencies.

The work is part of an effort by researchers at the DTU's NanoPhoton Center for Nanophotonics who are exploring a new class of dielectric optical cavities that enable deep subwavelength confinement of light through a principle the researchers have coined extreme dielectric confinement (EDC). By enhancing the interaction between light and matter, EDC cavities could lead to highly efficient computers with deep-subwavelength lasers and photodetectors that are integrated into transistors for reduced energy consumption.

In the new work, the researchers first designed an EDC cavity in the III-V semiconductor indium phosphide (InP) using a systematic mathematical approach that optimized the topology while relaxing geometric constraints. They then fabricated the structure using electron beam lithography and dry etching.

"EDC nanocavities have feature sizes down to a few nanometers, which is essential to achieve extreme light concentration, but they also come with a significant sensitivity to fabrication variations," said Xiong. "We attribute successful realization of the cavity to the improved accuracy of the InP fabrication platform, which is based on electron beam lithography followed by dry etching."

After refining the fabrication process, the researchers achieved a remarkably small dielectric feature size of 20 nm, which became the basis for the second round of topological optimization.

The researchers point out that although similar cavities with these characteristics were recently achieved in silicon, silicon lacks the direct band-to-band transitions found in III-V semiconductors, which are essential to harness the Purcell enhancement provided by nanocavities. "Prior to our work, it was uncertain whether similar outcomes could be achieved in III-V semiconductors because they do not benefit from the advanced fabrication techniques developed for the silicon electronics industry," said Xiong. The researchers are now working to achieve a practical nanolaser or nanoLED. (Source: DTU)

Reference: *M. Xiong* et al.: Experimental realization of deep sub-wavelength confinement of light in a topology-optimized InP nanocavity, Opt. Mater. Express 14(2), pp. 397-406 (2024); DOI: 10.1364/ome.513625

https://nanophoton.dtu.dk

OPC Foundation celebrates anniversary and LADS release

Based on OPC Unified Architecture, Spectaris presents the first industrial communication standard

As of December 14, 2023, the Laboratory & Analytical Device Standard (LADS) can be officially used and integrated within laboratory and analytical devices. After a four-year development phase, the first version is now available and has been guided by key use cases from industrial practice. LADS ensures that all laboratory equipment and connected applications speak the same language and can be networked quickly and cost effectively. Thanks to LADS, users are able to collate an individual set of devices that can exchange data with each other, regardless of their manufacturer or interface.

Source: OPC Foundation, 23/11/15

Celebrating 20 years of work with OPC UA

Mathis Kuchejda, chair of the analytical, bio and laboratory technology division at Spectaris emphasizes: "LADS enables the efficient networking of devices, automated systems, and processes and offers a decisive advantage in an increasingly competitive laboratory market."

Spectaris opted for the Open Platform Communications Unified Architecture (OPC UA) which provides the optimum framework for networking devices, systems, and processes within the lab, in particular because many machine standards are based on it. OPC UA, which celebrated its 20th birthday in November 2023, is used to define the service-oriented skeletal structure, whilst domain-specific extensions are defined via so-called companion specifications.

www.spectaris.de

Pilot project to recruit skilled workers

Federal Ministry and Spectaris test new concept at SPIE Photonics West in San Francisco

Source: Spectaris

(l–r): Matthias Ernst, Federal Employment Agency; Jörg Mayer, managing director of Spectaris; Dr Dorothea Schütz and Dr David Wolfmeyer, Federal Ministry for Economic Affairs and Climate Protection

At SPIE Photonics West in San Francisco, the Federal Ministry for Economic Affairs and Climate Protection (BMWK) presented a skills information module for the first time at its German Pavilion. In cooperation with the German Industry Association Spectaris, the initiative aimed to attract international skilled workers to the German labor market.

The pilot project in San Francisco focused on the photonics industry, which needs many qualified skilled workers. Interested academics learned about the simplified work and immigration opportunities to Germany.

The response to the new concept was positive. Both the BMWK and Spectaris drew a positive conclusion and are now considering continuing the project at other international trade fairs.

The STEM and skilled worker gap in Germany is growing. The Skilled Immigration Act is intended to pave the way for targeted measures to recruit skilled workers.

www.spectaris.de

SPIE honors new fellows for 2024

The international society for optics and photonics is welcoming 47 new fellows

This year, SPIE welcomes 47 members from all over the globe as new fellows of the society. They join their colleagues in being honored for their technical achievements, as well as for their service to the optics and photonics community in general and to SPIE in particular.

Fellows are members of the society who have made significant scientific and technical contributions in the multidisciplinary fields of optics, photonics, and imaging. Since the Society's inception in 1955, nearly 1,800 SPIE Members have become Fellows.

The inductees this year are high-profile leaders in academia, industry, and government. The 2024 Fellows cohort includes ASML director of system engineering Jan Van Schoot and ASML Research EUV program manager Mark van de Kerkhof; Meadowlark Optics chairman and founder Tom Baur; Duke University professor and electrical engineer Natalia Litchinitser; University of Technology Sydney professor, and physicist and materials engineer Igor Aharonovich; US Naval Research Laboratory research physicist Lynda Busse; Clemson University associate professor and associate dean of inclusion and equity Oliver Myers; Harvard Medical School professor and Wellman Center for Photomedicine at the Massachusetts General Hospital Tearney laboratory leader Guillermo Tearney; Centro de Investigaciones en Óptica researcher Amalia Martínez García; and ICube senior research scientist Paul Montgomery.

https://spie.org

New board member for OptecNet Deutschland

Adrian Mahlkow newly appointed, Andreas Ehrhardt and Horst Sickinger re-elected

At the general meeting of OptecNet Deutschland in Erfurt on December 11, 2023, the board members Dr Andreas Ehrhardt and Dr Horst Sickinger were re-elected and Dr Adrian Mahlkow, managing director of OptecBB, was elected as a new member.

"I am very pleased to help shape the activities and strategic development of OptecNet Germany as a new member of the board," emphasized Dr Adrian Mahlkow.

"As an umbrella organization of the regional innovation networks for optical technologies and quantum technologies, OptecNet Germany wants to generate a high added value for its association members. One main goal is to continuously develop existing and new services," stated Dr Andreas Ehrhardt, managing director of Photonics BW.

"With OptecNet Germany as an established platform for professional networking, we offer national and international events for the photonics industry," added Dr Horst Sickinger, managing director of Bayern Photonics.

In a strategic meeting on December 12, 2023, the managing directors of the regional innovation networks developed offers and services for future-oriented networking. They were based on a survey among the members of the regional innovation networks.

Source: Bayern Photonics

(l–r) Dr Adrian Mahlkow, Dr Horst Sickinger, Dr Andreas Ehrhardt

https://optecnet.de

NRW quantum roadmap established

North Rhine-Westphalia bundles activities for Quantum Technology 2.0, Fraunhofer ILT coordinates

At a kick-off meeting in Cologne on January 30, 2024, the starting signal for a roadmap was given that will bundle the ongoing activities in quantum technology at universities, research institutes, start-ups, and companies in the federal state of North Rhine-Westphalia (NRW), Germany. The two leading state ministries – for culture and science and for economy, industry, climate protection and energy – have commissioned the coordination office QT.NMWP.NRW and Forschungszentrum Jülich with implementing the roadmap. The Fraunhofer Institute for Laser Technology ILT in Aachen is responsible for coordinating it.

North Rhine-Westphalia has a vibrant quantum ecosystem. Across the state, universities and research institutions, start-ups and established companies as well as supporting initiatives are driving the development of quantum technology into a future market. The state government of NRW is initiating a quantum technology roadmap to bundle these activities, analyze opportunities and potential, and make optimal use of existing strengths and locational advantages. Dr Bernd Jungbluth coordinates the quantum roadmap NRW on behalf of Fraunhofer ILT in Aachen.

At AKL'24, the 'Forum Quantum Technology & Photonics' will be an all-day event on Wednesday, April 17, 2024.

www.ilt.fraunhofer.de

Million dollar endowment for postgrad scholarships

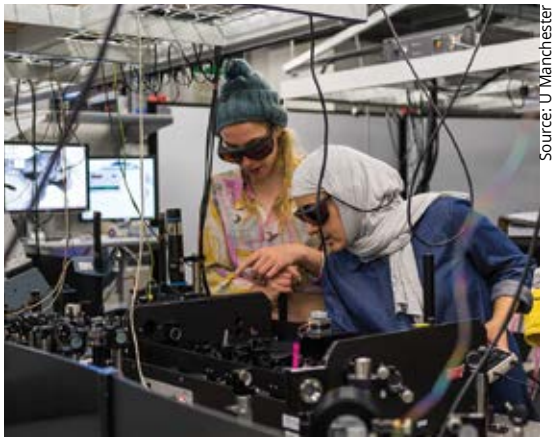
The University of Manchester and SPIE have established a photonics program

A 500,000 dollar gift from the SPIE Endowment Matching Program will be matched 100 % by the University and will be used to support both early-career and returning researchers from the University's Photon Science Institute in partnership with the Royce Institute, the UK's national institute for advanced materials research and innovation. The partnership was announced during the SPIE Photonics West conference in San Francisco.

With a goal of increasing diversity in photonics, the scholarship will have a particular focus on funding individuals returning to research following a career break or time in industry, and those pursuing unconventional career pathways or part-time study – situations often necessitated by caring responsibilities, for example.

Aligning current research and industrial needs for a robust training pipeline, an additional unique feature of the scholarship is an optional final-year placement of up to twelve months, during which students can develop industry-relevant skills in collaboration with local optics and photonics companies to ensure a sustainable workforce for the North West of England.

https://spie.org ■ www.manchester.ac.uk



Source: U Manchester

Researchers in a lab of the Photon Science Institute at the University of Manchester

Global networking for European photonics competitiveness

Driving growth and innovation through international collaboration

Source all images: EPIC

Group picture of the delegates from ten selected EPIC member companies, and the hosts from TII

In the first trimester, EPIC members had the opportunity to visit the Technology Innovation Institute (TII) in Abu Dhabi, United Arab Emirates. Beginning with insightful visits to the Quantum Research Center (QRC) and the Direct Energy Research Center (DERC), our members delved into cutting-edge research and networking opportunities. EPIC delegates showcased their expertise in precision optical and photonics imaging, wavefront sensors, ultrafast laser pulses, and integrated photonics to fulfill the current needs of the TII in the field of free-space optical (FSO) beam propagation technology and applications. Other destinations planned for this year include Japan, Taiwan, and India.

The participants were in the rain for almost 40 minutes, going from the Ferry Building to the Aquatic Park Pier in San Francisco

We also cannot forget Photonics West where we had the chance to meet with most of the members. From here, we heartily applaud the participants of the EPIC Members' Run who bravely ran or walked through rainy San Francisco. They deservedly won burgers and fries for breakfast!

https://epic-photonics.com

Upcoming EPIC events:

- 27 March 2024
  Networking Activities at OFC, San Diego, CA, USA
  EPIC Members Run at OFC
  EPIC VIP Networking Reception
  EPIC Members Lunch
- 8 April 2024
  EPIC Online Technology Meeting on Photonics Technologies to Improve Pharma Processes
  Online Event
- 9 April 2024
  EPIC Online session – Membership Benefits Information and Update
  Online Event
- 11 April 2024
  EPIC HR Workgroup meeting: Hiring in North America
  Online Event
- 12 April 2024
  EPIC Sustainability Workgroup Meeting
  Online Event
- 16 – 18 April 2024
  EPIC Annual General Meeting 2024
  Juan Les Pins, Nice, France
- 22 April 2024
  EPIC Online Technology Meeting on Quantum Communication
  Online Event
- 24 – 25 April 2024
  EPIC Technology Meeting on Photonics for the AgriFood Industry – Enlightening the Future at DigiFoods
  Oslo, Norway
- 22 – 26 April 2024
  EPIC Members Delegation to Japan
  Yokohama, Japan
- 29 April 2024 / 15:00 – 17:00 CEST
  EPIC Market Report on Raman Technology by Tematys
  Online Event

For the list of all events, visit:

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

EPIC

EUROPEAN PHOTONICS
INDUSTRY CONSORTIUM

Make it EPIC!

Driving Competitiveness of European Photonics Industry through an International Network

www.epic-photonics.com

"There are several advantages of being a smaller independent company"

Michael Porbadnik of Luxinar, interviewed by Antonio Castelo

Source all images: Luxinar

The managing director of the UK manufacturer of sealed CO_2 and ultrashort-pulse laser sources gives an insight into his career during a talk with EPIC's technology manager for bio-medical and lasers.

What is the background to your appointment at Luxinar?

After graduating with an MSc in physics from the Technical University of Munich in 1995, I worked for IBM and later for Philips Semiconductors in Germany who were at that time a manufacturer of microcontrollers and microchips. I eventually became a senior leader in the company's production control and industrial engineering department, and my work involved restructuring operations, excellence initiatives, and new market development.

After eight years I moved to Stryker in Freiburg, a medical device company. As global operations manager for navigation, I was responsible for the in-house production of complex medical instruments and devices for intra-operative navigation as well as the creation of a new business unit with a global manufacturing footprint in the Americas, Europe and Asia.

In 2009 I became global operations manager at Knorr-Bremse Entrance Systems, a supplier of braking and other safety-systems for rail and commercial vehicles. I was responsible for the production and supply chain of seven plants in the US, China, India, and Europe, concentrating on the production and field service of entry systems for railway vehicles and the metal processing and electronics industries.

Eighteen months later, looking for a more strategic role, I moved to Mayr-Melnhof, as head of region and general manager of MM Packaging Western Europe in Baiersbronn, engaged in the cardboard packaging of food, medical devices, personal care, and other products.

Then, in 2020, came Luxinar. Formerly known as Rofin-Sinar UK, Luxinar had been established in 1998 in Hull to produce CO_2 laser sources. Rofin-Sinar was acquired by Coherent in 2016. However, a year later under the European Commission's antimonopoly rules, Coherent was ordered to sell the UK branch which was acquired by CMR, a European investor, and rebranded as Luxinar in 2017. The new owners asked me if I would be interested in running the company, and I gratefully accepted as I felt it would be a great opportunity to use

DOI: 10.1002/phvs.202400005

Luxinar's headquarters in Kingston upon Hull

my knowledge and experience to successfully develop the company further.

How has Luxinar developed?
Over the past 25 years we have developed a versatile laser source portfolio catering for a diverse range of OEMs in the automotive manufacturing, electronics, fashion, food and beverage, packaging, glass, medical and pharmaceutical industries. Until recently, our main product line was sealed CO_2 laser sources based on a diffusion-cooled slab principle. These lasers are available with power levels from 60 W to 1 kW at three different wavelengths for applications such as laser ablating, cutting, drilling, marking, perforating, scribing, and welding of a wide range of materials such as ceramics, glass, paper and card, metals, plastics, rubber, wood, leather, and other textiles. We have traditionally been strong on high-speed marking systems for glass as our lasers have speeds typically beyond those of our competitors.

In the last two years, we have brought a second product line based on ultrashort-pulse lasers onto the market – our patented LXR series – which is available with three wavelength options and rated powers of up to 120 W. The target applications are in the semiconductor, electronics, medical device, micromachining, printing, security and automotive industries.

Our main office and production facilities are in the UK and we now have a workforce of around 220 with combined sales and service offices in Europe, the US, China and South Korea as well as an excellent network of distributors. To date, we have an installed base of over 25,000 lasers worldwide. In 2016 we moved to a purpose-built, state-of-the-art facility in Hessle, near Kingston upon Hull in England. Built on two levels, the building provides 7500 m^2 (81,000 ft^2) of manufacturing space, with room for future expansion. Our facility is located conveniently close to transport links to the rest of the UK and the world.

What did you learn most from your career before Luxinar?
I like taking on challenges, and every change in my career was always linked to a certain type of learning curve. For example, working in semiconductors gave me the knowledge of how to systematically set up and optimize stable processes to obtain high yields, lean production and six sigma. The medical device sector was all about regulations and innovation, and working in automotive gave me an insight into the importance of customer relationships. Similarly, by working in packaging I learned about standardization and offering customer-dedicated solutions. My aim with each challenge was to learn something new and to become a more rounded manager by having a variety of perspectives on the things that make a business organization successful.

But the most important thing I learned is that to get a company moving successfully you need to recruit talented people who fully understand the company goals and who are passionate about what they do. The second crucial factor is to create a high-performance environment that gives people the freedom to achieve the objectives in their own way without micromanagement.

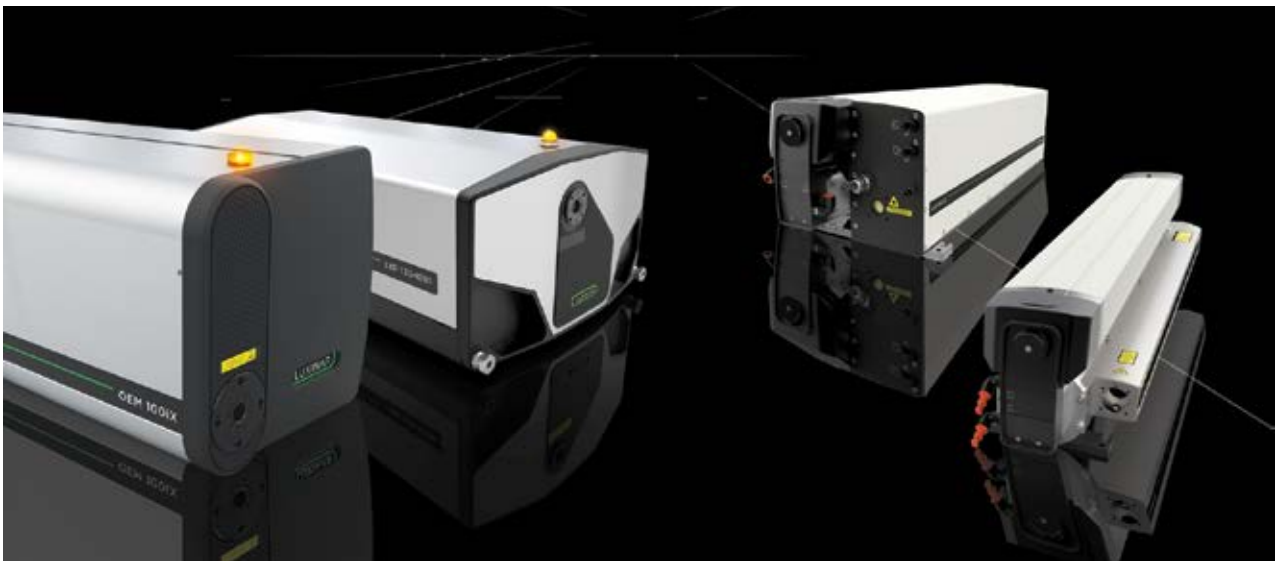
What were your main challenges when you took over as managing director?
After the divestment, Luxinar was a much smaller company, so we had to make investments in some areas like the sales and service organization. But in general, there are several advantages of being a smaller independent company as we have been able to be far more flexible and more customer oriented.

Company

Luxinar

At Luxinar, they have a singular focus: developing laser technology to enhance our world. The company has been at the forefront of laser technology for more than 25 years and is a leading manufacturer of sealed CO_2 laser sources up to 1000 W and ultrashort-pulse laser sources. They have an installed base of over 25,000 lasers worldwide in a broad spectrum of industries, including automotive, electronics, packaging and textiles, used for applications such as ablating, cutting, drilling, marking, perforating, scribing and welding.

www.luxinar.com



A selection of Luxinar's laser sources

Now we have direct market access and open-door sales offices with customer connections all over the world, and we have been able to adopt a very systematic approach to integrating our key customers into our development cycle.

When I started at Luxinar, the main challenge was Covid, which changed things overnight. But we decided to adopt a positive approach and take advantage of the situation to improve the company and to keep moving forward. Our business processes are systematically tuned in to continuous improvements. We have also strengthened our customer focus in new product development by implementing the Agile philosophy, i.e. an environment that encourages interdisciplinary teams of experts to work toward optimal market and customer-oriented solutions. We also streamlined the new product launch process by establishing an interactive cooperation between product development and operations that led to the launch of around thirty new products, including our LXR series of ultrashort-pulse laser sources.

How do you see the future?

Our aim is to grow by continuing to be a reliable partner for OEMs. As regards CO_2 laser sources and solid-state lasers, we anticipate further growth, both organic and inorganic. We are well prepared to achieve this growth as we have the necessary in-house expertise and know-how and we have laid the tracks for operational excellence. We will continue to strive to improve our solutions and provide better products for our customers' needs by focusing more on customizing certain performance features and optimizing products for specific markets.

But it is not just about what can be done with the technology; equally important is how we can make a difference for a customer. That is why we have established Agile as a way of finding solutions for customers, which will help to promote growth in Asia where customers are very receptive to an emphasis on specialization and customer orientation.

With regard to applications, we have high hopes for the future with the lithium battery segment where our laser sources can be used for a variety of processes such as laser cutting separator foils, cutting and notching electrodes, and battery case ablation.

What is your advice for the next generation of entrepreneurs?

Firstly, when you are developing a technology, always start from the perspective of customers' needs. Find out what their problems are then develop the best solution possible and don't limit yourself by having a preference for a particular technical solution. Secondly, think global: have a clear vision of where you want to go and don't get put off when things become difficult. Thirdly, recruit the best and most talented people you can find. Take the time to explain your goals and don't be a limiting factor; get out of the way and give them the freedom to use their initiative to achieve the goals in their own way.

Further reading: *Louise May (Luxinar):* Applications for CO_2 lasers in the automotive industry – How CO_2 laser technology assists automotive producers in product development and manufacture, Photonics-Views **20**(6), December 2023; DOI: 10.1002/phvs.202300039

Author

Antonio Castelo-Porta is a physicist specialized in optics and a program manager at the European Photonics Industry Consortium (EPIC). After obtaining a PhD in applied physics with a specialization in the laser processing of materials, he explored the industry as a sales engineer and sales manager for several added value distributors and manufacturers. At EPIC, Antonio is in charge of the development of the laser and medical fields, and all related technology and applications. He has a strong interest in new technology involving photonics, such as ultrafast lasers, new medical devices and spectroscopy solutions.

Dr. Antonio Castelo-Porta, EPIC – European Photonics Consortium Industry, 17 Rue Hamelin, Paris, France, e-mail: antonio.castelo@epic-assoc.com, Web: www.epic-assoc.com

DOI: 10.1002/phvs.202400005

Innovative measurement tool optimizes development

Reichenbacher relies on Ophir BeamPeek high-power laser beam analysis and power measurement system

Source all images: Reichenbacher Hamuel

The metalworking industry is evolving. Additive manufacturing methods – even in combination with machining treatments – are paving the way for more efficient processes and innovative designs. Reichenbacher Hamuel has recognized this potential. In very short order, the company has developed industrial additive manufacturing systems based on the laser powder bed fusion process. Here, measuring technology plays a decisive role.

Reichenbacher Hamuel uses the compact Ophir BeamPeek high power laser beam analysis and power measurement system from MKS Instruments for research and development as well as for quality assurance and maintenance. The Reichenbacher team was impressed by both the system's ease of operation and its wide range of measurement options.

Customized additive manufacturing systems

Reichenbacher, which is part of the Scherdel group, is known worldwide primarily for its high-quality 5-axis CNC machining centers that are used in aircraft, automotive, ship, and rail vehicle construction, as well as in the woodworking industry and by manufacturers of components made of aluminum, plastic, or composite materials. In the metal processing sector, the company has expanded its portfolio to include the design and production of large-format, industrial-scale, additive manufacturing systems. Together with experienced partners, Reichenbacher implements customized systems that integrate the entire process chain of laser powder bed fusion (LPBF). Knowing and verifying the parameters of the laser beam at every stage of development proved to be essential, as Dr Alexander Kawalla-Nam, head of additive manufacturing at Reichenbacher, explains: "Laser systems for additive manufacturing are very complex. Our large-format systems in particular, which have multiple laser sources, must be optimally

▲ All measurements taken with the Ophir BeamPeek device (while actively measuring, the chamber will usually be closed) are directly transferred to the BeamPeek software on the laptop outside the chamber

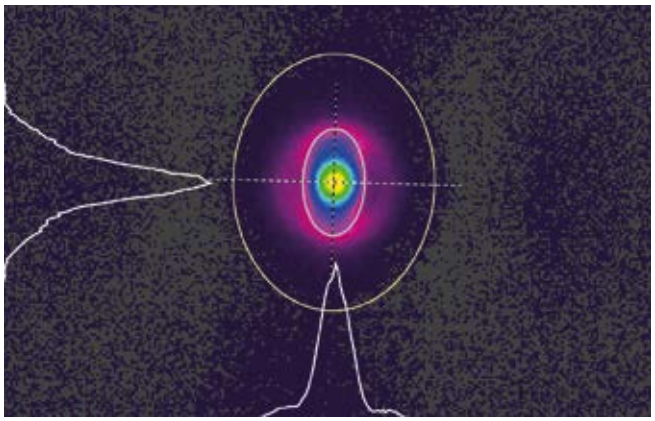


Fig. 1 A contaminated protective glass results in an elliptical beam

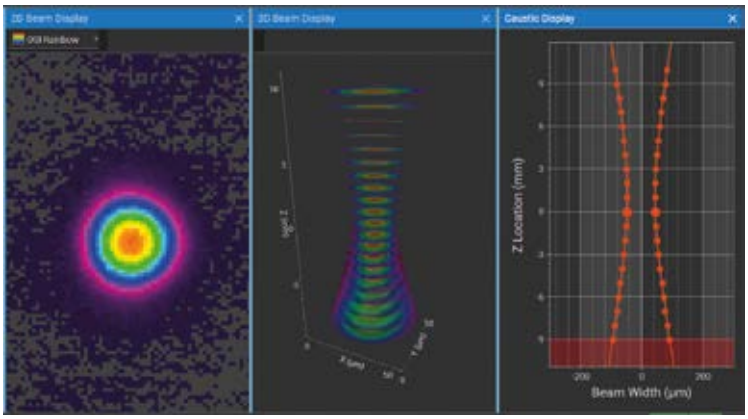


Fig. 2 After cleaning the glass, the beam is round and symmetrical

adjusted to ensure constant production quality. This is why we were looking for a measuring device that could be used for testing throughout the entire lifecycle of our products, from development to maintenance."

Handling without setup changes

Because the essential first step of any project is to define the requirements, the Reichenbacher team compiled the specifications for a measuring device that would suit their application. In terms of the range of functions, the machine manufacturer was concerned with measuring individual parameters of the beam, such as its diameter, position, and shape, as well as the power and power density. But the system should also be able to display the beam caustics, i.e. a representation of the beam from the processing optics to the focus and any subsequent expansion. Equally important to the team was ease of use: "We work with fine metal powders in space-constrained construction chambers, so we wanted to avoid water or air-cooling at all costs to make it easy to operate, also for the service technicians," explains Lukas Gahn, development and application engineer at Reichenbacher.

Innovation at just the right time

The team started a market analysis and evaluated various measuring devices that were already available. That was right when MKS Instruments was launching its new Ophir BeamPeek analysis system, which was developed specifically to meet the requirements of additive manufacturing. For Dr Kawalla-Nam, the timing was perfect: "The BeamPeek system appealed to us straight away: it is compact, it requires no water or air cooling, and its semi-automated analysis software also lets you calculate the beam caustic parameters and display them in relation to the building plane in the AM chamber. As beta testers, we were given the opportunity to share suggestions for optimization with the development team." The innovative measuring device uses a patented concept based on replaceable cooling inserts to absorb the resulting laser power. This avoids downtime between measurements without having to use water or active fans in the build space and is therefore ideal for measuring the lasers in the Reichenbacher LPBF systems. It delivers the beam profile, a focus analysis, and a power measurement, as well as the beam caustic in just a few seconds.

Flexibility saves time and money

Additive manufacturing systems from Reichenbacher are built individually according to the customer's requirements. They are also 'open' systems with regard to the material used. The beam parameters must be repeatedly measured and compared in order to optimally adjust the various laser sources, optics and materials to each other. Four fiber lasers with a laser power of 1 kW each work together on a single print job in the AMS 800 (build volume 800 × 800 × 500 mm) and the AMS 400 (build volume 400 × 400 × 500 mm). The quality of the manufactured component can only be guaranteed if all laser systems comply exactly with the specifications.

The team uses the Ophir measuring system regularly, starting with the development process: "Since the customer has a free choice in terms of the

Company

Reichenbacher Hamuel GmbH

Reichenbacher Hamuel GmbH is part of the SCHERDEL Gruppe and a globally recognized manufacturer of first-class CNC machining centers with a high level of innovation. Since 2020, Reichenbacher has also specialized in custom large-format and industrial 3D printing systems, providing the entire process chain from a single source. In the automation of LPBF (laser powder bed fusion) processes, Reichenbacher is breaking new ground with customized solutions.

www.reichenbacher.de

Company

MKS Instruments – Ophir

Ophir is a brand within the MKS Photonics Solutions Division. The Ophir laser measurement portfolio consists of power and energy meters as well as beam profilers measuring femtowatt to hundred-kilowatt lasers. Especially for industrial applications, MKS has developed several compact and integrated Ophir measurement devices for high power lasers. The robust solutions optimize productivity and enhance manufacturing quality.

www.ophiropt.com

type of powder they will be using, the laser source type also has to vary. The BeamPeek system quickly provides us with all the relevant parameters, both when evaluating the laser sources and when configuring the laser setup. This saves us valuable development time," reports Dr Kawalla-Nam.

Fast identification of sources of error

The beam analysis system also provides crucial information when it comes to troubleshooting, as this example shows. After carrying out an optimization step on the protective glass for a plant's optical systems, the team then made a test measurement using the BeamPeek system. In principle, a before-and-after comparison of the laser's beam parameters should prove whether the optimization was a success. Both the laser beam diameter in various planes and the laser power in the focal plane were measured, but there were inexplicable deviations in the measurement values. The reason quickly became clear when one looked at the shape of the beam: it was suddenly elliptical at the focal plane. After checking the optical components, this was traced back to contamination on the outside of the protective glass (not accessible from the build chamber). After the dirty piece had been removed, cleaned and reinserted, a new control measurement showed an almost perfectly round laser beam in the focal plane over the entire 80 – 1,000 W power range. (See measurement report, Figs. 1+2).

A partnership with a future

Measuring the laser beams at the building plane is essential for Dr Kawalla-Nam's team. The beam shape, laser power and beam caustics are key parameters for ensuring the quality of the system – and therefore also the production quality. When they only need to measure the laser power, the team will also sometimes use the even more compact Ophir Ariel Industrialized Laser Power Sensor with display. But most of the time, Lukas Gahn turns to the BeamPeek system: "Ophir Ariel is great when it comes to measuring laser power, but since we are primarily interested in the beam caustics, we usually work with the BeamPeek system. Even so, it only takes a few minutes to set up the measurement, which then only takes seconds."

*

This case study was prepared in cooperation with Reichenbacher Hamuel by Dagmar Ecker, MBEng.

The patent mentioned refers to U.S. Patent 11,874,163.

Fig. 3 Before starting the measurements latest parameters are checked by the engineer and the system is adjusted by using the pilot laser

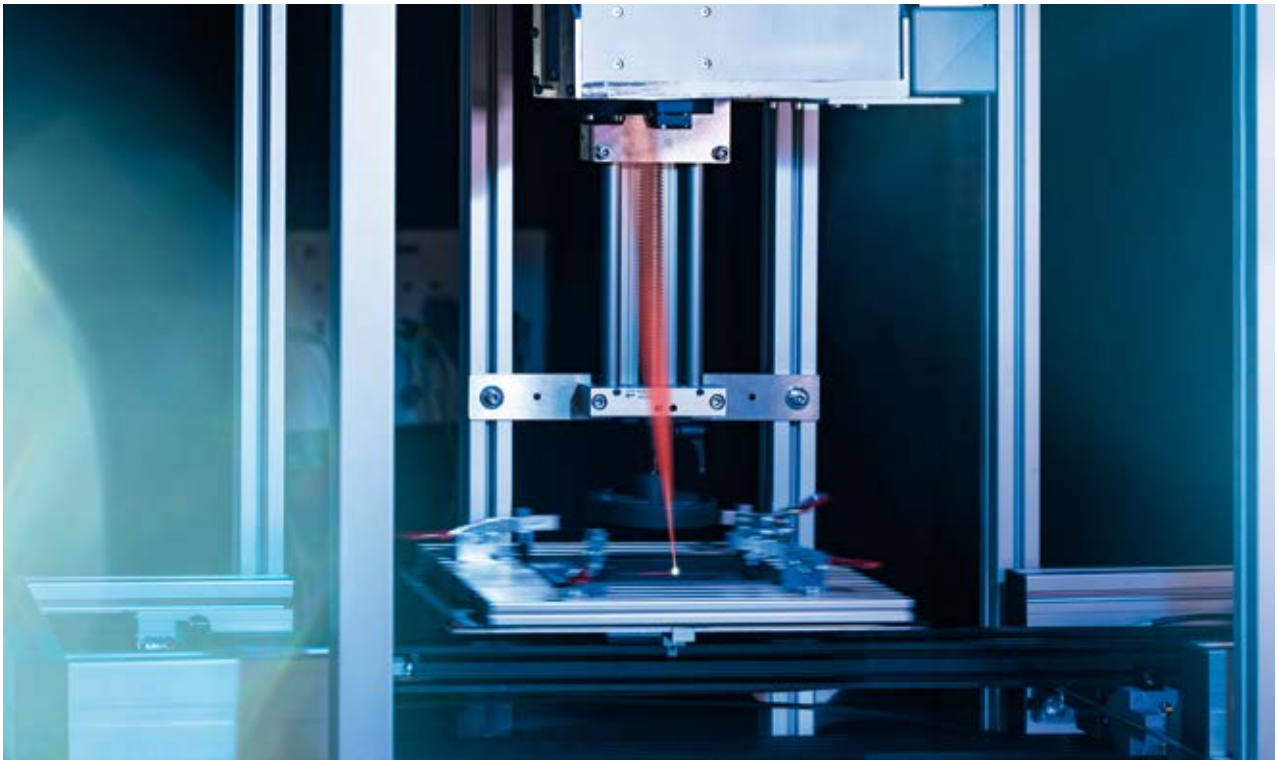
Reichenbacher Hamuel GmbH
Dr. Alexander Kawalla-Nam
Rosenauer Str. 32
96487 Dörfles-Esbach, Germany
phone: +49 9561 599-116
e-mail: alexander.kawalla-nam@reichenbacher.de
Web: www.reichenbacher.de

MKS | Ophir
Roland Heinze
Guerickeweg 7
64291 Darmstadt, Germany
phone: +49 6151 708-0
e-mail: roland.heinze@mksinst.com
Web: www.ophiropt.com

High precision laser welding for the electric vehicles of tomorrow

How to maximize output in bipolar plates and battery manufacturing

Ralf Nürnberg & Holger Schlüter



In the rapidly evolving landscape of e-mobility, the demand for electric vehicles (EVs) is growing fast, bringing with it significant challenges, but with those also come valuable opportunities for the industry. A critical aspect underpinning this growth is the need for efficient manufacturing solutions.

The processing of components such as metallic bipolar plates in fuel cell technology and batteries in various shapes and sizes constantly presents system manufacturers and suppliers with new challenges. These arise primarily from the complexity of the laser welding process itself. When analyzing the sticking points, it becomes apparent that there are several similarities between the two.

The parts to be joined are mostly thin sheets made of aluminum or stainless steel, which is why lasers with a high beam quality and a small spot diameter, usually single-mode lasers, are used. Due to the inconstant height of the parts, the short Rayleigh length of these lasers is a critical factor and therefore extremely precise positioning of the focus is necessary, otherwise sufficient coupling and welding cannot be guaranteed. This adaptive positioning cannot be achieved with 2D scanning systems at the required speed and precision, which is why 3D or 2.5D scanning systems are used despite the actually planar application. Since the welding geometries are located in a wider area, a large scan field is also beneficial.

Another contributor to complexity is the positioning of the weld seams on the parts' surfaces. The required tolerances are far more demanding than the current industry standards in the e-mobility or automotive industry.

In addition, both processes are in continuous operation, which means that other factors come to the fore, such as positional gain and drift. To consistently meet the accuracy requirements, these progressive inaccuracies must be continually compensated for.

▲ On-the-fly laser welding of bipolar plates (Source: Blackbird)

Once these factors are mastered, it must be ensured that the overall manufacturing concepts are scalable when transforming them to series and mass production. Increasing production quantity without compromising quality has become imperative as the industry strives to meet the soaring demand. This pursuit of maximizing output calls for an enhancement in the scalability of process technology. Only if this is pos-

sible can the solution be a fit for this challenging environment.

Setup of a reliable laser welding process

The similarities in the laser welding of bipolar plates and the contacts of round cell batteries allows the design of a system capable of processing both components perfectly. The core components are a scan system and the scanner control. The challenges in meeting the above-mentioned process requirements are the need for a large scan field, small optical magnification, compatibility with a single-mode laser source, and high precision weld positioning. The scanner control needs to have easily adaptable software with versatile programming and to provide a space and energy-efficient solution that is easy to integrate into shop floor layouts.

Finding a suitable system concept for e-mobility production

Considering the requirements, a suitable scan system is the fiberSYS scanner developed by Scanlab. The prefocusing scan head, which has minimum thermal shift and a high beam quality, is optimized for 1 kW single-mode fiber lasers. The mirrors cover a wide spectrum and the scan system has a port for easy sensor connection.

Thanks to its small footprint, it is possible to arrange multiple scanners in a small space, e.g. four units (as can be seen in Fig. 1) to create the maximum overlap of their respective working fields and allow joint operation in a large scan field. The system is available in three different spot diameters: 55 µm, 65 µm, and 75 µm.

To control the scan systems, Blackbird's ScannerControlBox (SCB) offers several benefits. It is a compact, reliable and lightweight scanner controller with a small footprint and good energy efficiency that perfectly fits modern manufacturing environments. Especially in tight e-mobility shop floor designs, it proves to be easy to integrate and space saving thanks to its wall mounting capability and stack ability.

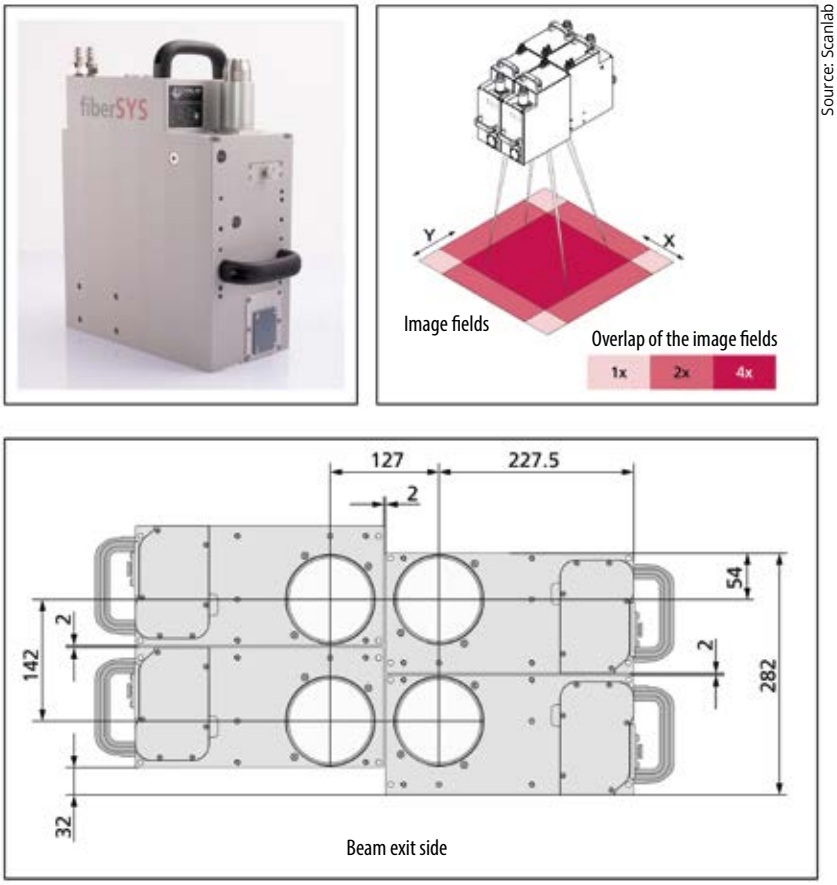


Fig. 1 The slim design of the fiberSYS allows that several fiberSYS scan systems can be arranged close to each other to achieve a maximum overlap of image fields

The highly integrated RSU (RobotSyncUnit) user interface enables communication with various handling systems and machine controls. Furthermore, the adaptable software design allows the individual parameterization (see Fig. 2) of all weld seams and the monitoring of safety-relevant parameters at the same time.

Optimizing the welding process for highest product quality

When examining the laser welding process to ensure the best welding quality, the main criteria are welding accuracy, the avoidance of defects and the definition of a suitable welding strategy. The thermal shift of the galvanometer scanner must be compensated for in order to ensure the highest accuracy. Detection of the part position and its orientation is indispensable for precise positioning of the laser beam.

The galvanometer drift and the positional inaccuracies can be simultaneously compensated for with a camera

Companies

Blackbird Robotersysteme

Blackbird manufactures solutions for remote laser welding with scanners. These systems can be seamlessly integrated into automated manufacturing lines. Blackbird's core competencies include the development of control technology, intuitive user software, and process monitoring solutions. Blackbird offers a broad range of pre-integrated solutions for series production in the automotive and e-mobility sectors, and numerous other industries.

www.blackbird-robotics.de

Meet us at AKL'24 – booth 02

SCANLAB

With about 40,000 systems produced annually, SCANLAB GmbH is an independent OEM manufacturer of scan solutions to deflect and position laser beams in three dimensions. Its exceptionally fast and precise high-performance galvanometer scanners, scan heads and scan systems are used in industrial materials processing and the electronics, food and beverage industries, as well as biotech and medical technology.

www.scanlab.de

Meet us at AKL'24 – booth 43

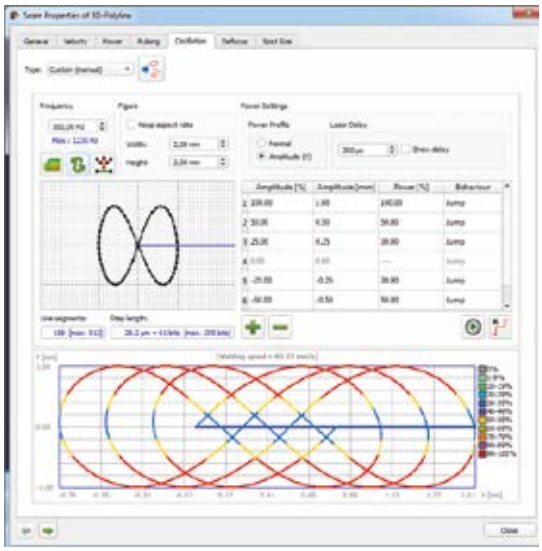


Fig. 2 The RSU software provides maximum flexibility with the individual setting of welding parameters for respective weld seams

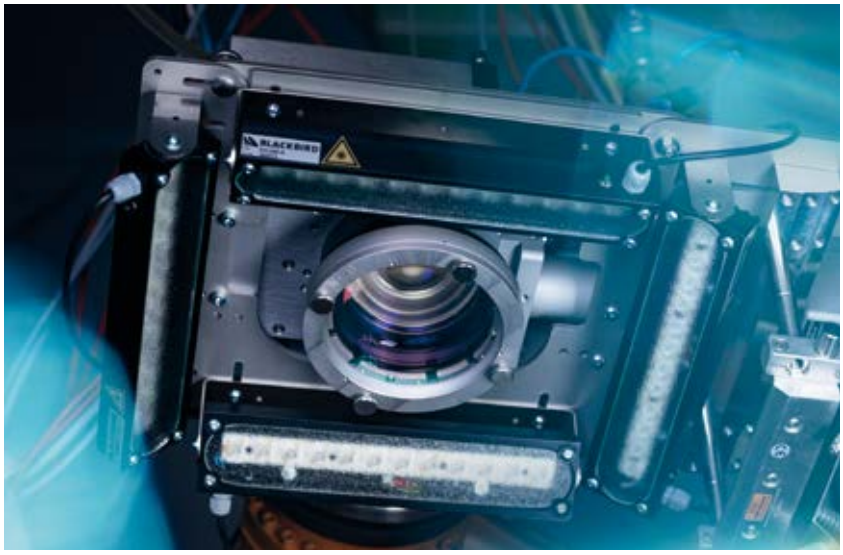


Fig. 3 The ScaVis camera system is able to detect the exact work piece position and orientation (Source: Blackbird)

system. The coaxial ScaVis camera system (see Fig. 3) enables the detection of component positions and orientations. It also compensates for drift, gain, and positional inaccuracies at the same time. In addition to that, a beam splitter for third-party sensor systems such as photodiode-based monitoring tools can be attached, which can help to ensure high welding quality.

Avoiding welding defects is crucial, especially when it comes to expensive and delicate materials used in bipolar plate production like thin stainless steel foils. Typical welding defects, which occur predominantly at high welding speeds, can be humping effects and undercuts.

A ring-shaped laser beam – in addition to a core beam – can be used to avoid these. This kind of power distribution is achieved with a ring mode laser or by using diffractive optical elements (DOEs). The advantage of DOEs is that they can be manufactured for any kind of power distribution and combined with single-mode and multimode laser sources alike. Furthermore, they can be retrofitted to an existing system, which allows the use of an existing laser without 'ring mode'.

The ring-shaped laser beam (Fig. 4) ensures defect-free welds at welding speeds of more than 50 m/min. For example, stainless steel sheets of 1.4301 can be welded at more than 70 m/min, compared to a welding speed of approximately 45 m/min without using ring-shaped laser profiles.

Defining the best welding strategy

Choosing the right welding strategy and building up process knowledge are essential when striving to master the challenge posed by the welding process. Overlapping seams need to be considered and equal power distributions and welding velocity need to be ensured for tight welds, which are crucial for the function of bipolar plates. Furthermore, accurate path planning is imperative to achieve highly accurate and thin welds. Skywriting is an intelligent path planning method that ensures perfect path matching at maximum velocities. It is also possible to combine it with power, focus and velocity modulation, which provides the user with the maximum flexibility when designing welding programs.

These technological pieces are necessary to complete the complex puzzle of handling the process itself. Due to the enormous quantities needed by the industry, the right setup is required to produce the highest output and be scalable at the same time. Accordingly, a static laser welding process is no longer sufficient.

More than a decade of on-the-fly (OTF) welding

Starting in 2008, Blackbird did early pioneering work to develop and implement OTF welding into production systems. Since that time, the company has established OTF as a standard industrial

Source: Blackbird

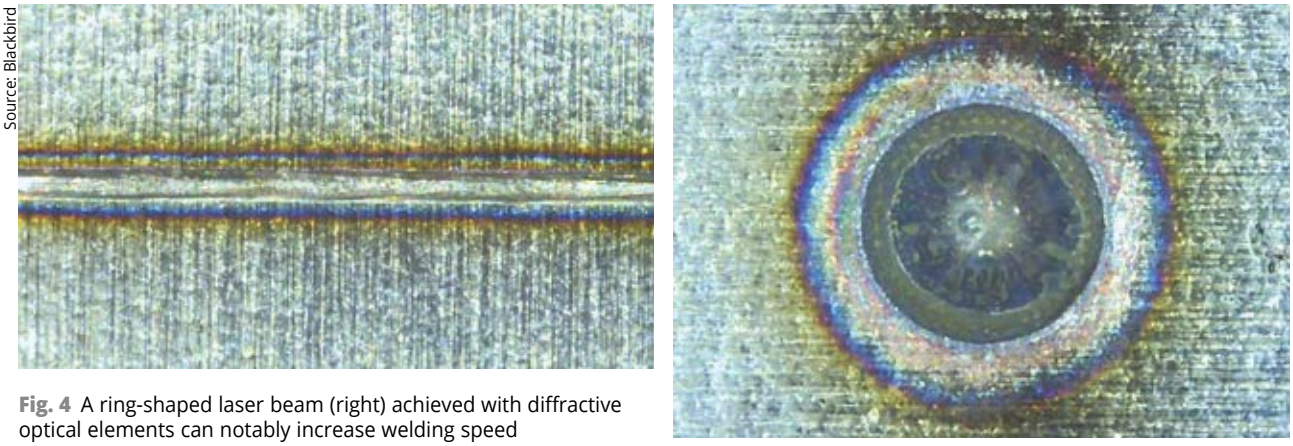


Fig. 4 A ring-shaped laser beam (right) achieved with diffractive optical elements can notably increase welding speed

process. Clearly, Blackbird is the market player with the longest experience and process knowledge and possesses manufacturing experience with multiple OEMs on a global scale.

Today, OTF is known as the most efficient laser welding process, welding in synchronization with the movement of the scanner or the part. In comparison with the static welding process, the laser-on time and the efficiency are increased drastically.

Adapting OTF to current process requirements

The design needs to be as reliable and sturdy as possible in order to maintain high positional accuracy during OTF processing. Handling with robots is not an option due to the lack of repeatability and accuracy. Therefore, handling with a linear axis implemented by Blackbird known as the OTF MotionSync Gantry was adapted to a continuous loop process design. The result was a new process type called OTF MotionSync Continuous. This control solution synchronizes the scanner movement with up to two linear axes or conveyor belts in real time. In an industrial setup (see Fig. 5), a hardware trigger (e.g. photoelectric sensors) marks the start of each welding run. After a predetermined delay, the system tracks the TCP (tool center point) position and only allows welding within a defined processing area if the expected position and the real position match. The next welding run starts once another part activates the trigger.

The ScaVis camera described above is not sufficient to guarantee and track optimal welding accuracy during movement since it was made for static processing only. Onboard processing is required to enable a 'vision-on-the-fly' system and ensure fast processing speeds. Predetermined shapes on workpieces can be detected with the help of a smart camera, and the resulting offset coordinates and distortions instantaneously calculated. These are subsequently transferred to the Open Interface Extension (OIE). This device can access the scanner program on the control card and implement offsets and distortions, giving the real part position during the running OTF process. In addition, the OIE can also adjust the focus positioning of the laser beam using height information provided by a clamping device or a sensor. The height between individual cells can deviate, especially in the welding of round cells, which can be compensated for by these means.

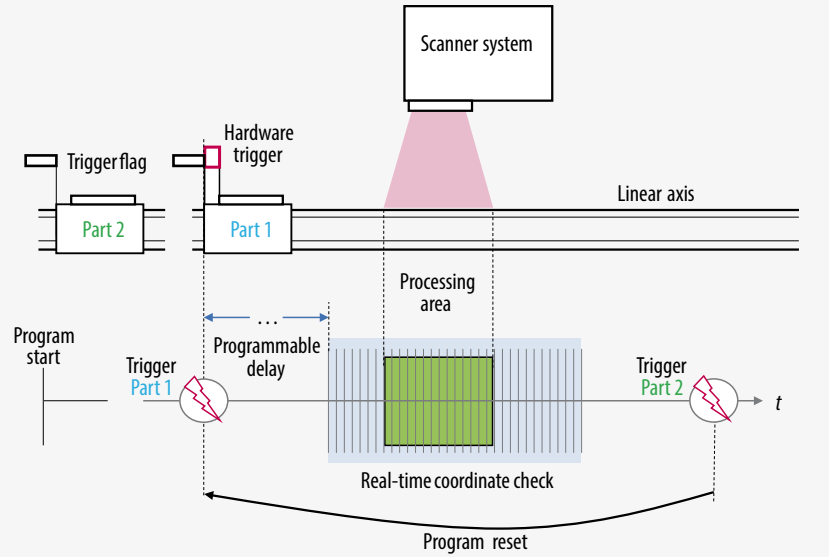


Fig. 5 Working principle of OTF MotionSync Continuous for sequential parts (Source: Blackbird)

Accurate and reliable welding can be achieved with the setup described above, perfectly suited to the requirements of e-mobility production in high quantities, and especially of bipolar plates and the contacts of round cells.

Future developments to be expected

As this level of processing, expertise alone might not be enough to fulfill the enormous requirement of the coming years. Blackbird is currently developing a concept to enable production with a large-scale scanner control system. Customers will be able to synchronize systems with one single interface using a frequency of up to 100 kHz from the first to the very last element. The controlling instance will be able to calculate the transformation values between several scanner systems. Implementing this concept will enable the highest processing output and scale up productivity even further.

DOI: 10.1002/phvs.202400007

Authors

Ralf Nürnberg joined Blackbird in 2019. Until 2021, he was part of the technical sales team, responsible for e-mobility projects. In 2022, he took over responsibility for product management to evolve the portfolio of specialized remote laser welding solutions to future-proof the company. Nürnberg studied mechanical engineering at the University of Erlangen-Nuremberg, specializing in laser and polymer technologies.

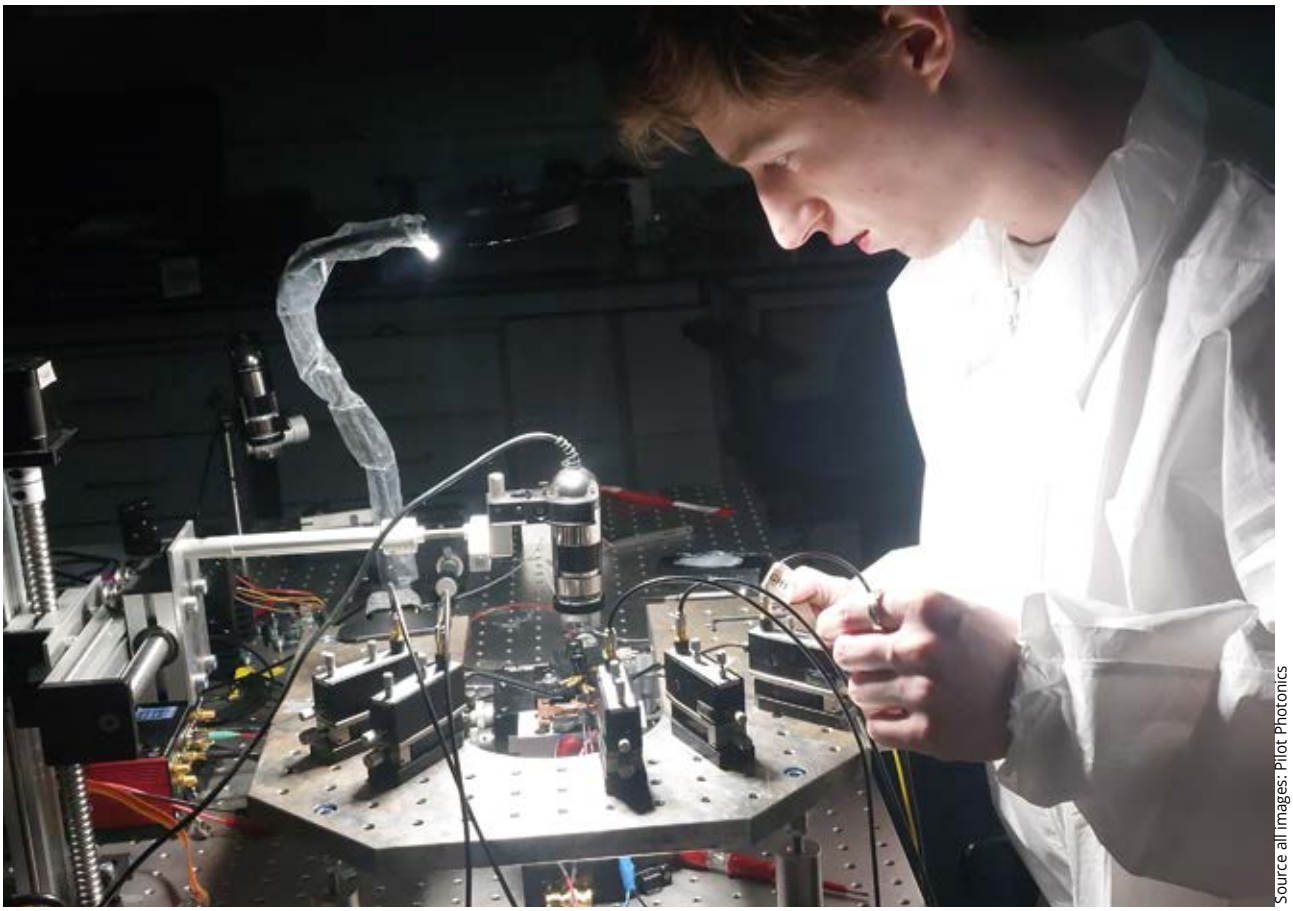
Holger Schlüter studied physics in Aachen and earned his PhD at the Fraunhofer Institute for Laser Technology there. Between 1996 and 2008, he held various positions in Germany and in the USA for Trumpf. He was CTO and COO at Technolas Perfect Vision in Germany and general manager of II-VI HighYAG. He has been head of business development for Scanlab for seven years.

Ralf Nürnberg, Blackbird Robotersysteme GmbH, Carl-Zeiss-Str. 5, 85748 Garching, Germany; phone: +49 89 307 484 700; e-mail: produktmanagement@blackbird-robotics.de, Web: www.blackbird-robotics.de ■ Dr. Holger Schlüter, Scanlab GmbH, Siemensstr. 2a, 82178 Puchheim, Germany; phone +49 89 800 7460, e-mail: info@scanlab.de, www.scanlab.de

Accelerating into production

Integrated tunable laser and comb laser assemblies boosted by the JePPIX InPulse pilot line

Desi Gutierrez, Shane Duggan, Frank Smyth, Caolán Murphy, and Gaurav Jain



Source all images: Pilot Photonics

The JePPIX InPulse pilot line projects, rooted in the objectives of accelerating InP PIC manufacturing and innovation, present Pilot Photonics with an excellent opportunity to enable a cost-effective transition from multiproject wafers (MPWs) to dedicated wafers with its two partners Smart Photonics and Fraunhofer HHI, two leading European PIC foundries. The chip quantities produced bolster design optimization and preproduction efforts for the company's flagship tunable and comb laser products.

Pilot Photonics is tackling major challenges in the optical communication industry with its integrated tunable laser assembly (iTLA) and integrated comb laser assembly (iCLA). Its iTLA stands out as the only commercially available solution that offers the combination of wide tuning, nanosecond switching and narrow linewidth, addressing important industry needs and resolving a long-standing industry hurdle. The iCLA emerges as a game-changer, replacing up to four traditional iTLAs with a single device. It offers a compact and efficient solution for optical communications and paves the way for the scalable expansion of coherent transceiver capacity.

These flagship products have recently transitioned into early pilot production, through various dedicated wafers, enabled by the JePPIX InPulse pilot line projects. These have provided invaluable support in Pilot's effort and commitment to bringing cutting-edge innovation to the market.

▲ Characterization and testing of bare dies in a probe station

iTLA: the elusive trifecta

Traditional semiconductor lasers capable of wide tunability usually have to compromise between a narrow linewidth and a rapid tuning speed. In optical fiber sensing systems, electronically tunable lasers have typically been used for their fast tunability over a wide tuning range, which is achieved using

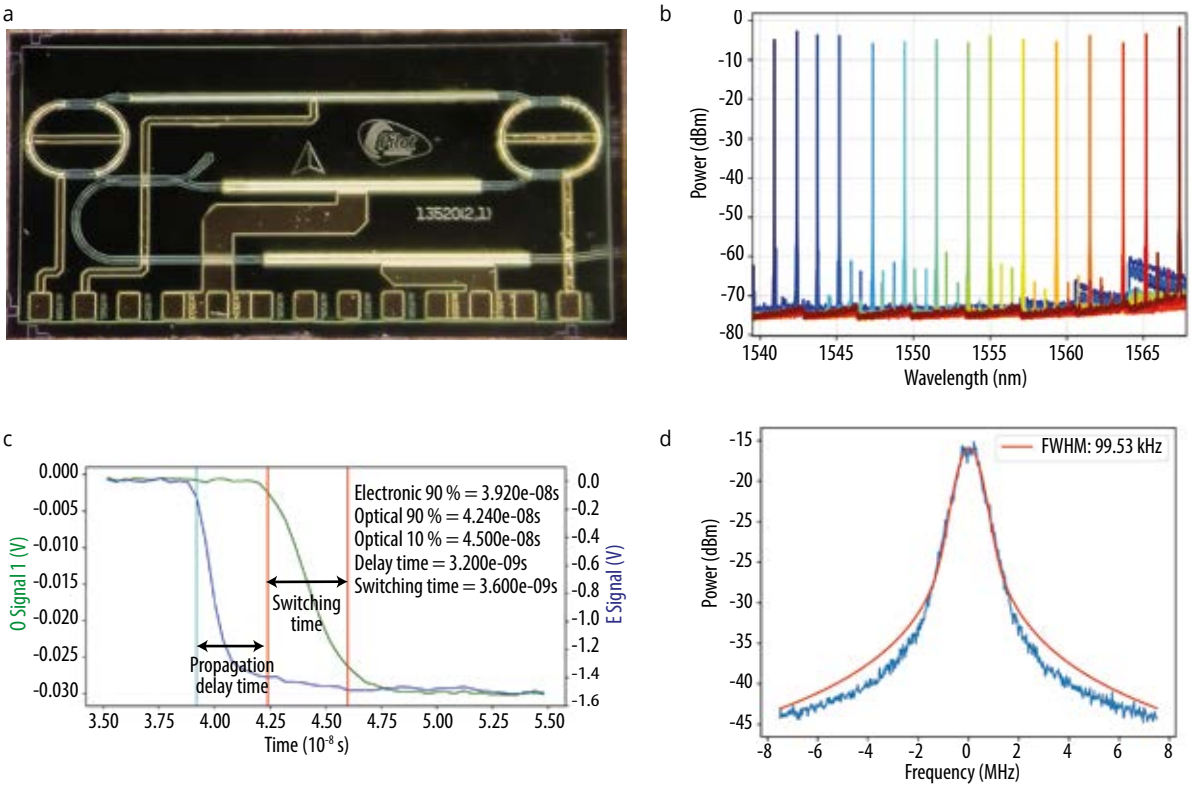


Fig. 1 (a) Pilot Photonics' iTLA PIC, formed of a looped cavity of gain and tunable rings, with SOA on the output. (b) Superimposed spectra of single-mode emission across the tuning range in the C-band. (c) Switching time measurement using a frequency discriminator, showing <4 ns switching speeds. The blue trace corresponds to the electrical switching signal, and the green trace corresponds to the optical signal. (d) Optical linewidth measurement using the delayed self-heterodyne technique, showing an optical linewidth of 100 kHz.

a current injection tuning mechanism. However, these lasers suffer from linewidth broadening that renders them unsuitable for demanding phase-sensitive applications such as coherent optical communication and frequency modulated continuous wave (FMCW) lidar or optical coherence tomography (OCT). Alternatives such as thermal tuning can improve linewidth, but dramatically reduce switching speeds, limiting their applicability in these applications.

Pilot's iTLA has received a great response from the market. There is a strong demand for new and existing pluggable transceiver applications, but the availability in the O-band and the ultrafast switching is also generating interest for newer applications, including coherent optical communication systems in the datacenter, and fast optical switching applications.

Pilot Photonics together with their fabrication partner Smart Photonics are

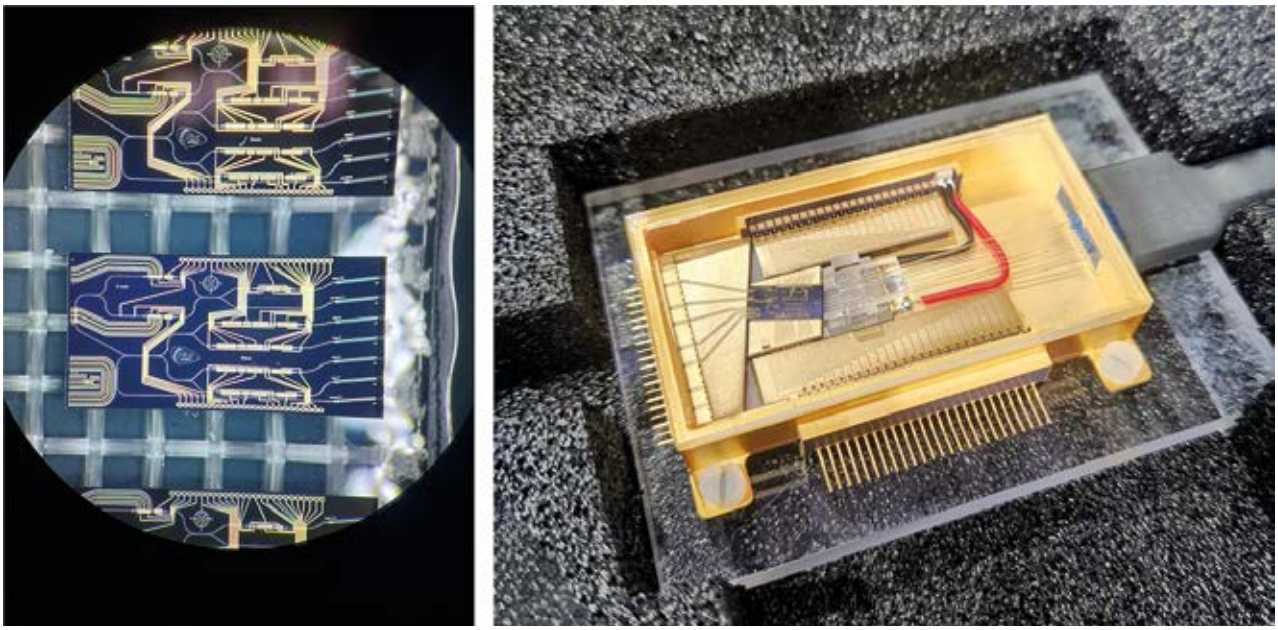


Fig. 2 Pilot Photonics' iCLA PIC (l) and butterfly gold box (r) deliver four coherent wavelengths on individual fibers for modulation

bringing this tunable laser to market, fabricated on a monolithic InP chip and utilizing an active-passive integration scheme. The design employs a looped cavity with an active section that provides the optical gain, and two ring-resonators that act as transmission filters for wavelength selectivity through Vernier tuning (Fig. 1a). The ring-resonators are electro-optically tuned by the application of a reverse-bias voltage. This approach achieves remarkably low dark currents in the milliampere range and enables nanosecond-level switching speeds (Fig. 1c) with minimal power consumption. The laser boasts an impressive tuning range exceeding 30 nm (Fig. 1b), available in both C and O-bands, with an output power of >14 dBm, a narrow linewidth of 150 kHz (Fig. 1d) and RIN <-150 dB/Hz, enabling high order coherent modulation formats and switching speed across the spectrum of less than 10 ns.

Currently available in a 14-pin butterfly package, or integrated into a laboratory instrument, the company is now developing a nano-iTLA module for high volume applications, as shown in Fig. 3.

iCLA: The quadruple iTLA replacement for coherent transceiver scaling

In a landscape where bandwidth demands continue to grow, coherent optical communication systems strive to keep up with relentless traffic growth. Traditionally, this challenge was met by boosting data rates on single-wavelength channels. However, that strategy is becoming increasingly challenging in terms of cost and technical feasibility.

The integrated comb laser assembly (iCLA) is a pioneering solution to scale coherent transceiver capacity by producing multiple parallel wavelengths from an optical frequency comb laser, enhancing spectral efficiency in core networks by enabling tighter channel spacing and facilitating the minimization of intrachannel guard bands. Moreover, the inherent phase relationship between wavelengths simplifies digital signal processing (DSP) and enhances transmission quality. By delivering multiple coherent wavelengths from a singular chip, the iCLA promises reductions in cost, size, power consumption, and complexity, potentially replacing up to four independent iTLAs and thereby streamlining the optical network infrastructure.

The iCLA, engineered as a monolithic InP chip (Fig. 2), incorporates Pilot Photonics' patented gain switching technique to exploit comb-enhanced capabilities. Gain switching directly modulates a laser to produce an optical frequency comb with laser emission at several different wavelengths simultaneously, with an adjustable frequency spacing. In the iCLA, the comb is integrated with an active optical demultiplexer for on-chip comb line filtering based on an injection locking technique. This picks and separates any four of the wavelengths into separate waveguides,

Company

Pilot Photonics

Located in Dublin, Ireland, Pilot Photonics develops innovative tunable and comb lasers encapsulated in photonic integrated circuits that are fabricated by European III-V foundries. Evolving their tech, they now offer C-band and O-band fast tunable lasers, high-frequency modulated lasers, and integrated laser assemblies in miniaturized monolithic formats, butterfly packages, or as part of the LYRA range of software-supported benchtop laser modules.

www.pilotphotonics.com

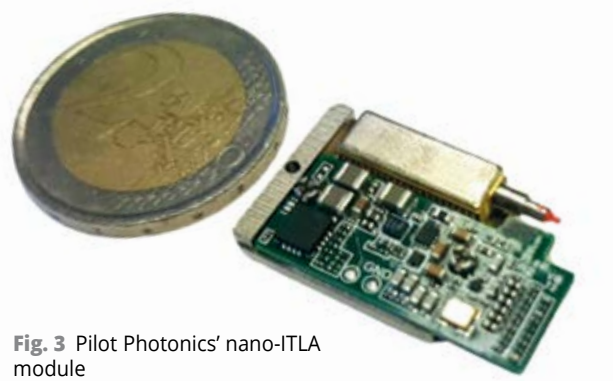


Fig. 3 Pilot Photonics' nano-ITLA module

maintaining excellent phase coherence and optimal power to feed optical engines for modulation. This approach provides noise-free amplification of the comb lines, delivering four coherent, equally or unequally spaced, phase-matched outputs that boast power levels comparable to individual iTLAs, while also achieving superior spectral efficiency and control. Pilot Photonics' iCLA is currently under development and will be sampling in 2024.

The evolutionary leap from MPWs to pilot production via JePPIX

The photonics landscape in Europe is maturing well, powered by strategic initiatives like the JePPIX pilot line InPulse project. The Joint European Platform for Photonic Integration of Components and Circuits, or JePPIX for short, serves as a central hub for the PIC community in Europe, bringing together a multitude of stakeholders that include designers, foundries and manufacturers, and end-users, to accelerate the development, production, and adoption of PIC technology.

For Pilot Photonics, the support of JePPIX has been central to its journey as it enabled access to the Smart Photonics and Fraunhofer Heinrich Hertz Institute (HHI) PIC foundries. They provided MPWs, which are a cost-effective solution that allows multiple users to share the same wafer, thereby reducing the manufacturing cost for each participant. For Pilot, MPWs served as a platform to test and validate new designs, but also enabled early prototypes that provided swift insights into market reception. This direct feedback loop allowed for continuous iterations and refinements to prototypes without the significant financial commitments typically tied to dedicated wafer runs.

While MPWs facilitated quick design and test cycles as well as cost benefits, they presented challenges in scalability and bespoke customization beyond initial market validation. The JePPIX InPulse project has been instrumental in facilitating the transition toward dedicated wafers and early volume production for Pilot Photonics. This next phase has given the company the ability to refine and tailor their products, aligning them closely with the broader market's demands, and enabling scale-up. Moreover, greater visibility and collaboration around the fabrication process has paved the way for more predictable yields and accelerated time-to-market.

Conclusion: Pilot Photonics' path forward

Bringing advanced PIC based products to market is challenging for small companies. Thanks to the JePPIX InPulse project, Pilot Photonics is transitioning from development to pilot production with its flagship products, and is poised to meet the needs of its customers for both single wavelength and multiwavelength coherent transceivers.

*

This work was supported by the Irish Government's Disruptive Technology Innovation Fund (DT20180268), the European Commission's SME instrument phase 2 under Grant Agreement 881158, and the JePPIX Inpulse pilot line. The authors would also like to acknowledge Smart Photonics and Fraunhofer HHI for their support.

DOI: 10.1002/phvs.202400008

Authors

Desi Gutierrez is director of photonics at Pilot Photonics. She joined the company in 2012 and completed her industry-based PhD with Dublin City University, Ireland, in 2017, focused on the development of unique optical transmitters for high performance optical networks. She leads the PIC and optoelectronics design team, responsible for architecting and designing photonic integrated circuits and driving systems.

Frank Smyth is co-founder and CTO of Pilot Photonics. His previous position was as the executive director of the Connect Center for Future Networks. He graduated with a PhD from Dublin City University in 2009, and held a scholarship position at Bell Labs, Crawford Hill, New Jersey, before founding Pilot Photonics in 2011.

Shane Duggan is principal PIC design engineer at Pilot Photonics. He obtained his PhD in Integrated Photonics research at Tyndall National Institute in Cork, Ireland. Shane is particularly experienced in photonic integrated circuits, designing different laser devices and bringing system architectures to the chip level. His present work spans simulation, mask layout and characterization.

Caolán Murphy is a senior photonics engineer at Pilot Photonics. He completed his PhD at Trinity College Dublin, Ireland, in 2022 on the topic of tunable laser design and characterization. His current work at Pilot Photonics includes the chip-level validation of photonic integrated circuits, as well as characterizing and testing prototype iTLA units.

Further author:

Gaurav Jain, Pilot Photonics

Dr. Desi Gutierrez, Dr. Shane Duggan, Dr. Caolán Murphy, Dr. Frank Smyth, Dr. Gaurav Jain, Pilot Photonics, Invent Building, Dublin City University, Glasnevin, Dublin D09PH2K, Ireland, +353 700 7593, e-mails: desi.gutierrez@pilotphotonics.com, shane.duggan@pilotphotonics.com, caolan.murphy@pilotphotonics.com, frank.smyth@pilotphotonics.com, gaurav.jain@pilotphotonics.com, Web: www.pilotphotonics.com, pilot-photonics, pilotphotonics

Program of the Technological Conference AKL'24

Wednesday, April 17, 2024

FORUM – Functional Surfaces by Laser Processing

from 8.00 Check-in and coffee reception

Tribology, wear and corrosion protection
Chairman: *Dr. Thomas Schopphoven*, Fraunhofer ILT, Aachen (D)

10:00 **Functional surfaces by laser processing – a process overview**
Dr. Christian Vedder, Fraunhofer ILT, Aachen (D)

10:30 **Modern solutions for modern manufacturing – Using laser material deposition to manufacture, repair and enhance complex parts**
Dr. Doug Hamre, Apollo-Clad Laser Cladding, Leduc (CAN)

11:00 **Applications and use cases for functional surfaces by Extreme High Speed Laser Material Deposition (EHLA)**
Josh Barras, TWI Technology Centre (Yorkshire) Ltd, Catcliffe (UK)

11:30 **Laser processes for improving tribological properties**
Dr. Thomas Kiedrowski, Robert Bosch GmbH, Renningen (D)

12:00 Lunch – Visit of the accompanying exhibition

Electronic layers
Chairman: *Dr. Christian Vedder,* Fraunhofer ILT, Aachen (D)

14:00 **Laser systems for energy-efficient drying of battery electrodes**
Dr. Simon Britten, Laserline GmbH, Mühlheim-Kärlich (D)

14:30 *to be determined*

15:00 **LIFT for electronic layers**
Dr. Ralph Domnick, Ara-Coatings GmbH & Co. KG, Nordhorn (D)

15:30 Coffee break – Visit of the accompanying exhibition

Optical surfaces

16:30 **An overview of laser-based optics manufacturing**
Dr. Edgar Willenborg, Fraunhofer ILT, Aachen (D)

17:00 **New developments in Selective Laser Etching (SLE) for photonic applications**
Kaushik Budheliya, LightFab GmbH, Aachen (D)

Evening Event (19:00 – 23:00 Uhr)

FORUM – Digitalization and AI in Photonic Production

from 8:00 Check-in and coffee reception
Chairman: *Prof. Carlo Holly*, Fraunhofer ILT, Aachen (D)

10:00 **Cooperation as a success factor – Integrating the digital ecosystems ofusers and laser manufacturers**
Michael Lebrecht, Mercedes-Benz AG, Sindelfingen (D)

10:30 **OEE increase through digital networked manufacturing systems in laser material processing**
Marco Holzer, TRUMPF Laser AG, Schramberg (D)

11:00 **Hey Siri! What is the quality of this laser weld?**
Dr. Markus Kogel-Hollacher, Precitec Optronik GmbH, Neu-Isenburg (D)

11:30 **Quo vadis Additive Manufacturing? – Increase vertical market integration through digital production**
Dr. Simon Höges, GKN Additive, Bonn (D)

12:00 Lunch – Visit of the accompanying exhibition

Chairman: *Peter Abels, Fraunhofer ILT, Aachen (D)*

14:00 **Automated non-destructive testing in battery production using laser-based excitation and detection of ultrasound**
Dr. Wolfgang Rohringer, XARION Laser Acoustics GmbH, Wien (AT)

14:30 **Implementation of an AI-based process monitoring system to save on downstream quality assurance**
Dr. Michael Ungers, Scansonic MI GmbH, Berlin (D)

15:00 **AI for laser welding: Where are the limitations?**
Thibault Bautze-Scherff, Blackbird Robotorsysteme GmbH, Garching bei München (D)

15:30 Coffee break – Visit of the accompanying exhibition

16:30 **Safe brake disk production with digital sensor technology**
Stefan Mann, Fraunhofer ILT, Aachen (D)

17:00 **Sensors and data fusion for optimized process monitoring in any laser application**
Christoph Franz, 4D Photonics GmbH, Isernhagen (D)

FORUM – Quantum Technology and Photonics

from 8:00 Check-in and coffee reception
Chairmen: *Dr. Bernd Jungbluth,* Fraunhofer ILT, Aachen (D) and *Florian Elsen,* RWTH Aachen University – Chair for Laser Technology LLT, Aachen (D)

10:00 **DLR Quantum Computing Initiative – Shaping the Quantum Computing Ecosystem in Germany**
Dr. Karla Loida, DLR Quantencomputing Initiative, Deutsches Zentrum für Luft und Raumfahrt e.V. (DLR), Köln (D)

10:30 **MAGIC Quantum Computers**
Dr. Michael Johanning, eleQtron GmbH, Siegen (D)
11:00 **QRydDemo – A quantum computer demonstrator based on neutral atoms**
Dr. Florian Meinert, Universität Stuttgart, Stuttgart (D)
11:30 **Photonic Quantum Computing: superiority by excellent scaling capabilities**
Dr. Stefan Hengesbach, QuiX Quantum B.V., Enschede (NL)
12:00 Lunch – Visit of the accompanying exhibition
14:00 **Quantum network demonstrations inside the lab and on metropolitan scale**
Prof. Ronald Hanson, QuTech, Delft (NL)
14:30 **Practical distribution of useful entanglement across New York City**
Dr. Mehdi Namazi, Qunnect, Inc., New York (USA)
15:00 **Application scenarios of quantum technology at Deutsche Telekom**
Dr. Marc Geitz, Deutsche Telekom AG, T-Labs, Berlin (D)
15:30 Coffee break – Visit of the accompanying exhibition
16:30 **Low-noise quantum frequency converters for the quantum internet**
Fabian Geus, Fraunhofer ILT, Aachen (D)
17:00 **Enabling quantum technologies through scalable single photon detector solutions**
Dr. Alexander Eich, Pixel Photonics, Münster (D)

Evening Event (19:00 – 23:00 Uhr)

Technology Business Day

from 8:00 Check-in and coffee reception

Laser markets
Chairman: *Prof. Arnold Gillner,* Fraunhofer ILT, Aachen (D)

12:30 **Global and European market for laser sources**
Dr. Thierry Robin, TEMATYS, Paris (F) article → page 40
13:00 **Heroes and rising stars in the German and global industrial laser market**
Dr. Stefan Ruppik, Coherent, Hamburg (D)
13:30 **Status quo and prospects for the U.S. laser market**
Dr. Henrikki Pantsar, TRUMPF Inc., Farmington (USA)
14:00 **Status quo and prospects of the Chinese laser market**
Dr. Bo Gu, BOS Photonics, Boston (USA)
14:30 Coffee break – Visit of the accompanying exhibition

Laser applications in energy technology
15:30 **Laser technology: Paving the way for fuel flexibility in gas turbines**
Dr. Sebastian Piegert, Siemens Energy, Berlin (D)
16:00 **Laser technology in the production of metallic bipolar plates – from application to series production**
Patrick Müller, Gräbener Maschinentechnik GmbH & Co. KG, Netphen-Werthenbach (D)
16:30 **Advances in dual-beam laser technology and real-time laser process monitoring for battery production**
Stefano Cattaneo, IPG Photonics S.r.l., Cerro Maggiore (I) article → page 52
17:00 **Terawatt with light: Laser processes in photovoltaics – Manufacturing and potential of tomorrow**
Andreas Brand, Fraunhofer-Institut für Solare Energiesysteme ISE, Freiburg (D)

Evening Event
19:00 – 23:00 Dinner with presentation of the "Innovation Award Laser Technology" in the Coronation Hall of Aachen's Town Hall

Thursday, April 18, 2024

Gerd Herziger Session

from 7:30 Check-in and coffee reception

Impact of digitalization and AI on value creation and business models in laser technology
Chairman: *Prof. Constantin Haefner,* Fraunhofer ILT, Aachen (D)

8:30 **Opening speech**
Prof. Constantin Haefner, Fraunhofer ILT, Aachen (D)
9:00 **Digitalization and AI – How are digitalization and AI changing business models and value creation in laser technology?**
- *Dr. Hagen Zimer,* Member of the Management Board and CEO Laser Technology, TRUMPF SE + Co. KG, Ditzingen (D)
- *Dr. Christopher Dorman,* Executive Vice President, Lasers Business, Coherent, Glasgow (UK)
- *Dr. Christoph Rüttimann,* CTO Bystronic Group, Niederönz (CH)

09:30 **Panel discussion with the speakers**
10:40 Coffee Break – Visit of the accompanying exhibition

Digitization in Photonic Production,
Chairman: *Prof. Constantin Haefner,* Fraunhofer ILT, Aachen (D)

11:10 **Data analytics/AI – Rocket science or just standard? Examples and outlook**
Werner Reichelt, Head of Sales Digital Business, Festo SE & Co. KG, Esslingen (D)
11:35 **Status quo and perspectives of AI usage in laser beam joining of e mobility components at Audi AG**
Dr. Jan-Philipp Weberpals, Subject Specialist Laser Beam Processes for Car Body Construction and Electromobility, Audi AG, Neckarsulm (D)
12:00 **Application of AI for smart design of optical systems used in laser material processing**
Prof. Carlo Holly, RWTH Aachen University – Chair TOS, Aachen (D)
12:30 Lunch – Visit of the accompanying exhibition

Session 1: Additive Manufacturing

Laser Powder Bed Fusion LPBF
Chairman: *Tim Lantzsch,* Fraunhofer ILT, Aachen (D)

14:00 **Additive Manufacturing for sustainable tooling applications**
Dr. Stefan Leuders, voestalpine Additive Manufacturing Center GmbH, Düsseldorf (D)
14:30 **High power laser technology for Area Printing® – A scalable powder bed metal Additive Manufacturing method**
Dr. Andrew Bayramian, Seurat Technologies Inc., Wilmington (USA)
15:00 **Status Quo and perspectives of AM for series production in the aerospace industry**
Frank Rethmann, Airbus Helicopters Deutschland GmbH, Donauwörth (D)
15:30 Coffee Break – Visit of the accompanying exhibition
16:00 **Shuttle transfer to Fraunhofer ILT**

Laser Technology Live
16:30 **Laser Technology Live at Fraunhofer ILT**
19:30 **Shuttle transfer to Eurogress Conference Center**

Evening Event
20:00 – 23:00 Networking with Snacks at Eurogress Conference Center – Exhibitor area

Session 2: Optical Systems

Optical systems and beam shaping
Chairman: *Dr. Martin Traub,* Fraunhofer ILT, Aachen (D)

14:00 **The shape of things to come: All-fiber kW beam shaping for high productivity industrial processing**
Dahv Kliner, nLIGHT Inc., Vancouver (USA)
article → page 59

14:30 **Fast and adaptive beam steering with cascaded scan systems**
Dr. Holger Schlüter, Scanlab GmbH, München (D)

15:00 **Complex freeform surfaces: Design and manufacture of low loss beam shapers for high power laser applications**
Dr. Stephen Kidd, PowerPhotonic Ltd., Dalgety Bay (UK)

15:30 Coffee Break – Visit of the accompanying exhibition

16:00 **Shuttle transfer to Fraunhofer ILT**

Laser Technology Live
16:30 **Laser Technology Live at Fraunhofer ILT**
19:30 **Shuttle transfer to Eurogress Conference Center**

Evening Event
20:00 – 23:00 Networking with Snacks at Eurogress Conference Center – Exhibitor area

Session 3: Laser Beam Sources

Solid State and Fiber Lasers
Chairman: *Hans-Dieter Hoffmann,* Fraunhofer ILT, Aachen (D)

14:00 **Achieving the fiber laser stability at atom trap wavelengths**
Thorge Holm, NKT Photonics Technology GmbH, Köln (D)

14:30 **High-power laser source with coherent beam combiningand dynamic beam shaping for welding applications**
Dr. Robert Bernhard, Civan Lasers Europe GmbH, Hannover (D)

15:00 **2 µm fiber lasers for innovative applications**
Dr. Peter Fuhrberg, Futonics Laser GmbH, Katlenburg-Lindau (D)

15:30 Coffee Break – Visit of the accompanying exhibition

16:00 **Shuttle transfer to Fraunhofer ILT**

Laser Technology Live
16:30 **Laser Technology Live at Fraunhofer ILT**
19:30 **Shuttle transfer to Eurogress Conference Center**

Evening Event
20:00 – 23:00 Networking with Snacks at Eurogress Conference Center – Exhibitor area

Session 4: Medical Technology

Laser systems for medical applications
Chairman: *Dr. Achim Lenenbach,* Fraunhofer ILT, Aachen (D)

14:00 **Minimally invasive laser surgery in cancer therapy**
Dr. Karsten Sassenscheid, KLS Martin SE & Co. KG, Freiburg im Breisgau (D)

14:30 **Femtosecond laser surgery in ophthalmology**
Dr. Gregor Stobrawa, Carl Zeiss Meditec AG, Jena (D)

15:00 **Stereotactic laser craniotomy for awake neurosurgery**
PD Dr. Peter Reinacher, Universitätsklinikum Freiburg, Freiburg im Breisgau (D)

15:30 Coffee Break – Visit of the accompanying exhibition

16:00 **Shuttle transfer to Fraunhofer ILT**

Laser Technology Live
16:30 **Laser Technology Live at Fraunhofer ILT**
19:30 **Shuttle transfer to Eurogress Conference Center**

Evening Event
20:00 – 23:00 Networking with Snacks at Eurogress Conference Center – Exhibitor area

Friday, April 19, 2024

Session 1: Laser Beam Sources

Ultrashort-pulse lasers
Chairman: *Dr. Peter Rußbüld*t, Fraunhofer ILT, Aachen (D)

8:30 **Ultrashort-pulse lasers for processing with atypical wavelengths**
Dr. Martynas Barkauskas, LightConversion, Vilnius (LT)

9:00 **Industrial 1 kW/10 mJ UKP-Laser**
Dr. Dominik Bauer, TRUMPF Laser AG, Schramberg (D)

9:30 **Making ultrashort pulses shorter with multipass cells**
Prof. Oleg Pronin, n2-Photonics GmbH, Hamburg (D)

10:00 Coffee break – Visit of the accompanying exhibition

Lasers with tailored wavelength
Chairman: *Dr. Bernd Jungbluth,* Fraunhofer ILT, Aachen (D)

11:00 **High energy UV lasers for display and green energy applications**
Dr. Robin Rammelsberg, Coherent LaserSystems GmbH & Co. KG, Göttingen (D) article → page 44

11:30 **Frequency-converted lasers for applications in the manufacturing industry**
Dr. Klaus Albers, TRUMPF Laser AG, Schramberg (D)

12:00 **New pulsed 3 µm laser beam source – potential for revolution in plastic surface processing?**
Edwin Büchter, Clean-Lasersysteme GmbH, Herzogenrath (D)

12:30 Lunch – Visit of the accompanying exhibition

Diode lasers
Chairwoman: *Dr. Sarah Klein,* Fraunhofer ILT, Aachen (D)

14:30 **Performance and power scaling of blue diode lasers**
Dr. Matthias Ackermann, Laserline GmbH, Mülheim-Kärlich (D)

15:00 **Advanced VCSELs and new applications in heating and drying**
Dr. Holger Mönch, TRUMPF Photonic Components GmbH, Aachen (D)

15:30 **Advances in laser diode pumps – pioneering high-energy DPSSLs for the petawatt regime**
Dr. Prabhu Thiagarajan, Leonardo Electronics US Inc., Tucson (USA)

16:00 **Final lecture: Photonics in focus – Laser inertial confinement fusion as an opportunity for industry**
Prof. Constantin Haefner, Fraunhofer ILT, Aachen (D)

16:30 End of the lectures

Session 2: Cutting and Joining

Cutting
Chairman: *Dr. Alexander Olowinsky,* Fraunhofer ILT, Aachen (D)

8:30 **High-speed Laser Blanking – higher productivity with a new concept**
Hasan Sarac, Automatic-Systeme Dreher GmbH, Sulz am Neckar (D)

9:00 **Remote operation for laser cutting – The path to autonomy**
Benedikt Braig, TRUMPF Werkzeugmaschinen SE + Co. KG, Ditzingen (D)

9:30 **Laser cutting for e-mobility**
Dr. Frank Schneider, Fraunhofer ILT, Aachen (D)
10:00 Coffee break – Visit of the accompanying exhibition

Welding
Chairman: *Dr. André Häusler,* Fraunhofer ILT, Aachen (D)

11:00 **Next generation tactile laser welding and brazing – Innovation of a proven laser processing head technology**
Dr. Björn Wedel, PT Photonic Tools GmbH, Berlin (D)
11:30 **Process improvement through innovative beam shaping in laser welding**
Gwenn Pallier, CAILABS, Rennes (F)
12:00 **Laser meets synchrotron – Visualizing and understanding process dynamics in laser beam welding**
Christoph Spurk, RWTH Aachen University – Chair for Laser Technology LLT, Aachen (D)
12:30 Lunch – Visit of the accompanying exhibition

Joining of plastics and transparent materials
Chairman: *Maximilian Brosda,* Fraunhofer ILT, Aachen (D)

14:30 **Welding of glass by USP lasers for electronics, semiconductors and medical applications**
Dr. Jens Gottmann, LightFab GmbH, Aachen (D)
15:00 **Machine concept for laser welding of plastics in flexible production scenarios**
Manuel Sieben, GF PolyMerge GmbH, Geretsried (D)
15:30 **Laser-based bonding of conducting metal path on thermoplastic textiles for smart textiles applications**
Friederike Brackmann, Fraunhofer ILT, Aachen (D)
article → page 56
16:00 **Final lecture: Photonics in focus – Laser inertial confinement fusion as an opportunity for industry**
*Prof. Constantin Haefner, F*raunhofer ILT, Aachen (D)
16:30 End of the lectures

Session 3: Surface Technology

Laser Material Deposition
Chairman: *Dr. Thomas Schopphoven*, Fraunhofer ILT, Aachen (D)

8:30 **Light as eyes and as tools – High productivity and high resolution Laser Material Deposition**
Hiroyuki Nagasaka, Nikon Corp., Kumagaya Saitama (JPN)
9:00 **5-axis LMD at high speed – Challenges and applications**
Dr. Johannes Finger, IIC-AM GmbH, Makino Asia Pte Ltd, Aachen (D)
9:30 **Laser scanning in combination with hybrid repair process on molding tools**
Thomas Hauke, DMG MORI Ultrasonic Lasertec GmbH, Stibshausen (D)
10:00 Coffee break – Visit of the accompanying exhibition

Microstructuring
Chairman: *Dr. Dennis Haasler,* Fraunhofer ILT, Aachen (D)

11:00 **High speed wafer grooving with UV-USP lasers (wafer scribing)**
Dr. Kees Biesheuvel, ASMPT Laser Separation International (ALSI) B.V., Beuningen, (NL)
article → page 48
11:30 **Unlocking nature's self-cleaning on PV panels through large-scale laser functionalization**
Dr. Tim Kunze, Fusion Bionic GmbH, Dresden (D)
12:00 **Laser material processing in the electronic consumables sector**
Dr. Stefan Janssen, LG Electronics, Inc., Pyeongtaek (KOR)
12:30 Lunch – Visit of the accompanying exhibition

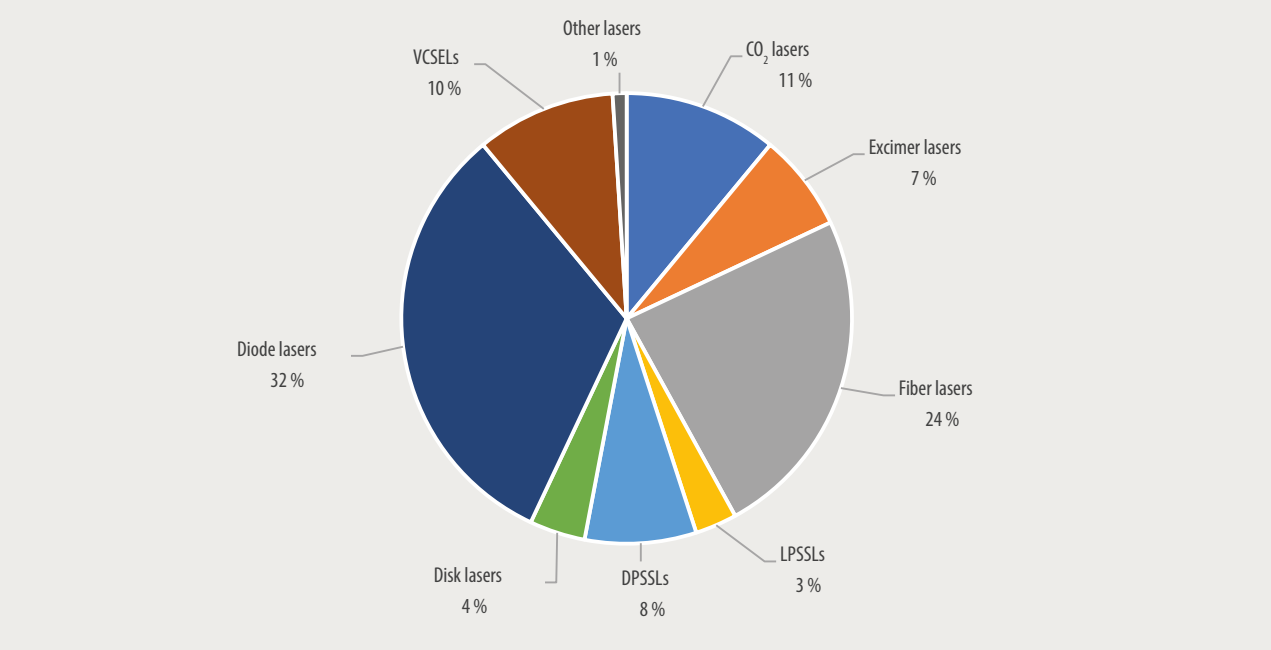
Polishing and thin film processing
Chairman: *Dr. Edgar Willenborg,* Fraunhofer ILT, Aachen (D)

14:30 **Laserprocesses in thin film technology: Applications and opportunities**
Samuel Fink, Fraunhofer ILT, Aachen (D)
15:00 **Using AI to automate and accelerate process parameter development for laser polishing of metals**
Sven Linden, Fraunhofer ILT, Aachen (D)
15:30 **Pulsed laser deposition in mass production for high-TC superconductor coatings**
Dr. Ralph Delmdahl, Coherent LaserSystems GmbH & Co. KG, Göttingen (D)
16:00 **Final lecture: Photonics in focus – Laser inertial confinement fusion as an opportunity for industry**
Prof. Constantin Haefner, Fraunhofer ILT, Aachen (D)
16:30 End of the lectures

Laser sources: global market and trends

After some challenging years, the laser source market experienced significant growth in 2021 and 2022

Thierry Robin, Jacques Cochard, and Kimon Moratis



The laser industry experienced significant growth in 2021 and 2022, reaching a value of 19.3 billion US dollars in 2022 after two challenging years in 2019 and 2020. Despite the global effects of the war in Ukraine, the ongoing trade war between the United States and China, and the aftermath of the Covid-19 pandemic, this industry showed remarkable resilience. The demand for laser sources in both industry and consumer products has significantly accelerated their sales. If this trend is not affected by any destabilizing factors, the global laser sources market is expected to reach a total value of 26.8 billion US dollars by 2027, with a growth rate of 6.8 %.

Tematys conducted a study in 2023 for Optica and Spectaris on the global market of laser sources, categorized by technology and application. The full report is available for the members of the two associations and this article summarizes the results obtained in the study.

Theodore Maiman demonstrated the first generation of coherent and monochromatic light in 1960. Since then, laser sources have been instrumental in advancing progress in various technological fields such as industry, communications, medicine, defense, R&D, sensing, IT, and consumer goods. Table 1 provides a breakdown of the most common laser technologies and their respective applications.

After experiencing a slight growth between 2018 and 2020 that was influenced by various factors, including the Covid-19 pandemic, the global laser sources market rebounded quickly in 2021 with a growth rate of over 12 % compared to the previous year. The value of the global laser market as of 2022 was estimated to be nearly 19.3 billion US dollars, with industrial applications accounting for almost 50 % of the total market, as shown in Fig. 1.

▲ **Fig. 1** Market share of the most common laser technologies for 2022. DPSSL: diode-pumped solid-state lasers; LPSSL: lamp-pumped solid-state lasers (Source: Tematys / Optica / Spectaris, 2023)

Lasers for industry

Lasers are widely used in industry for materials processing, marking, engraving, and photolithography. High-power materials processing (>1 kW) is mainly used to cut or weld thick metal sheets or tubes. Lasers offer maintenance, efficiency, and operational cost advantages over mechanical cutting methods such as blades, punch presses, and waterjet

cutters. The dominant source for these processes in the past were CO_2 lasers, but in recent years they have been largely replaced by fiber lasers, disk lasers, and direct diode laser systems. SSL-based systems (solid-state lasers) are more environmentally friendly than CO_2 lasers as they can save up to 70 % of the power consumption.

Micromaterial processing involves cutting, welding, drilling, micro-annealing, and additive manufacturing techniques accomplished with lasers that have an average output power of less than 1 kW. This process is commonly used for materials such as plastics, wood, ceramics, and others used in the electronics industry. Micromaterial processing typically uses SSLs such as fiber or disk lasers, or CO_2 lasers. Excimer lasers are used in the processing of semiconductors, particularly for the amorphous silicon annealing required in display fabrication.

CO_2 lasers were traditionally used to mark materials, but they have been partly replaced by fiber and diode lasers. Laser marking is an effective and environmentally friendly alternative to traditional methods.

Photolithography is a crucial step in the semiconductor device manufacturing process. Lithography systems using excimer lasers were introduced in the early 1990s to reduce feature size. These systems used ArF and KrF sources emitting at 193 nm and 248 nm respectively. To address the challenge of ≤5 nm processes, extreme UV (EUV) lithography systems were developed that use 13.5 nm light emitted by a droplet of Sn plasma. This also provides another opportunity for CO_2 lasers to regain their market share as they are the sources that generate the plasma.

Applications	CO_2	Excimer	Fiber	LPSSLs	DPSSLs	Disk	VCSELs	Diode	Other
kW material processing	x		x			x		x	x
sub-kW material processing	x	x	x	x	x	x	x	x	
Marking and engraving	x		x		x			x	
Telecommunications			x				x	x	
Sensing and instrumentation	x		x	x	x		x	x	x
Laser pumping								x	
Medical	x	x	x	x	x		x	x	
Lithography	x	x						x	
Displays								x	
Optical storage								x	
Printing								x	
Lighting								x	
Military and defense			x		x		x	x	x
R&D			x		x			x	

Table 1 The industry of laser sources broken down by technology and its respective application segments

Lasers for communications

As depicted in Fig. 2, lasers for communications represent the largest market segment next to industrial applications with 21 % of the market. They are essential for telecommunications and data distribution due to the increasing need for faster information processing and transmission. The optical transceiver is a crucial component for implementing fiber-to-the-home and metropolitan area network scale communications. In its basic form, it integrates a laser source to transmit information and a detector to convert light into electrical signals. Optical modules for telecommunications typically use DFBs (emitting at 1,260 nm – 1,625 nm) due to their precise control over emission wavelength, linewidth, and output power.

These modules are also used to provide node-to-node communication protocols in the computer stacks commonly found in data centers. For high bandwidth data transmission over short distances (up to several hundred meters), datacom transceivers primarily use VCSEL arrays emitting near 850 nm and 910 nm.

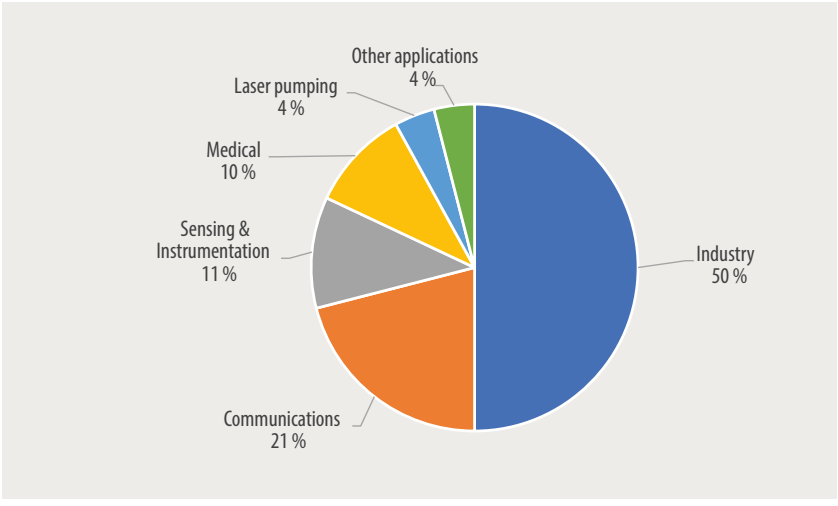


Fig. 2 Market share of the application segments of laser sources for 2022 (Source: Tematys / Optica / Spectaris, 2023)

Company

Tematys

Since 2010, Tematys has offered a comprehensive range of services to companies and research institutes in the fields of optics, photonics, and sensors. Our team of highly qualified consultants is committed to delivering a comprehensive understanding of trends, markets, and innovations in photonics technologies and their applications. Tematys has more than two hundred customers in twenty countries (Europe, North America, Asia). Our clients are companies of any size, from international groups to SMEs and start-ups. We have also developed a special expertise in technology transfer and R&D valorization dedicated to research organizations and laboratories.

www.tematys.com

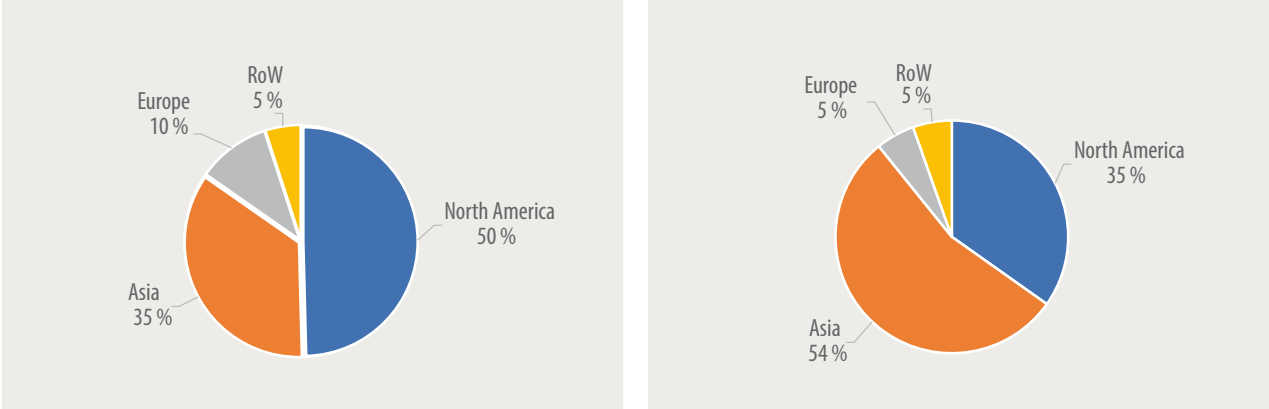


Fig. 3 Comparison in fundraising (as capital investment) in all photonics companies and in laser sources companies – breakdown by geographical area (2019-2023). IPO, loans and public subsidies are not taken into account (Source: Tematys, 2024)

Lasers for sensing, instrumentation, and optical pumping

Lasers for sensing and instrumentation represent 11 % of the total market. This segment includes applications such as spectroscopy, lidar, optical fiber sensing, life sciences, and sensing in consumer electronics where a laser source is used to measure physical quantities.

Optical fiber sensors can measure temperature, pressure, displacement, acceleration, rotations, vibrations, flow rate, chemical concentrations, and electrical fields. Fiber lasers, VCSELs, and DFBs are the most commonly used sources. Fiber sensors play an integral role in various domains, including fossil fuel detection and extraction, infrastructure monitoring, industrial and process control, military, and homeland security. The lidar method uses wavelengths from UV to NIR to measure distances and to map objects and surfaces. Lidar commonly uses laser diodes, but DPSSLs or fiber lasers may be used depending on the application. Lidar has various applications, such as in navigation systems, autonomous driving and automotive safety, robots and drones, topography, military, and law enforcement.

High-precision spectroscopy measurements require narrow and ultrafast pulses across a broad range of wavelengths, which are typically provided by mode-locked DPSSLs. Examples of applications include optical tweezers and absorption, fluorescence, and Raman spectroscopy. Life sciences have notable applications in biotechnology, medical devices, and drug design. Techniques in life sciences that rely on laser sources for measurements include DNA sequencing, flow cytometry, and optical coherence tomography.

Lasers are also used in consumer electronics that millions of people use daily, playing a crucial role in interaction and productivity. VCSELs are commonly used in optical mice and gesture recognition devices.

Solid-state lasers are optically pumped by a flash lamp or, more commonly nowadays, with another laser. These lasers typically use high-power diode bars or stacks with output powers ranging from several watts up to 1 kW. They offer several advantages over flash lamps, including wall-plug efficiency and robustness. Optical pumping currently has a 4 % market share in the laser source market.

Lasers for medical applications

Lasers have several advantages over traditional medical tools and are extensively used in ophthalmology, dentistry, and surgery. Medical applications and cosmetics hold a 10 % share of the total laser sources market. Laser incisions are more precise than those performed with scalpels, reducing the risk of damaging nearby tissue. The laser-generated heat assists in sterilizing the area while simultaneously sealing blood vessels, reducing bleeding, swelling, and scarring, and accelerating healing in some cases. Femtosecond SSLs are used for cataract surgery, while in combination with excimer lasers they can be used for vision correction operations such as lasik.

In dentistry, Q-switched lasers replace drills for tooth operations and are used for the removal of biopsies and lesions. Er:YAG or Ho:YAG SSLs are used for general surgery procedures involving tissue and section cutting. In aesthetic operations, SSLs are employed for hair, spider-vein, wrinkle, skin coloration, and tattoo removal.

Lasers for defense, R&D and other applications

Other applications for laser sources are mainly in the defense and R&D segments. The most common tools for precise targeting and guiding munitions are laser designators, which are primarily based on DPSSL sources. Diode lasers are used in firearm sights for target acquisition, while QCLs are used for IR countermeasures. In recent years, fiber lasers with output powers in the order of hundreds of kilowatts have started to be deployed against unmanned aerial systems, cruise missiles and artillery.

In the R&D segment, high-power DPSSLs are used in plasma physics, electron and ion acceleration, time-resolved spectroscopy, and nuclear waste management. Lasers are used in quantum applications to generate entanglement through spontaneous parametric down conversion and to pump semiconductor nanostructures. A small portion of the market, less than 1 % for each segment, is for lasers used in lighting, displays, printing, and optical data storage.

Fundraising in laser source companies

Tematys collected and processed data on private investments in photonics companies from 2015 to 2023. The annual number of deals (fundraisings) remained steady throughout the period, with the lowest value occurring during the Covid-19 pandemic. However, the amounts invested increased significantly in 2021 and 2022 after remaining stable from 2016 to 2020. On average, US photonic companies raise five times more annually than their European counterparts. While the amounts raised in Asia were similar to those in Europe in 2015, they have since increased dramatically, surpassing the amounts raised in Europe.

Laser source companies raised around 500 million US dollars in the last five years. Fig. 3 shows a geographical comparison of fundraising for all photonics companies and laser source companies. The proportions of Asia and North America are reversed. There is also a greater funding gap between Europe and North America or Asia for laser sources.

Trends in the laser source market and technology

Investment tracking can improve the understanding of market and technology trends. This section highlights the trends for laser sources.

Laser 3D printing uses a laser to melt powdered materials to manufacture components and whole products. This technology has gained popularity in recent years, particularly in the aerospace, automotive, and medical industries, due to its precision, reduced waste, ability to create complex geometries, and greater design flexibility.

High-power diodes efficiently produce intense light beams and are used in various applications, from industry to medicine. Advances in semiconductor technology have made diodes smaller, more efficient, and cost-effective.

As digitalization, machine learning, and the Internet of Things (IoT) continue to evolve, they generate a vast amount of data and an increasing need for **high-speed laser communication**. Furthermore, using lasers for FSO (free-space optical) communication enables long-distance data transmission where it is either impossible or impractical to use optical fibers. An excellent example is communication between satellites and Earth. FSO communications typically use either diode or fiber lasers operating near 1,550 nm, depending on the distance and power requirements.

Laser sources are increasingly used in **quantum technology**. Integrating the principles of quantum mechanics with laser technology generates new concepts for computing, sensing, and secure communications.

Microlasers can be integrated into compact devices, benefiting from reduced power consumption and potentially lower production costs. They have applications in telecommunications and medical devices. Innovations such as photonic-crystal surface-emitting lasers (PCSEL) could improve the data rate, efficiency, and power performance.

*

The authors would like to thank Optica and Spectaris for funding the study. Special acknowledgements go to Jose Pozo and Wenko Süptitz for their assistance.

DOI: 10.1002/phvs.202400013

Authors

Thierry Robin has over twenty years of experience in technological innovation and marketing in the optics and photonics industry. He has managed more than fifty projects in optics as a team manager in several research and technology organizations. He is a founder and partner of Tematys. Robin graduated from the École Polytechnique, Paris (France). He holds a master's degree from the École Normale Supérieure, Paris (France), and a PhD from the École Polytechnique.

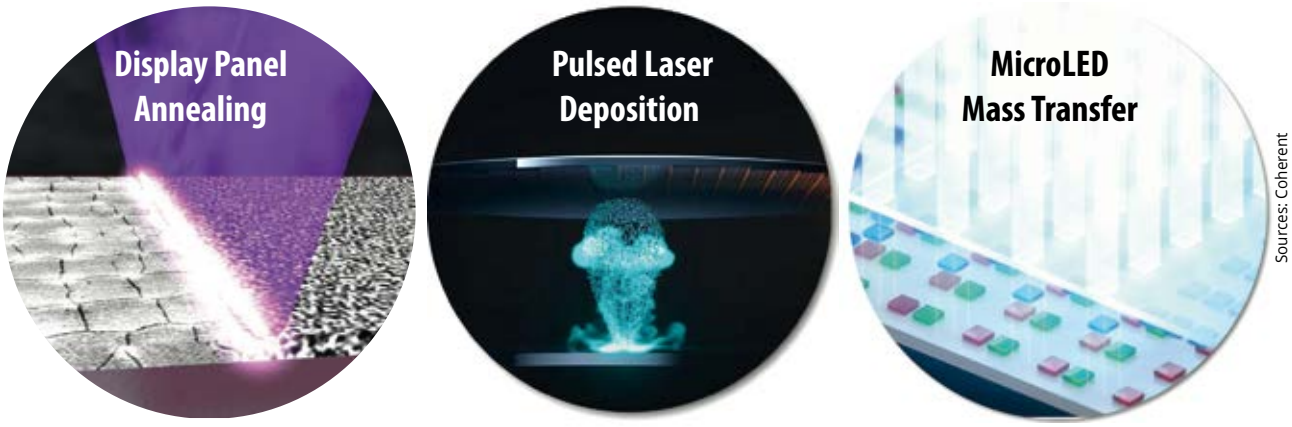
Further authors:
Jacques Cochard, Dr Kimon Moratis (both: Tematys)

Dr. Thierry Robin, Tematys, 6 Cité de Trévise, 75009 Paris, France; phone: +33 6 4808 6332; e-mail: trobin@tematys.com, Web: www.tematys.com, tematys

High-energy UV lasers for display and green energy applications

UV laser-based material deposition, modification, and transfer

Robin Rammelsberg, Ralph Delmdahl, and Oliver Haupt



Sources: Coherent

The next generation of power saving displays, superconductivity-driven carbon-free energy generation, semiconductor manufacturing, and also refractive eye surgery largely hinge on photonics-based precision manufacturing. They all benefit from the unique technical properties of excimer lasers, namely the laser's short wavelength in the ultraviolet range of the spectrum and the high pulse energy output. Gen 8 display fab expansion, capacity upscaling of superconducting tapes for future fusion reactors, and new tool developments for inspection and thin film manufacturing in the semiconductor industry are in full swing, and enabled by UV laser system technology.

▲ **Fig. 1** Display annealing, superconductor tape thin-film deposition, and microLED mass transfer have one thing in common: they all need high-energy UV laser pulses for the process.

The active matrix organic light-emitting diode (AMOLED) displays used in most cellphones today are utterly gorgeous – bright and sharp – and beneath the surface, manufacturers have engineered them to use less power. That is important because the display typically uses more battery power than anything else in the phone. There is an enormous amount of technology that has been applied to actually make all of this happen, and pulsed high energy UV lasers already play an absolutely vital role at the very first step of fabricating the device circuity. This is when a thin layer of silicon – the semiconductor at the heart of all modern solid-state electronics – is created on a large panel called the 'mother glass'.

The problem is amorphous

Thin film transistors (TFT) control the individual pixels in AMOLED displays. These TFTs are built on a thin silicon layer of about 50 nm which is deposited by a CVD process on the substrate. But there is a little problem with this layer of silicon: it is amorphous. In amorphous silicon, the individual atoms are arranged in an irregular and disordered fashion, resulting in low electron mobility of ~0.5 cm^2/Vs. Building TFTs with this kind of silicon layer would ultimately result in displays with a low refresh rate, poor resolution, and high power-consumption.

TFTs are made for mobile devices from polycrystalline silicon (p-Si) where the atoms are fairly regularly ordered to avoid these disadvantages. The electron mobility can be as much as two hundred times higher than that of amorphous silicon. P-Si can be created by heating up the amorphous silicon to about 900 °C, but these high temperatures cannot be used in display production, mainly because they deform the substrate. Instead, low temperature polycristalline silicon (LTPS) is formed by annealing the amorphous Si layer with high energy pulses from UV lasers. The laser source of choice for display manufacturers are XeCl Excimer lasers emitting at 308 nm with a combined pulse energy of up to 6 J and power of up to 3.6 kW (Coherent, TriVYPER). The laser pulses are formed by a sophisticated optical system into a long thin line (up to 1.5 m × 450 µm) which, pulse by pulse, melts the a-Si layer on the panels to form p-Si.

The Excimer lasers and optical systems have been industrially used for the annealing process for more than twenty years. They have continuously

been developed further to improve their performance, process diagnostics, and component lifetime and have proven to be cost effective and very reliable.

Today, the mother glass panels are usually 1.5 m × 1.85 m (GEN 6.5) in size, although phone makers want to make them even larger to lower the cost of individual displays. Next will be the adoption of OLEDs into IT, and the industry will move to GEN 8.7 (2.29 m × 2.62 m) panels that have more than twice the area. The latest products available, like the LineBeam 1300-G8 from Coherent (Fig. 2), can process these large panels with a roughly 1.3 m × 450 µm line with energy density at the substrate between 300 and 500 mJ/cm^2. The best process quality for high-end smartphone displays is provided by the Excimer laser's high pulse energy and its low pulse energy fluctuation of typically below 0.1% standard deviation.

Fig. 2 LineBeam 1300-G8 with TwinPython laser to anneal GEN 8.7 mother glass. The TwinPython delivers four beams at 355 nm and 600 Hz of 1 J each to the LineBeam system (Source: Coherent)

In an effort to reduce the cost of operation, solid-state pulsed UV laser sources have recently become available on the market as an alternative to Excimer lasers in this particular application. Strong advances in technology, especially in third harmonic generation crystal lifetime, have made this possible. A unique product giving an unequalled, very high pulse energy of up to 4 J at 355 nm and 2.4 kW power from four subunits is the Coherent TwinPython (Fig. 2). It is an ideal source when high UV pulse energy, reliability, and longevity are needed. Its spatial beam fluctuation is minimized while further improving pulse energy stability.

AMOLED technology now gives us thin displays for smartphones and TVs with fabulous colors and resolution. But display manufacturers are already progressing towards volume production of the next 'big thing' in displays: microLED displays. Based on small (<50 µm) inorganic LEDs, this fast-emerging technology promises several advantages. First, it is immune to the premature aging that can sometimes affect OLED emitters. It can also deliver higher brightness with higher contrast. In addition, it is a scalable technology with the potential for the production of large TVs and public displays at a more economical price point as well as for ultra-compact displays in VR/AR applications.

MicroLED displays have actually been around for a while in limited volumes, but now display manufacturers are figuring out how to take these into full-blown production. It turns out that lasers are playing several critical roles.

MicroLED displays

MicroLED displays are among the most promising technology for very small and large displays. The market adoption will strongly depend on the cost of the display. Shrinking microLED sizes with additional throughput and yield improvements are the keys to a wider usage of the technology.

Several processing steps are required where lasers can help to produce microLED displays in an economical way. It starts with the laser lift-off (LLO) where the microLEDs are

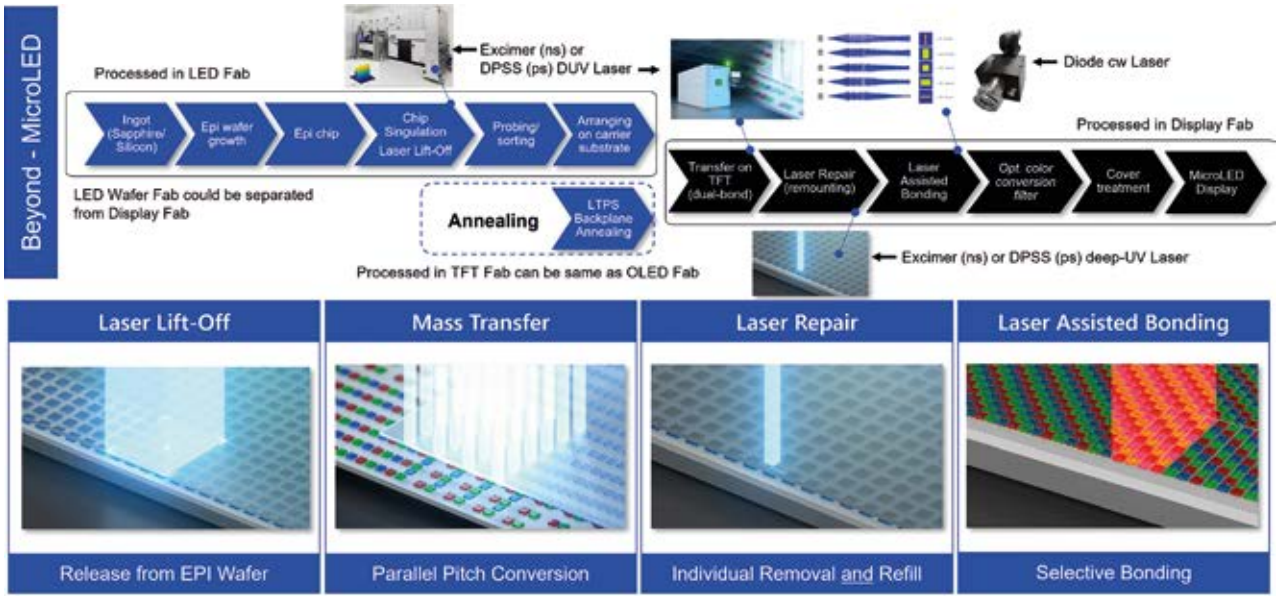


Fig. 3 MicroLED manufacturing process flow (Source: Coherent)

Fig. 4 MicroLED process results and UV transfer system (Source: Coherent)

removed from the epitaxial wafer, most commonly a 6″ or 8″ sapphire wafer. The material combination of sapphire and GaN requires short UV light to avoid damage to the GaN layers which are (a) the microLED material and (b) the LED side where the laser interaction happens. This is later the customer-facing side of the individual microLED in the display where damage is not acceptable. Every consumer display larger than a VR > 1″ display requires a pitch conversion when transferring the individual microLEDs from the tightly packed epiwafer configuration to the display pixel pitch. Laser-based mass transfer is already an established process and used at some display manufacturers to produce microLED displays. Bad or broken microLEDs need to be removed and refilled in a repair step. The requirements for their removal and refilling are the same as for the transfer, so a highly precise, individual UV laser beam is necessary to place a new microLED into the same position where the bad microLED was removed. Finally, a laser-assisted bonding process can be used to thermally bond the microLEDs to the backplane.

LIFT – changing the pitch

In laser-induced forward transfer (LIFT), pulses from an ultraviolet (excimer) laser enter through the transparent back of the carrier. The laser light passes both the carrier and the adhesive and interacts with the remaining buffer layer of the GaN. This delivers a transfer with almost no residues and no impact on the microLED customer-facing surface if short UV wavelengths are used. This physically blows the dies off and pushes them onto the final display panel, which is placed in close contact but with a gap that has to be larger than the thickness of the microLEDs to avoid collisions. Adhesive on the final glass panel holds the microLEDs in place. Now comes the critical piece of magic, the change in the pitch (die spacing). The rectangular laser beam passes through a mask that has holes in it. The beam is then demagnified 2.5× or 5× so that the projected pattern of holes are the same distance apart as the pixels in the final display. In this way, only every 5th, or 10th, or any other chosen integral multiple of the LED pitch on the epiwafer, is pushed across a tiny gap of a few micrometers to the display by a laser pulse. The carrier is then moved over very slightly relative to the fixed beam and mask to get to the adjacent set of microLEDs. The display panel is moved a larger distance, and the process is repeated.

The microLEDs are very tiny parts and handling such small pieces requires a perfect combination of the UV laser, the optical beam shaping and precision. It is like a symphony where all musicians must play well together to make a perfect sound. We have developed a system architecture and the process results are superior for microLEDs down to 5 µm, as shown in the image. Again, microLED displays will only enter the market when the prices are comparable to other technology. With our laser-based mass transfer solution, we are contributing our part to the processing cost roadmap. High throughput of the smallest microLEDs with the highest yields – a future-proof approach.

Company

Coherent

Coherent Corp. is a global leader in materials, networking, and lasers for the industrial, communications, electronics, and instrumentation markets. The company was founded in 1971 and is headquartered in Saxonburg, Pennsylvania. Today, the company operates in more than twenty countries around the world and empowers market innovators to define the future through breakthrough technologies, from materials to systems.

www.coherent.com

Meet us at AKL'24, booth 42

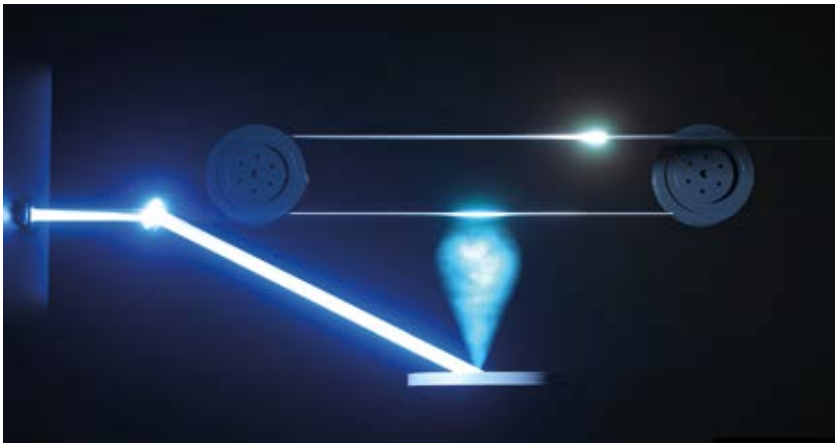


Fig. 5 Reel-to-reel PLD setup principle for HTS tape production (Source: Coherent)

Pulsed laser deposition

Pulsed laser deposition (PLD) uses nanosecond UV laser pulses to evaporate a target material that will subsequently condense on a substrate. Because of the pulsed nature during deposition, the density of the plasma is orders of magnitude higher compared to chemical deposition technology. In addition, the kinetic energy of ablated pieces can be tuned via the laser fluence. The unique feature of PLD as a line-of-sight deposition technique enables the deposition of material films of complex stoichiometry with good crystallinity, which is pivotal in growing high-temperature, superconducting thin films)

Fig. 6 PLD manufacturing of HTS tapes (Source: Coherent / Faraday Factory Japan)

Faster path to fusion with HTS tapes

Pulsed laser deposition is the key enabler to producing high-temperature, superconducting (HTS) tapes for fusion magnets. HTS tapes use yttrium barium cuprate (YBCO) thin films as superconducting thin film material and change the fusion roadmap by providing an order of magnitude better high field performance than incumbent low-temperature superconductors (LTS) based on niobium alloys. To provide sufficient critical current density in a fusion reactor's high magnetic field environment of up to 20 T, the YBCO material must be deposited epitaxially as a biaxially-ordered, polycrystalline thin film of a few microns in height with excellent grain alignment and a specific nanoscale defect structure facilitating high supercurrent transport unimpeded by the magnetic field.

Among the processing routes for YBCO thin film deposition, PLD provides the most favorable microstructure and growth kinetics. PLD-made tape material delivers superior high field performance and forms the backbone of today's fusion magnet developments. HTS magnets enable a higher magnetic field strength and with it an order of magnitude smaller size and cost of magnetic confinement fusion reactors. With HTS tapes as conducting material, private fusion companies project net energy fusion milestones within this decade. With the PLD production technology for HTS tapes in place, fusion as a zero-carbon and baseload-capable energy source may become reality early enough to play a role in mitigating global warming.

Excimer lasers boost HTS tape manufacturing

PLD mass production of HTS tapes uses 308 nm excimer laser wavelength, which is ideal for YBCO target absorption. As the thin film deposition rate in PLD scales with the available laser power, 308 nm laser technology from Coherent for PLD production has evolved orders of magnitude in laser pulse energy and the available repetition rate.

LEAP excimer lasers are the backbone of today's industrial, three-shift YBCO tape manufacturing. The annual HTS-tape production capacity for fusion magnets has been scaled up using three-shift manufacturing with multi-hundred Watt excimer laser-based PLD production, and the worldwide HTS tape output is now measured in thousands of kilometers.

Summarizing, the scalable power as well as the pulse energy of Coherent excimer lasers and high-power UV system technology boost innovations in displays, carbon-free energy generation, semiconductor manufacturing and ophthalmology alike. In our era of transformative technologies, photonic solutions are key to a safer and more sustainable future in a power-hungry world.

DOI: 10.1002/phvs.202400011

Authors

Robin Rammelsberg is director of research and development at Coherent in Göttingen. He holds a PhD in physics from Ruhr University Bochum and has worked on pulsed UV laser technology and its applications for more than twenty years.

Ralph Delmdahl is a product marketing manager at Coherent in Göttingen. He holds a PhD in chemistry from Braunschweig Technical University and a master's degrees in economics and business administration from the Open University in Hagen.

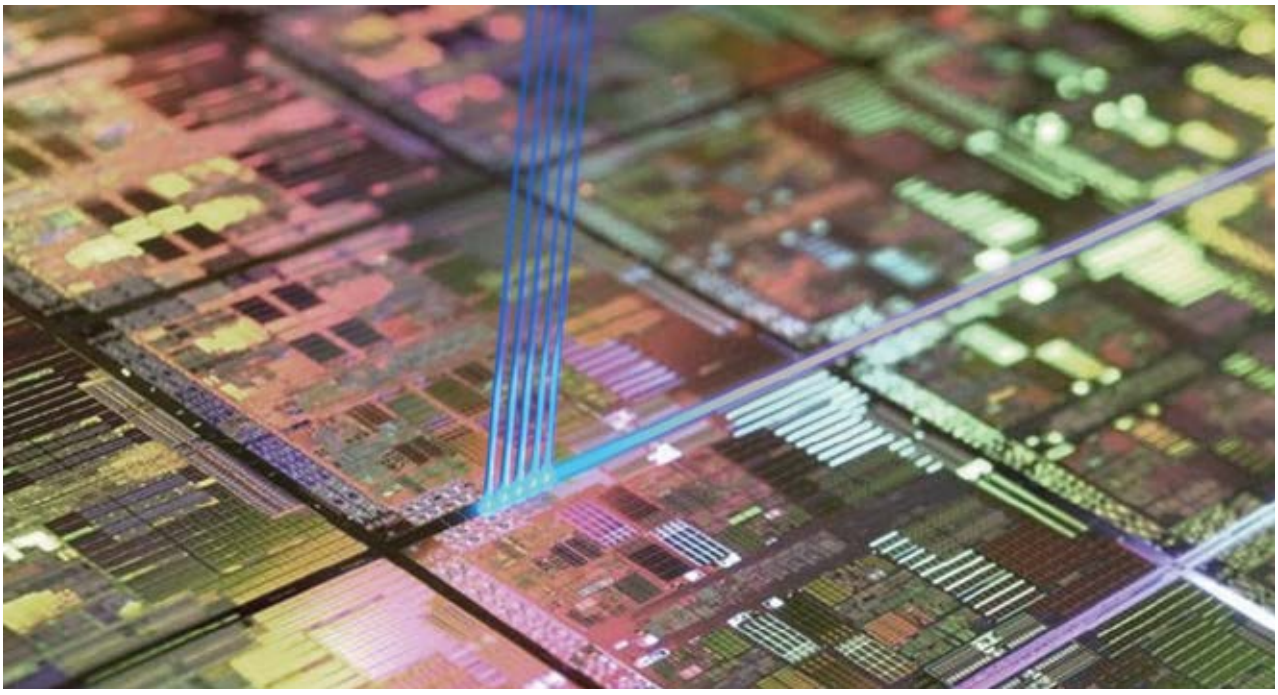
Oliver Haupt is director of strategic marketing for the display equipment market at Coherent. He holds a PhD in mechanical engineering from the University of Hannover, focusing on laser processes for brittle materials.

Dr. Oliver Haupt, Coherent LaserSystems GmbH & Co. KG., Hans-Böckler-Str. 12, 37079 Göttingen, Germany; phone: +49 551 6938 458; e-mail: oliver.haupt@coherent.com, Web: www.coherent.com; robin-rammelsberg-1916011b7 ralph-delmdahl-a1730a8 oliver-haupt-2499275a

High speed wafer grooving with UV-USP lasers

Addressing semiconductor requirements: high die strength and low burr height

Kees Biesheuvel & Patrick Huberts



This article explores the application of ultraviolet ultrashort-pulse (UV-USP) laser grooving in tandem with other process steps such as plasma dicing as a practical approach to enable advanced microelectronic packaging. The non-contact nature of UV-USP laser grooving, along with its ability to ablate material with minimal lateral thermal damage, results in clean and precise grooving lines.

One of the first high volume manufacturing laser applications in the semiconductor industry was to use a nanosecond UV laser to remove the low-k structures from the dicing street prior to blade sawing. The laser process prevents delamination and cracking of these delicate top structures in the dicing street, after which the devices are separated using a mechanical blade saw. Used for many years with reasonable satisfaction, several developments in semiconductor devices are pushing the industry to a new laser grooving process technology.

Both in next generation memory applications (3D NAND) as well as in advanced micro and logic applications, the active layer stack is increasing beyond a 10 µm thickness up to 30 µm thickness. Since the active layers are increasing but the total packing height needs to remain the same, the actual silicon wafer substrate thickness is reduced (already below 50 µm thickness). As the Si substrate gets thinner, the die strength of the devices after singulation becomes more important. It is generally known that a nanosecond UV laser grooving process does not provide sufficient die strength with typical values of 250 – 350 MPa. A general request from the industry is to achieve a die strength value above 700 MPa.

A second quality criterion is the burr height on the edge of the device after separation. More advanced packing is moving to (micro) bump die interconnect rather than wire bond. A UV nanosecond laser grooving process is not able to generate burrs below 2 µm. These are some of the key quality improvements that the industry is looking for, apart from no chipping and delamination in the adjacent active structures to the groove and a smooth perfect U-shape profile.

▲ **Fig. 1** High-speed wafer grooving with UV USP lasers (Source all images: ASMPT ALSI)

All these requirements can be addressed when moving towards an ultrashort-pulse duration regime for laser processing.

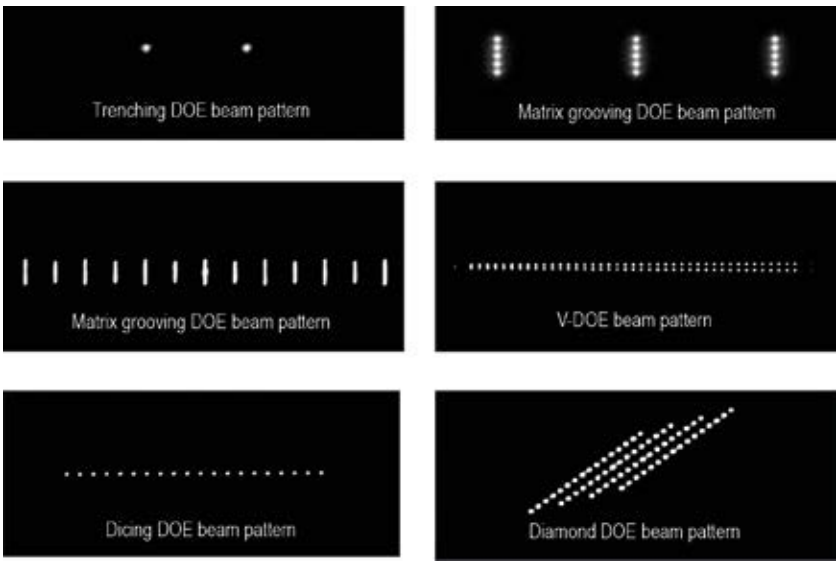


Fig. 2 Several different beam patterns generated by diffractive optical elements

Alternative dicing methods after laser grooving

Wafers with low-k layers require a laser grooving step to remove the metal test structures and low-k layers before the actual wafer separation step can take place. These wafers are even more challenging as the groove weakens the wafers, resulting in a serious risk of wafer breakage. The traditional process of reference is nanosecond laser grooving followed by blade dicing. The width of these grooves is typically in the range of 40 – 50 µm to be wide enough for the blade saw to fit the laser groove.

An alternative separation technique is stealth dicing before grinding, which creates a small modification layer inside the wafer. In this process flow, a stealth dicing process is applied prior to grinding the wafer, which locally weakens the wafer. Once the grinding process has reached the required thickness, the wafer can be separated by expansion of the tape or by applying a mechanical breaking force if the die size is smaller than 1 mm. A constraint for the stealth dicing process is that metal structures cannot be present. Removing the metal can be achieved by creating a narrow groove with a laser. In addition, the cost of the stealth dicing system is significantly higher than the blade saw tools.

A third alternative is plasma dicing, which separates the dies by etching through the Si substrate. The main advantage of this technology is the very high die strength, since the removal process does not affect the sidewall structure or the ability to create arbitrary die shapes. Another advantage is that, after plasma dicing, there is no burr remaining, essential for hybrid bonding. The disadvantages of this technology are the high investment costs together with the limited flexibility since a different mask set is required for each different die size. In addition, the etching process cannot etch through passivation, metal, or polymers such as die attach film (DAF) or film on wire (FOW). Therefore, plasma dicing technology also requires a first step such as laser scribing to remove these layers prior to etching through the Si, which further increases the costs.

UV-USP to reduce burr and the heat-affected-zone

ASMPT's patented multibeam laser technology has been used for several years by many assembly and packaging companies. This technology is easily adjustable to various applications by optimizing the laser beam patterns on the wafer. As the goal for all laser technologies is to achieve the best possible throughput while guaranteeing the required quality, optimizing the beam pattern improves the quality of the top surface and die sidewall, thereby reducing the burr and the heat-affected zone (HAZ) and increasing the die strength.

How our UV-USP grooving technology works

The typical process flow of fast laser grooving of wafers is to first scribe the top layer on both sides of the groove, so called trenching, and then remove the material on the inside of the trenches,

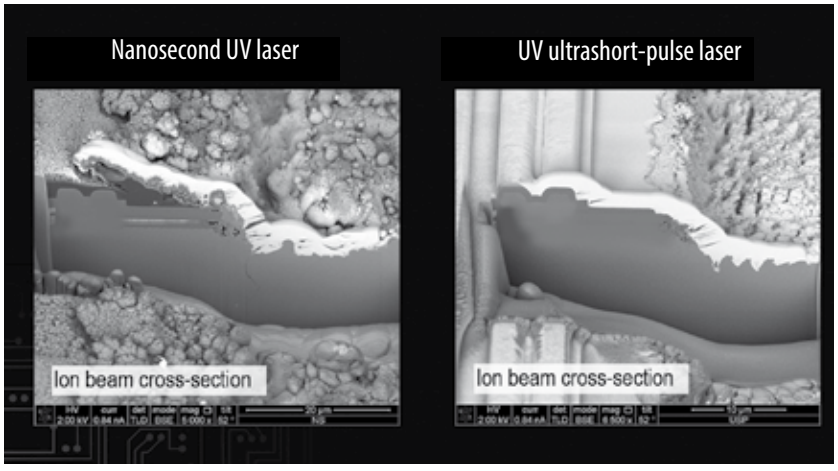


Fig. 3 Focused ion beam cross-section of left part of a groove processed with a nanosecond UV laser and an ultrashort-pulse UV laser

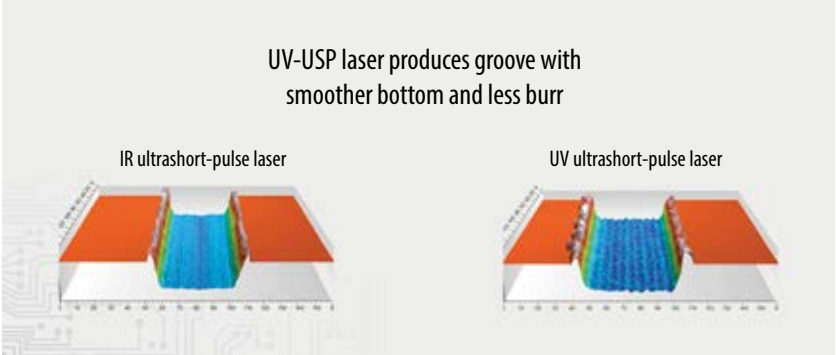


Fig. 4 Silicon wafer with 5 µm transparent top layer

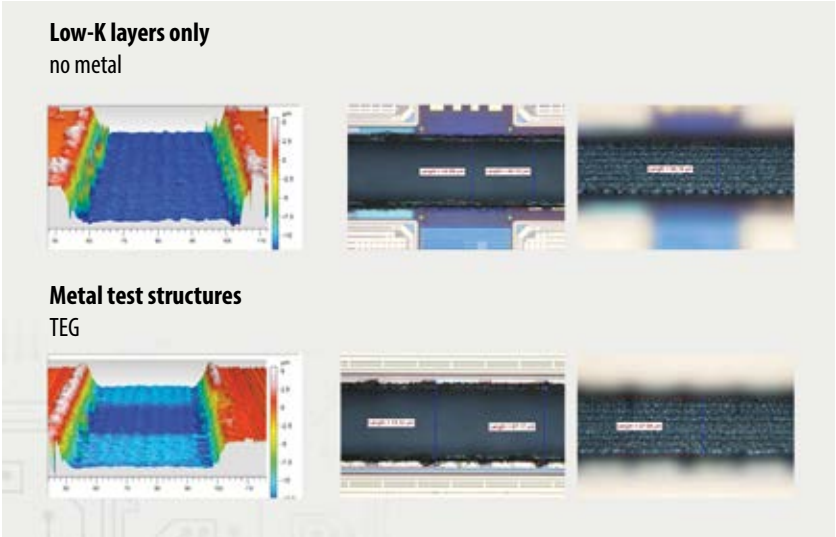


Fig. 5 UV-USP laser groove at a location with only a low-k layer without metal test structures, and at a location with metal test structures

so-called grooving. Trenching is to limit the flow of energy during the high-power grooving steps. Trenching requires relatively low power and is typically performed at high repetition rates to maximize the processing speed. In principle, the two trenching scribes on either side of the groove are executed in parallel in a single pass by splitting the laser beam into two beams at the correct distance from each other.

The removal of the material between the trenches, the actual grooving step, is performed at the highest repetition rate for which the maximum laser power is available.

Grooving at high speed using a DOE

A diffractive optical element (DOE) was designed to produce a beam pattern that optimizes the available pulse energy with the required groove width and depth. The laser processing tool can vary between multiple DOEs within a single grooving recipe to produce the best groove at the highest speed. The DOEs comprises one-dimensional as well as two-dimensional beam patterns and allow different intensities for individual beamlets.

The tool is equipped with a static laser beam delivery system with a moving wafer stage and an active damping mechanism to achieve the high accuracy of ±1.5 µm for a full-size 12-inch wafer.

How using shorter pulses can result in high die strength

The laser removal process in the UV nanosecond laser regime is melt-driven, and the residual thermal energy introduces a relatively large melt pool and heat-affected zone (HAZ). The resolidification of the Si after the laser processing introduces defects into the Si substrate. These defects range from voids and cracks in the micrometer range to lattice defects in crystalline Si with respect to a defect-free monocrystalline substrate. When these defects are put under tension during die strength testing, they can cause early cracking of the die and therefore a reduction of the die strength.

USP lasers operate with much shorter pulses at high pulse intensities and the material removal mechanism in these pico to subpicosecond regimes is not melt but ablation driven, without requiring the material to go through a melt phase to be removed. The HAZ is smaller and the resolidified and deposited material forming a burr is much lower. As a result, the die strength using USP laser grooving is significantly higher than for nanosecond laser grooving.

Difference between UV and IR wavelengths

Although ultrashort-pulse laser processing includes nonlinear absorption, the linear absorption is still critical to achieve high quality. When processing metal test structures next to transparent low-k layers, the UV wavelength provides a significantly better quality than the IR wavelength of a similar pulse duration. With UV-USP laser processing, material absorption differences are less important, and metals, polymers, glasses, and silicon removal rates are more similar. UV-USP lasers can achieve

Company

ASMPT ALSI

Established in 2001 as a spin-off from Philips Semiconductors, ASMPT ALSI invented advanced technology for multibeam laser dicing and grooving.
Their Laser 1205 machine enables semiconductor manufacturers to lower their costs, cutting accurately through various wafer materials with minimal thermal impact and high productivity. ASMPT ALSI is leading the market in processing RFIC, VSCEL, DDI, Thin Si, and SiC applications. As part of the ASMPT group, ASMPT ALSI provides solutions for electronic manufacturing at every step: from equipment to multifactory-level automation for smart manufacturing, covering components for electronics, mobile communications, computing, automotive industrial, and LED displays.

www.alsi.semi.asmpt.com

sharper, well-defined grooves, and edge sidewalls with the same optical arrangement and spot sizes.

UV-USP laser system for high volume manufacturing

Ultrashort-pulse lasers have already been around for a long time. Only in the last couple of years have these lasers become interesting for the semiconductor industry because industrial UV-USP lasers with a high beam quality and sufficient pulse energy are now available. ASMPT was the first to deliver a UV-USP laser system to their customers for high volume manufacturing. The trend of using higher-powered lasers has started and investigations into utilizing these higher powers while controlling the quality are ongoing. Moving the laser beams via galvo or polygon scanners and generating multiple laser beam patterns via spatial light modulators (SLMs) are all still under investigation.

DOI: 10.1002/phvs.202400009

Authors

Kees Biesheuvel received a PhD from the Vrije Universiteit in Amsterdam and was a post-doc for several years at the University of Rochester, NY, USA. Kees has over 25 years of experience in laser processing and is currently principal process engineer at ASMPT ALSI.
His expertise includes laser spectroscopy with single mode Ti:Sapphire lasers, crystallization with high power excimer lasers, drilling of injection nozzles with Q-switch CO_2-lasers, welding with high-power fiber lasers and grooving of semiconductor materials with ultrashort-pulse lasers.

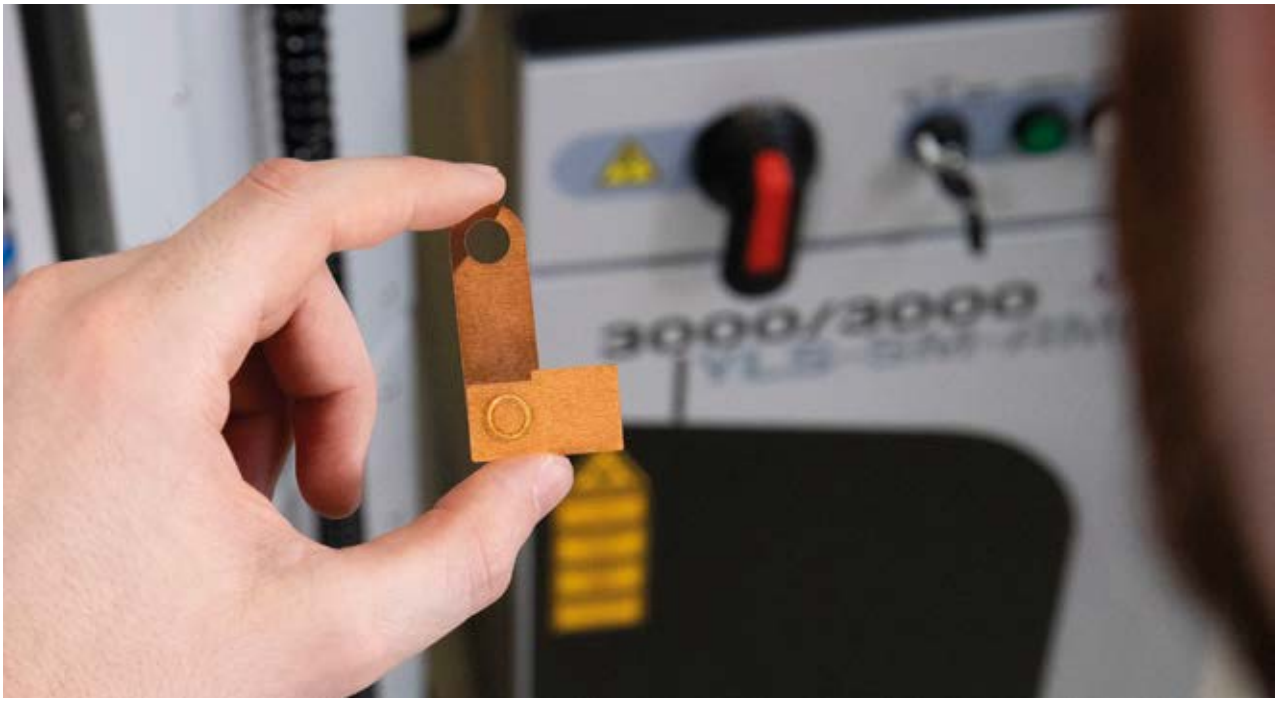
Patrick Huberts began his career in R&D at Philips Consumer Electronics and Assembleon and has accumulated over 25 years of experience in electronic and semiconductor manufacturing.
As head of business and marketing at ASMPT's ALSI business unit, Patrick oversees business development, product management, and marketing for laser dicing and grooving solutions. He holds a bachelor's degree in electronics from the University of Applied Sciences in Eindhoven, The Netherlands.

Dr. Kees Biesheuvel, ASMPT ALSI B.V., Platinawerf 20, 6641 TL Beuningen, The Netherlands; phone: +31 24 2042826; e-mail: kees.biesheuvel@asmpt.com, Web: www.asmpt.com; ASMPTALSI ALSI, Kees-Biesheuvel-55950b1, Patrick-Huberts-296139b

Dual-beam lasers meet challenges of the automotive industry

Versatile control of spatial energy deposition lowers the process cost and improves quality and productivity

Alexei Markevitch, Michael Wiener, and Iurii Markushov



The challenges of transport electrification require the adoption of new manufacturing techniques. Lasers excel in most difficult tasks due to their ability to deliver energy with great precision, and their temporal and spatial control. Dual-beam, adjustable mode beam (AMB) technology enables the versatile spatial control of laser energy deposition, providing wide process windows for defect-free welding and focal spot positioning. The AMB technology improves process quality and speed in dissimilar material welding, copper welding and in structural aluminum welding across many applications in the automotive industry – from the production of batteries and drivetrains to structural body parts.

The automotive industry must reduce its production costs and improve the reliability of electric vehicles (EVs) to encourage their mass adoption. Significant contributions to high EV costs are the low speed and low quality of dissimilar metal, copper and structural aluminum welding with traditional lasers or non-laser methods. Legacy welding technologies induce hot-cracking, spatter, porosity, and humping, and may input an excessive amount of heat, making batteries a fire hazard and compromising vehicle structural integrity.

The hot-cracking results from high thermal gradients, related to the material type and energy input rate. Spatter, porosity, and seam humping arise due to keyhole collapsing and irregular melt pool dynamics because of keyhole instability occurring at high welding speeds. Fiber lasers with concentric adjustable mode beams (AMB) offer a solution to these problems.

AMB lasers produce a coaxial laser ring around an inner core beam. The additional ring energy increases the opening of the keyhole and provides extra energy at the top of the weld. A larger keyhole opening reduces the pressure in the keyhole and suppresses spatter, reducing or completely eliminating the underfill caused by material loss. The extra energy at the top of the weld increases the active time of the melt pool, giving it more time to settle before solidification, reducing

▲ Example of a copper battery busbar welded with AMB Laser Technology (Source: IPG Photonics)

porosity and surface cracking, resulting in improved surface appearance and mechanical strength of the joint. Because each welding job has unique requirements, the core and ring power and area must be optimized for the maximum speed, the best quality and the width of the stable process parameter window.

Optimizing the spatter-free process window

Production of automotive batteries involves challenging welding of aluminum, copper, and steel. These materials must be melted in close proximity to heat sensitive battery components such as seals, gaskets, and separators and, most importantly, also close to flammable lithium salt organic electrolyte. The welding depth must be precisely controlled in materials varying in thickness from tens of microns to a few millimeters to protect these components and prevent cell damage. Overwelding may result in cell puncture, while underwelding can affect the battery's structural integrity and electrical joint resistance. AMB fiber lasers with single-mode (SM) cores are the best solution to control the keyhole depth at the fastest welding speed while inducing minimal heat input. The keyhole depth increases with laser power and is inversely proportional to the welding speed, Fig. 1.

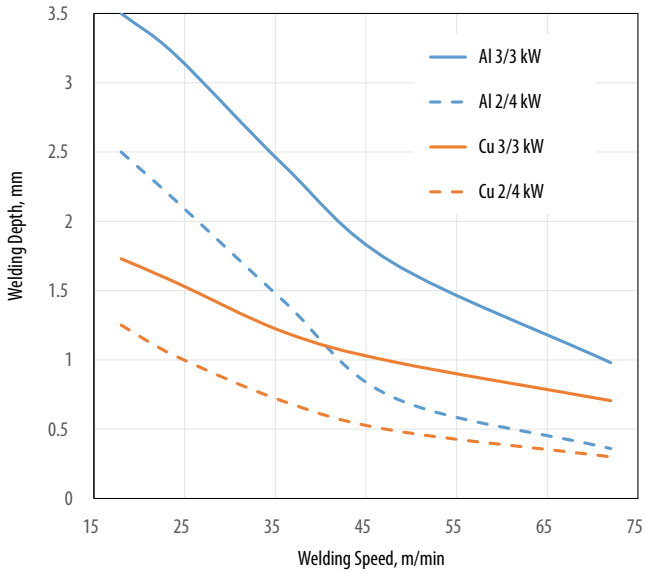


Fig. 1 Welding depth vs. speed for SM-AMB welding of aluminum and copper. Single-mode core 2 kW and 3 kW, total 6 kW laser power (Source: IPG Photonics)

To reduce the equipment cost, some manufacturers minimize the amount of ring laser power, often working near the threshold of spatter-free welding conditions, Fig. 2. In many cases, the width of the spatter-free welding process window is either narrow or none-existent, i.e. spatter is only reduced but not completely eliminated, Fig. 2a. Studies conducted by IPG have shown that the width of the stable spatter-free process window can be increased by choosing the optimal ratio of core and ring diameters, while also reducing the ring power threshold for spatter-free welding, Fig. 2b.

Optimizing the focal position process window

Welding with a single laser beam is done at a defocused position above the beam waist with a typical focal spot position tolerance of ±0.5 mm. Outside the optimal position, the laser intensity is either too high, resulting in overwelds and punctures, or too low, and the amount of spatter can also vary widely. Considering the typical variance of the welded part's height of ±1 mm, keeping the focal spot within the proper distance is only possible by using expensive 3D scanners with additional positional sensors that also slow down the process. AMB dual concentric beam welding solves this problem by increasing the stable process window by a typical factor of 4 to 6, or at least ±2 mm, well within the desired requirements. Unlike single beam welding, the optimal focal distance position of AMB welding is typically in the middle of the focal spot Raleigh length. It is believed that the increase in the focal spot process window is due to interference of the core and ring energy, with the ring energy additionally contributing to the center of the melt pool when the focal spot is shifted up or down relative to the workpiece.

Application 1: Minimizing heat input in electric drivetrain manufacturing

Copper and aluminum welding are ubiquitous in EV production, including copper hairpins in stators, copper contacts in inverters and both metals in battery tabs and foils. Because Cu and Al have high reflectivity at infrared wavelengths, it is often stated that blue or green lasers are preferred over IR lasers for Cu and Al welding. However, Cu and Al reflectivity decrease with increasing temperature, undergoing a

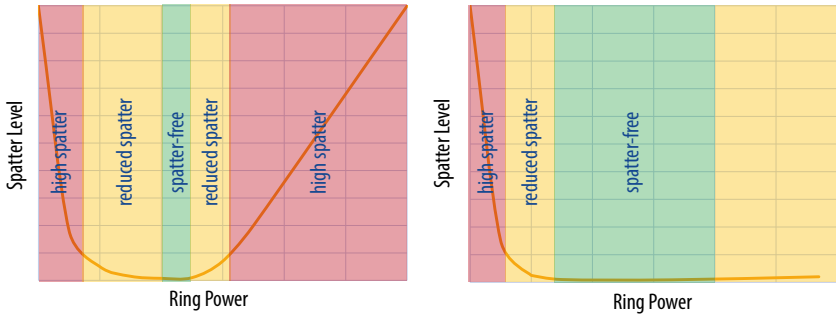


Fig. 2 Optimizing core/ring sizes for consistent spatter-free welding: (a) a narrow process window with larger ring power threshold and (b) a wide process window with lower ring power threshold (Source: IPG Photonics)

Company

IPG Photonics

The major provider of fiber laser technology, enabling greater precision, higher productivity and more flexible production, gives customers the power to transform materials across any application and industry. The company mission is to make its fiber laser technology the tool of choice in mass production. IPG accomplishes this mission by delivering superior performance, reliability, and usability at a lower total cost of ownership compared with other types of laser and non-laser tools.

www.ipgphotonics.com

Meet us at AKL'24, booth 53

Laser	Material thickness, mm	Welding speed, m/min	Peak temperature at 5 mm from the weld, deg C
Green 1.8 kW	0.5 Cu + 0.5 Cu	60	108
Blue 1.8 kW	0.5 Cu + 0.5 Cu	160	95
IR-AMB 4 kW	0.5 Cu + 0.5 Cu	400	46

Table 1 Cu welding speeds with a YLS-AMB-QCW laser
Source: Thick Cu completely spatter-free welding technology for e-mobility, Denso Corporation, LMP Symposium 2023, Atsushi Fukunishi https://www.jwes.or.jp/mt/kenkyu/lmp/LMP2023program.pdf

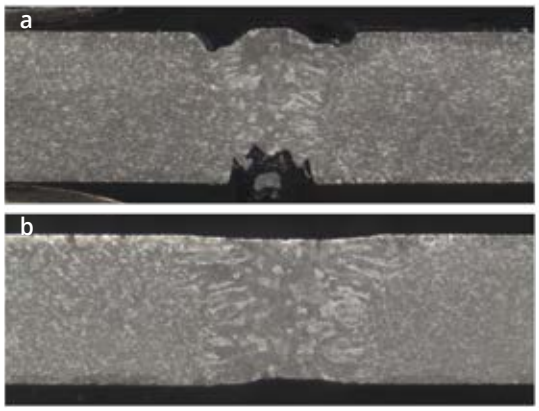


Fig. 3 Butt joint 5182 Al AMB vs. regular laser (a) single beam laser, (b) dual beam YLS-AMB laser (Source: IPG Photonics)

jump at their melting points, where it catches up with the absorption of green and blue. Green and blue lasers are also much more prone to scattering off the metal vapor plume typically present above the melt pool (scattering is proportional to the inverse of the fourth power of the wavelength), having much more difficulty reaching the material than an IR laser.

After a few microseconds, as soon as high peak laser power overcomes solid metal reflectivity, the IR laser beam is efficiently absorbed by the established melt pool.

There is a strong requirement to minimize the heat input in most EV welding applications. The high peak power required to overcome solid metal reflectivity may be detrimental to very thin materials like foils. Therefore, while blue and green lasers may have an advantage over infrared lasers in conduction welding of very thin Cu or Al materials, infrared lasers emerge as the best choice in materials thick enough for keyhole welding (even microkeyholes 100 – 200 µm deep).

The use of different laser technologies for Cu welding in electrical car inverters has been extensively studied by a major car manufacturer. They found that IPG's YLS-AMB laser in long pulse modulated quasi-cw (QCW) mode provides the fastest spatter-free welding speed with the smallest heat input, smaller than that of blue or green lasers. Table 1 shows the welding speeds from this study.

The QCW mode brings additional benefits to EV manufacturers such as air-cooling, critical for EV facilities that cannot tolerate water use, and a reduction of the total purchased power in applications limited by laser peak power.

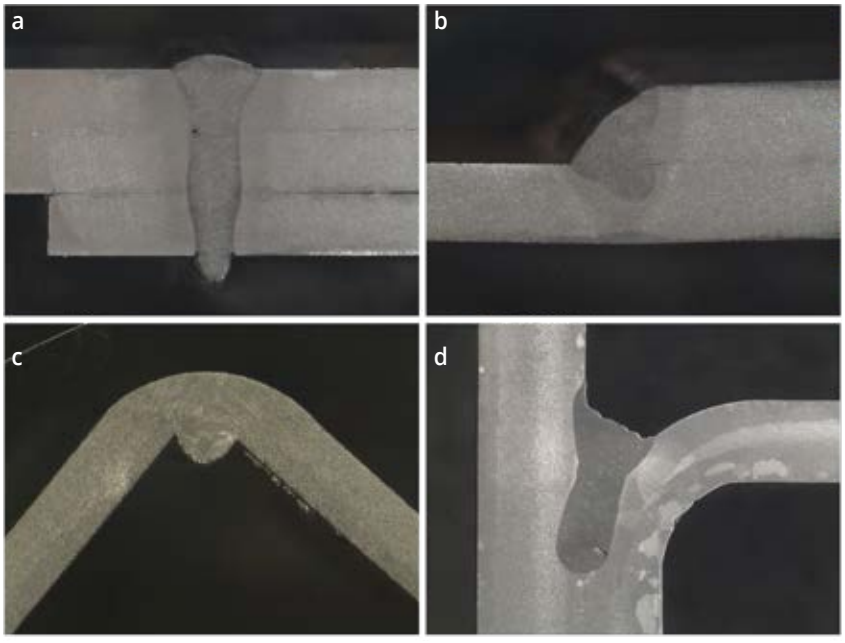


Fig. 4 Different Al 6xxx geometries (a) lap joint 3 × 2 mm plates, 4047 wire (b) Al 6111 lap fillet joint 2 mm to 2 mm, 4047 filler wire (c) corner joint, no filler wire, (d) 6082 coach joint, 4047 wire (Source: IPG Photonics)

Application 2: Structural 5xxx and 6xxx aluminum welding

To increase the fuel efficiency and extend the travel range of vehicles of all types, including those in heavy industry, railways, ships and air, their weight can be reduced by replacing their structural and body steel parts with 5xxx and 6xxx grade aluminum. Laser welding is increasingly used to join structural aluminum, sheet metal or thin-walled machined components where low heat input is critical. The high weld speed, consistency, and low heat input are attractive features of the process. The shortcomings of standard single beam welding processes have been an excessive surface roughness or undercuts in the weld surface, underfill due to loss of material from spatter ejection, and unacceptable internal porosity levels. Cracking and porosity reduce the structural integrity while a poor visual finish requires post processing. Although these problems can be mitigated to some extent at lower welding speeds by using two-sided argon shielding, high-power dual beam AMB lasers are the best solution, allowing fast welding speeds to be achieved, giving an excellent weld quality, reducing shielding argon gas use and simplifying the setup.

In the following example, 5xxx series aluminum was welded by a regular single-beam laser and a YLS-AMB laser without the use of root shielding gas. Parent material expulsions during welding were significantly reduced, minimizing the undesirable undercut on the top and bottom of the weld, Fig. 3.

Fig. 4 shows four 6000x aluminum geometries welded with the AMB laser: lap, lap fillet, corner and coach joints.

With no centerline cracking or other defects that are typically observed with traditional single beam lasers, these welds have a strength equal to or stronger than that of the parent material. An excellent class A surface appearance can be achieved as well as hermetic seals.

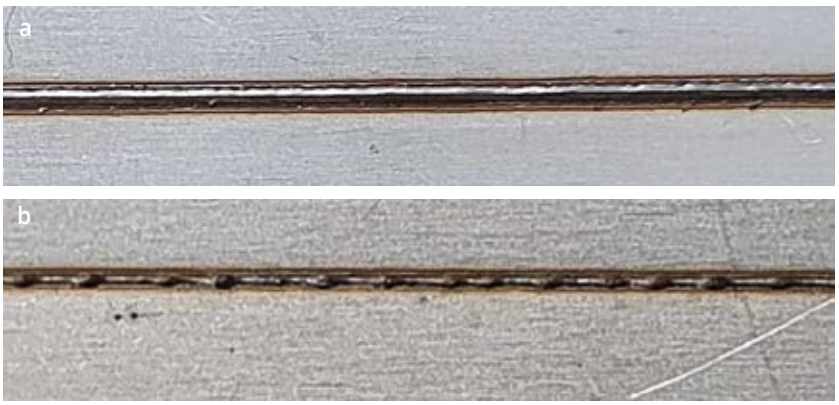


Fig. 5 Laser welding steel with 180 (a) and 80 µm spot diameters (b) at the same speed (Source: BBW Laser Technik)

Application 3: Eliminating the humping effect in high-speed welding

The welding speed is increased in large scale production by increasing the laser power. One of the challenges in high-speed welding is the development of the so-called humping effect – periodic raises and collapses of the melt pool resulting in irregular bulges and troughs resembling stitches along the weld seam. The humping is caused by an interplay of molten metal capillary forces and melt pool dynamics. The minimum speed at which the humping effect develops depends on the material, the beam focus diameter and the laser power. The effect of the beam focus is shown in Fig. 5.

With steel for fuel cells, for example, the humping starts in a range of 400 – 600 mm/s. Although beam wobbling can mitigate humping, it requires fast scanners and slows down the process. Preheating the surrounding substrate and stabilizing the melt pool dynamics by dual beam technology have proven to be the most effective solution to increasing the minimum humping speed, with the best results achieved by concentric beam AMB technology.

In one example, BBW Laser Technik tested a single-mode core AMB laser source from IPG, the YLS-2000/4000-SM-AMB, a laser with a 2 kW core beam and a 4 kW ring beam. The core beam produced a very small 25 µm diameter focal spot, while the ring beam had a diameter of ~180 µm, a ratio of 1:7. In the lap welding tests, two 0.5 mm steel sheets were welded on top of each other. By adjusting the power and speed, the welding depth and the humping limit speed were compared for a single-beam, single-mode technique vs. a dual beam with the AMB ring switched on. With added ring power, the humping is suppressed with an acceptable welding quality of 1,000 mm/s, increasing the welding speed more than twice. Hump-free welding speeds of 1 m/s can be realized with single-mode AMB lasers, of interest when welding large bipolar or radiator plates installed in electric vehicles.

Conclusion

Laser manufacturing is rapidly expanding, replacing non-laser technologies. Lasers excel in challenging welding applications, improving welding quality, part yield and lowering the cost of production. One of the great advantages of lasers is their versatility and adaptability to different process requirements. AMB dual core-ring lasers deliver energy with great control over the spatial intensity distribution, eliminating the typical defects encountered in single-beam welding such as spatter, cracking, porosity, and humping. The proper choice of AMB laser parameters provides wide process windows for the focal point position and spatter-free welding conditions. AMB lasers improve the process speed and quality in the welding of copper, aluminum, and dissimilar metal combinations in battery manufacturing and in the welding of structural aluminum and steel.

DOI: 10.1002/phvs.202400010

Authors

Michael Wiener has more than twenty years of experience in laser processing. He is the applications manager at IPG's lab in Novi, Michigan, supporting customers in North America.

Iurii Markushov is vice president global applications at IPG Photonics. He has ten years of experience in laser welding and material processing applications and is responsible for coordinating IPG's Applications Labs worldwide, including their research and development activity.

Alexei Markevitch has more than twenty five years laser experience in academics and industry. His PhD in physical chemistry at Wayne State University explored the interactions of polyatomic molecules with ultrafast lasers. Also holding master's degrees in chemical engineering (Mendeleev Institute of Chemical Technology) and atmospheric chemistry (University of Michigan), Alexei leveraged his diverse technical background in sales and marketing at Coherent and IPG Photonics.

Michael Wiener, IPG Photonics Corporation, 46695 Magellan Drive, Novi, MI 48377, USA; phone: +1 617 955 6699; e-mail: mwiener@ipgphotonics.com ■ Iurii Markushov, Alexei Markevitch, IPG Photonics Corporation, 377 Simarano Drive, Marlborough, MA 01752, USA; phone: +1 508 506 3813/2621, e-mails: imarkushov@ipgphotonics.com, amarkevitch@ipgphotonics.com, www.ipgphotonics.com

Laser applications for smart textiles

In the textile industry, lasers are already used in many ways. And cutting, bleaching, engraving, or positioning were just the beginning

Friederike Brackmann & Alexander Olowinsky

Textiles are not only used for clothing but have also found application in many other areas. They do not have to have electronic components to be considered smart textiles. For example, they can be combined with biomedical substances to detect germs and bacteria, or light can be guided along a fiber and emitted in areas where the surface has laser-induced defects. However, the most common combination is with electronic components.

Lasers can be used in a variety of ways in the textile industry. The first application was the cutting of patterns. Some advantages of the laser are the ability to follow complex geometries, no physical contact and consequently no stretching of the material and sealing during cutting when not only natural fibers such as wool or silk are used and part of the yarn is thermoplastic fibers. Some reasons for manufacturers to use a laser cutting system are the reduction of production time and costs, the extreme accuracy, the reduction of material waste and the adaptability to many materials. Another common application is laser marking and engraving, the main difference to cutting being in the depth of processing. The laser beam induces only slightly changes in appearance or coloration during laser marking. The marking itself is waterproof and extremely durable. Engraving can be done with the same equipment but with different process parameters [1]. Laser marking in textile technology replaces dry processes such as sand blasting, hand sanding, destroying, and grinding which are the most environmentally polluting technologies. Furthermore, the technique is faster, more accurate and versatile [2].

Smart textiles

The definition of smart textiles is that they are able to sense or react to environmental conditions or stimuli, which can be mechanical, thermal, magnetic, chemical, or electrical as well as from other sources. Examples of other functions of smart textiles are the release of medication or moisturizer, help with controlling the vibration of muscles, or the regulation of the body temperature. These examples mainly belong to the healthcare sector, but their use can be aesthetic as well to change the color, light up a fabric or, in the future, to display pictures and videos.

▲ **Fig. 1** Laser-bonded conductive track on textile (Source all images: Fh. ILT)

Smart textiles can be classified into three categories. Passive smart textiles have an additional feature not adapt-

ing to the environment such as a highly insulating coat or antimicrobial, anti-odor, antistatic or bullet-proof capabilities. Active smart textiles represent the second generation. Those textiles have actuators and sensors allowing them to adapt their functionality to the environment. Examples are shape memory, water resistance, or vapor absorbing fabrics and electrically heated suits. Ultrasmart textiles are the latest generation, and they can sense, react, and adopt to environmental changes and stimuli. Functional materials must be used to make textiles smart. Such materials are, for example, metal as a fiber or threads woven or knitted into the textile or added to conventional printing inks to create conductivity.

Another way is the use of conductive polymers maintain the natural texture of the material, while a variation in resistance over time and a high response time are two problems to name. Optical fibers integrated into the textile are used to transmit data signals or light and to detect deformations due to stress and strain. There are many more materials, but for the presented ones, lasers are already used as an alternative tool in laboratory scale for production [3]. What a conductive track applied with a laser looks like can be seen in Fig. 1.

Smart textiles have a wide range of applications, many of which are medical, sport, fashion, military, and personal protection. Medical uses are the most common as the textiles build a bridge between humans and wearable devices and can monitor several vital signs such as the heart rate, respiration rate and skin temperature. Textiles are flexible and lightweight and adapt to the shape of the human body. In fashion, illumination is the main interest, for example, multicolor LED fibers can be integrated into clothing [4].

Bonding of conductive tracks with a blue laser

A laser can be used to join conductive tracks out of metal foil on textiles. When a wavelength is chosen that is well absorbed by one of the joining partners – textile and metal – no additional preparation steps are needed. A pretreatment like punching might be needed to embroider conductive tracks onto textiles, depending on the structure and material. A disadvantage is the stiffness of embroidered areas as well as damage to the cloth by the needle.

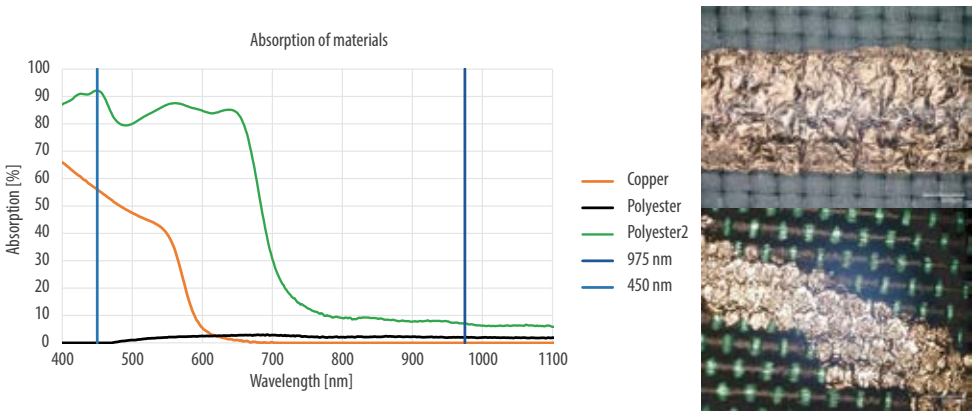


Fig. 2 Absorption of two polyester textiles and copper (975 nm and 450 nm are highlighted) and conductive tracks of the two textiles (Polyester on top and Polyester2 underneath)

Screen printing of conductive tracks is the other common method of creating conductive tracks, but screen production, changing and cleaning involve a great deal of effort while the pastes that are used show low conductivity and are toxic. With the use of a laser, no pretreatment is necessary, metal with a high conductivity can be used directly, and the laser process can be combined with other laser machining processes like cutting or engraving.

First trials were carried out with an optics system called Globo from Leister Technologies, which is specially designed for welding plastics. The laser beam within the optics is focused by an air-bearing, frictionless rotating glass sphere, which also acts as a clamping device applying the necessary joining pressure. The optics are built in combination with a diode laser system emitting a 975 nm beam at a maximum power of 100 W. The optics are fixed and an x-y axes system is used to join the two materials along specific paths and contours. The materials used were a copper foil and a polyester textile. One problem is that neither the metal nor the textile have good absorbance at this wavelength. An absorber is needed, which is an extra step in the process and not desirable. Nevertheless, it was shown that it is possible to bond the metal foil (copper) with a thickness of 1 µm with different types of textiles. Pure thermoplastic materials like polyamide and polyester were used as well as mixed fabrics consisting of polyester/cotton and polyester/viscose in various concentrations of the thermoplastic part.

Tensile tests and abrasion tests were carried out with an inspection of the conductivity of the tracks after a certain number of abrasion cycles. The results have shown that it is possible to create conductive tracks showing conductivity after 10,000 cycles with a decrease of about 30 %. The higher the proportion of thermoplastic fibers in the textile, the better the bonding of the metal foil to it. More material is melted that forms a bond of the basis of chemical and physical forces. Force and form fit are unlikely because of the surface structure and the materials itself. The amount of non-thermoplastic fibers has a big influence. On one hand, it is an important factor for the remaining tensile strength after the bonding; on the other hand, there is a decrease of abrasion resistance because of areas where no material is melted and forming a bond with the metal foil.

Blue lasers with a wavelength of 450 nm have become state-of-the-art in the manufacturing process of batteries. Copper has an absorption of between 50 – 60 % compared with less than 5 % for the NIR spectrum at 975 nm. This feature can be used to remove the absorber and the extra process step. The copper absorbs the energy of the laser and transfers the heat into the textile,

Company

Fraunhofer Institute for Laser Technology ILT

With over 480 employees and more than 40 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 more than 35 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 AKL'24

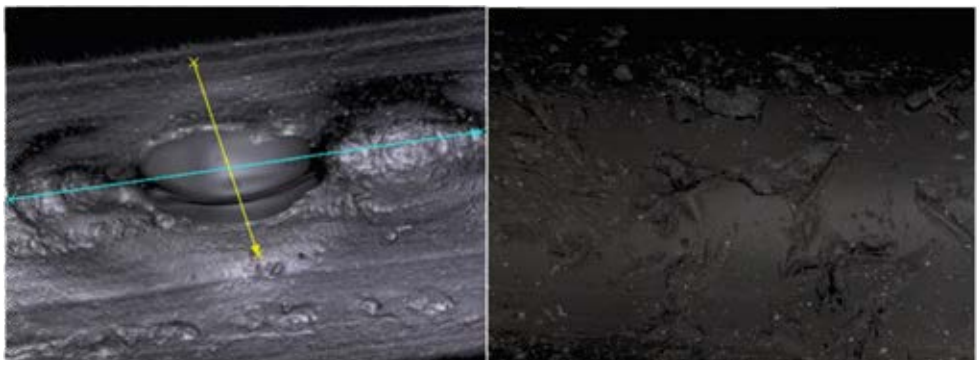


Fig. 3 left: thermal defect, right: mechanical defect

which partially melts where the heat is applied, and the tracks are built. The order of the stack must be considered depending on the color of the textile.

Fig. 2 shows the absorption of the copper foil and two textiles with a conductive track consisting of the same thermoplastic raw material (polyester) but different specifications of color and yarn density. It can be seen that the surface structure also has an influence on the appearance of the conductive track after bonding, and probably on the abrasion resistance as well. When the height difference between warp and weft is big, the abrasion is not equal and might lead to a destroyed conductive track without reaching 10,000 abrasion cycles. Another important factor for the durability in daily use is the washability and resistance against bending. These tests as well as finding parameters fulfilling the needs are planned in further investigations and trials. The research is part of the IGF project 22915 N "LasH-TexMat – Laser welding as a process for the production of hybrid textile material composites".

Author

Friederike Brackmann is a research assistant and project manager in the polymer welding and transparent materials group at the Fraunhofer ILT. She studied textile engineering at RWTH Aachen University, and her aim is to combine laser and textile technology.

Further author:
Dr.-Ing. Alexander Olowinsky, Fraunhofer ILT

Friederike Brackmann, MSc, Dr.-Ing. Alexander Olowinsky, Fraunhofer Institut für Lasertechnik ILT, Steinbachstr. 15, 52074 Aachen, Germany; phone: +49 241 890-6161, fax: +49 241 890-6121; e-mails: friederike.brackmann@ilt.fraunhofer.de, alexander.olowinsky@ilt.fraunhofer.de, Web: www.ilt.fraunhofer.de

Light emitting fibers to cure UV adhesives

Another way of using the laser for the production of smart textiles is the structuring of polymer optical fibers (POF) made of plastic. Their main application is short-range data transmission, but they are also used for light applications in textiles and sensor technology. Optical fibers out of silica perform better when transmitting light and data. In terms of elasticity or brittleness and the Young's modulus of the adhesive, the polymer fibers are preferable.

The curing time of adhesives ranges from seconds to days. Most adhesives have a long curing time but UV-curing adhesives complete their curing within seconds. Their sensitivity is in the wavelength range of 365 nm – 460 nm and they are based on acrylates or acrylate modifications. Photo initiators start the reaction and, depending on the layer thickness of the adhesive, it is completed after a few seconds. It is mandatory at the moment that one joining partner is transparent for UV-radiation. Joining non-transparent parts such as metals or filled plastics is not possible. The idea of the IGF project 22722 N "OpTexBond – Integration of fiber-optic textiles in bonded joints for the photo-initiated curing of adhesives on radiation-intransparent joining partners" is to create a solution for this problem. POFs are bi-component monofilament fibers consisting of a core made of polymethyl methacrylate (PMMA) and a thin fluorinated cladding. To use POFs to cure UV-adhesives, it is necessary to insert defects into the cladding to achieve lateral emission of the coupled UV radiation.

The defects can be manufactured chemically, mechanically, or thermally. What mechanical and thermal defects look like can be seen in Fig. 3. Thermal defects with a laser have the shape of a drop, and melt is pushed to the side and solidifies into mounds. Mechanical defects created with particles are like scratches at the surface, irregular in size and not controllable. Chemical defects are not controllable as well and they are made by placing the POF in acidic solution. When the surface of the POF is damaged, the total internal reflection is no longer fulfilled locally and light is coupled out in these areas. Simulations are used to determine the size of the defects and their distribution in order to achieve homogeneous emission over the entire surface to be bonded. A textile structured all over in the same contribution leads to an exponential decrease of the lateral emitted light. Not only is the process development a task at Fraunhofer ILT but also the development of an optical system adapted to the light coupling into the fiber.

*

The IGF project no. 2272 N of the Forschungsvereinigung Schweißen und verwandte Verfahren e.V. des DVS, Aachener Str. 172, 40223 Düsseldorf, is funded by the Federal Ministry of Economics and Climate Protection via the AiF within the program for the promotion of joint industrial research (Industrielle Gemeinschaftsforschung IGF) on the basis of a resolution of the German Bundestag. The IGF project no. 22915 N of the Forschungsvereinigung Forschungskuratorium Textil e.V. – FKT, Reinhardtstraße 41-16, 10117 Berlin, is also funded by the Federal Ministry of Economics and Climate Protection via the AiF within the program for the promotion of joint industrial research (Industrielle Gemeinschaftsforschung IGF). The authors would like to thank the companies of the project committee for their constructive cooperation, provision of equipment and test materials and for the stimulating discussions.

DOI: 10.1002/phvs.202400006

[1] *Y. P. Angelova:* Factors influencing the laser treatment of textile materials: An overview, Journal of Engineered Fibers and Fabrics, 2020; 15, DOI: 10.1177/1558925020952803

[2] *Y. Angelova, L. Lazov, S. Mezinska:* Innovative Laser Technology in Textiles Industry: Marking and Engraving, Proceedings of the 11th International Scientific and Practical Conference, Volume III, 12 – 21, 2017, DOI: 10.17770/etr2017vol3.2610

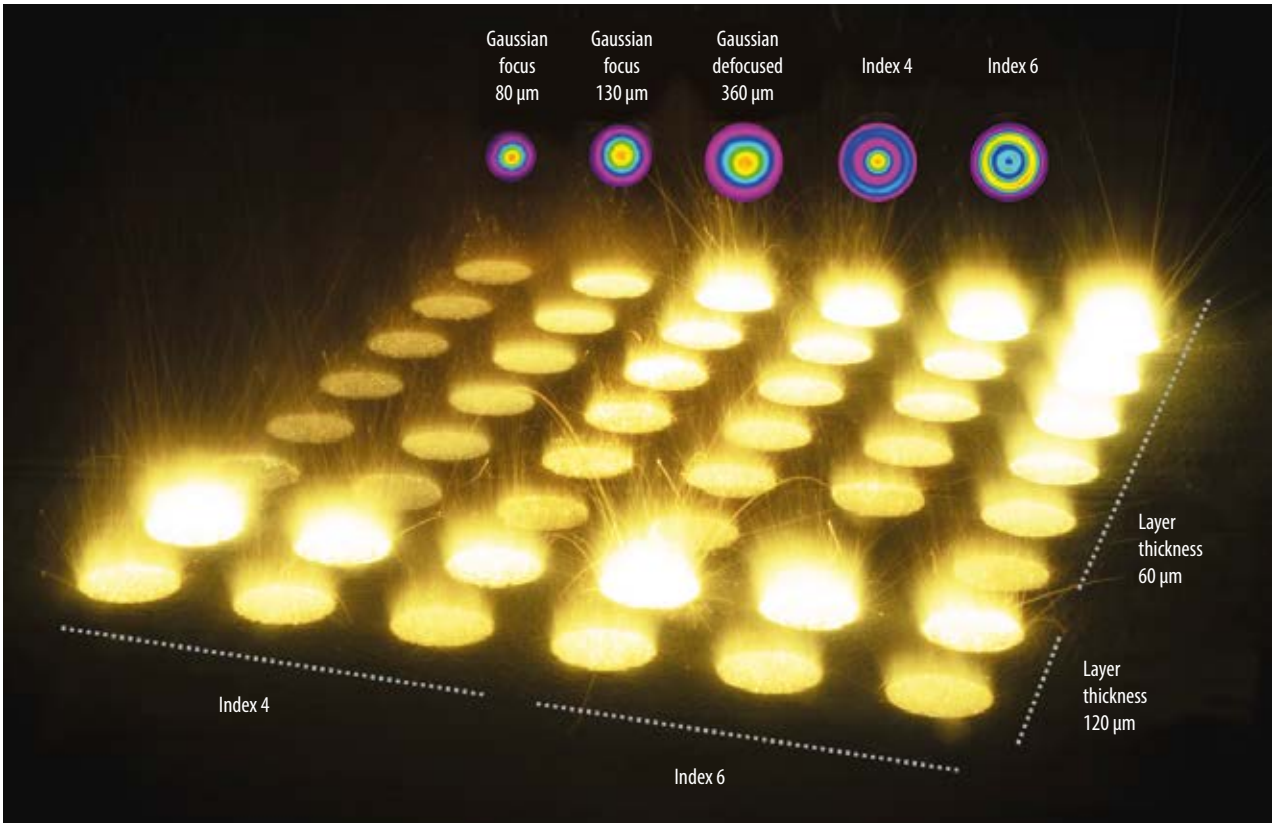
[3] *M. Syduzzaman, S. U. Patwary, K. Farhana, S. Ahmed:* Smart Textiles and Nano-Technology: A General Overview, J Textile Sci Eng 5:181, 2015, DOI: 10.4172/2165-8064.1000181

[4] *E. Ismar, S. K. Bahadir, F. Kalaoglu, V. Koncar:* Futuristic Clothes: Electronic Textiles and Wearable Technologies, Global Challenges 2020, 4, Wiley-VCH Verlag, Weinheim, DOI: 10.1002/gch2.201900092

The shape of things to come

All-fiber kW beam shaping enables high-productivity industrial processing

Dahv Kliner & Alex Kingsbury



All-fiber beam shaping is revolutionizing laser-based manufacturing. This capability is a commercially accessible reality in cutting, welding, and additive manufacturing tools released by leading integrators worldwide. These advanced tools increase productivity and part quality and introduce entirely new production capabilities, driving the displacement of legacy lasers and non-laser technologies in existing applications and spurring the development of new markets.

Material processing is the largest segment of the laser market, with macro processing (kW-class laser powers) making up over half of this segment through more than 3 billion US dollars of annual laser sales. Macro processing has experienced more than two decades of nearly uninterrupted growth, driven by several laser advances, including increased power, efficiency, and reliability, and a steady decrease in price. One technology has dominated these advances: fiber lasers, which now comprise well over half of the macro processing market. The dominance of fiber lasers results from their significant practical and performance advantages, particularly at high power, because of their elimination of free-space optics. Free-space optics and their associated mounts, alignment fixtures, and cooling infrastructure result in substantial system complexity and cost, increase size and weight (especially problematic for process heads), cause optical loss, suffer from thermal lensing at high power, and introduce instability and failure modes because of their sensitivity to alignment, environmental conditions, and contamination. Fiber lasers minimize or eliminate all of these problems.

▲ The build rate, material quality, and spatter production in a laser powder-bed fusion tool depend on the laser beam size and shape (Source: F. Eibl, Aconity3D)

In recent years, another trend has emerged that is providing further laser performance advantages in existing applications and, importantly, enabling entirely new capabilities. This trend is beam shaping, specifically the delivery of laser beams with optimized, tunable spatial and divergence profiles.

It has long been recognized that the laser beam size, shape, and divergence determine the materials processing per-

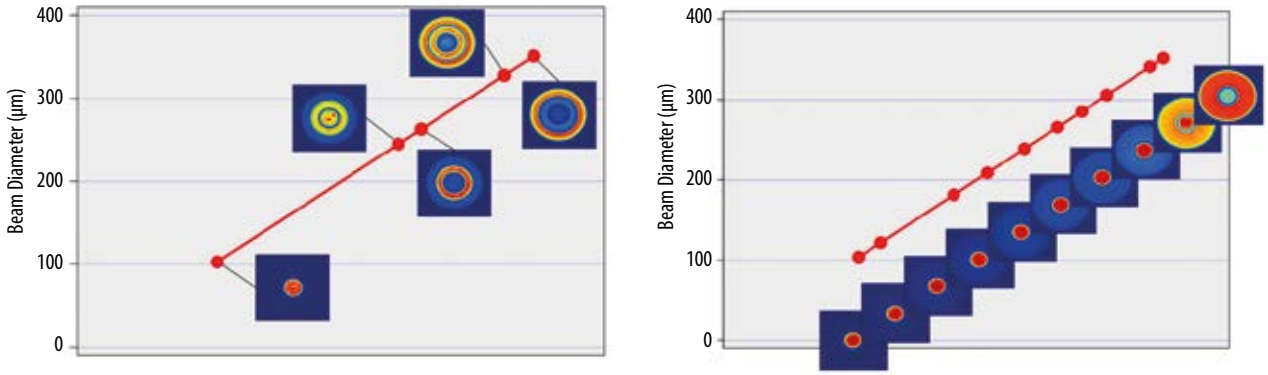


Fig. 1 Typical beam settings for three-zone (left, 3 – 5 kW) and two-zone (right, 3 – 20 kW) CFX fiber lasers used in metal cutting and welding. The images show near-field spatial profiles, and the corresponding second-moment ($D4\sigma$) beam diameters are given on the y-axes.

formance by controlling heat input into the workpiece, which in turn determines the feature size, part quality, production rate, process window, and process flexibility (e.g., materials compatibility). These metrics ultimately determine the tool productivity and versatility and thus the economics of the production process.

Most lasers have fixed beam characteristics, and various downstream methods have been developed to optimize and vary the beam shape. Most methods employ manually changeable or motorized free-space optics such as zoom process heads, fiber couplers with variable launch conditions, switchable optics, or deformable mirrors. These approaches have shown the value of being able to optimize and tune the beam characteristics, but they suffer from the known disadvantages of free-space optics.

More recently, a family of lasers has emerged that use all-fiber technology to provide a composite beam shape comprising a central spot surrounded by a ring. In this approach, different fiber lasers are coupled into different guiding zones (cores) in a fiber to provide the composite beam shape. While eliminating free-space optics, this technology is not tunable in the same sense as the previous free-space technologies because only one beam shape is available at full power. The laser power must be reduced in one of the guiding zones to realize other beam shapes. This design has proven advantageous in applications for which the desired beam shape is known and does not need to be significantly varied, such as welding in battery production lines.

Corona fiber lasers

nLight has developed an all-fiber technology, Corona, which allows real-time tuning of the beam shape with no loss of power [1]. Briefly, the output of a fiber laser is coupled (spliced) to a fiber that enables the beam characteristics (position, shape, etc.) within the fiber to be varied by perturbing the fiber, and the perturbed beam is 'trapped' in one or more separate guiding zones of a multicore output fiber to generate the desired beam shape.

The number and dimensions of the guiding zones in the Corona feeding fiber can be optimized for different applications. For example, Fig. 1 shows typical beam profiles for three-zone and two-zone feeding fibers in the CFX product family. In both cases, the diameter of the central core is 100 µm, and the outside diameter (OD) of the largest ring is 330 µm. For the three-zone fiber, the OD of the central ring is 215 µm. We have found that supplying predefined beam shapes, as shown in Fig. 1, is preferable to continuous tuning of the shape for process optimization and stability. Industrial lasers

Company

nLIGHT Inc.

nLIGHT Inc. is a leading provider of high-power semiconductor and fiber lasers used in the industrial, microfabrication, medical, aerospace, and defense markets. nLIGHT's industrial fiber lasers are used for materials processing, including metal cutting, welding, and additive manufacturing. nLIGHT is headquartered in Camas (WA, USA), with additional sites in Hillsboro (OR, USA), Longmont (CO, USA), Farmington Hills (MI, USA), Torino (Italy), Vienna (Austria), Lohja (Finland), Shanghai (China), and Seoul (South Korea). Its fiber lasers are sold worldwide through direct sales and a global distributor network. nLIGHT (LASR) is publicly traded on the US Nasdaq stock exchange.

www.nlight.net

Meet us at AKL'24, booth 55

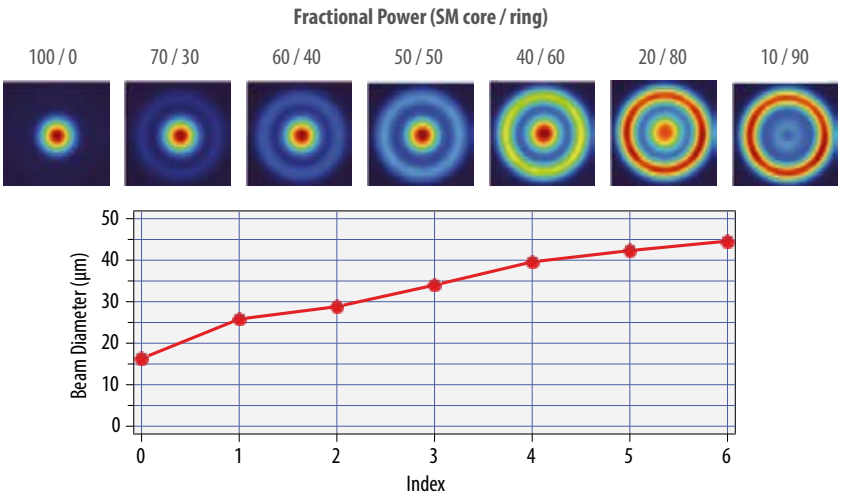


Fig. 2 Typical beam settings for AFX fiber lasers used in additive manufacturing and thin-sheet welding. The images show near-field spatial profiles, and the corresponding second-moment ($D4\sigma$) beam diameters are given on the y-axis.

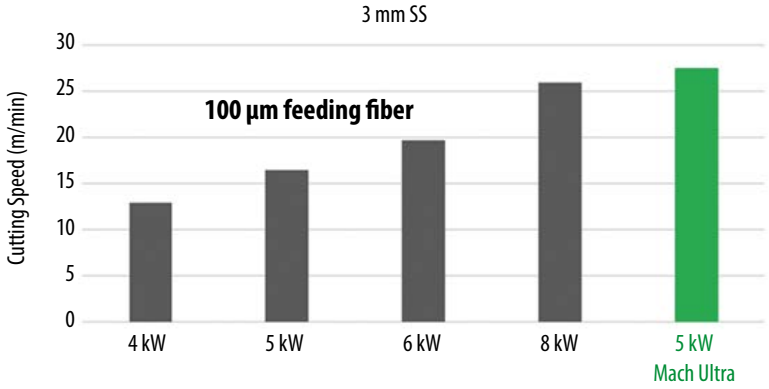


Fig. 3 Cutting speed for 3 mm stainless steel with N_2 assist gas for a conventional fiber laser (100 µm feeding fiber) at 4, 5, 6, and 8 kW (grey bars) and for Mach Ultra (50 µm beam diameter) at 5 kW.

are often deployed in electrically noisy environments, in which analog control signals can be unstable on a variety of timescales. By providing defined, digitally selectable beam shapes (known as 'Index' settings), the end user is ensured that the beam characteristics will be stable for years. CFX fiber lasers are widely used in metal cutting and welding. The settings shown in the left panel of Fig. 1 are those typically used for cutting. For welding applications, it is advantageous to provide additional beam shapes, as shown in the right panel of Fig. 1.

Fig. 2 shows typical beam profiles for the AFX product family, which employs a single-mode (SM) input laser. In this case, the central core provides an SM beam (mode-field diameter ≈14 µm), and the surrounding annulus has an OD of 40 µm.

Applications

Metal cutting

Metal cutting is the largest industrial market for high-power lasers, with laser revenue of >2 billion US dollars annually. This application was pioneered by CO_2 lasers. By 2017, fiber lasers had largely displaced CO_2 lasers because of their numerous advantages. In particular, for cutting thin sheet with N_2 assist gas, fiber lasers provided significantly higher cutting speeds. CO_2 lasers maintained an advantage, however, for one important application: cutting of mild-steel plate (thickness above ~6 mm) with O_2 assist gas, where CO_2 lasers offered significantly better edge quality than legacy, fixed-beam fiber lasers. As a result, job shops had to either accept poor performance for mild-steel cutting or maintain both CO_2 and fiber laser tools.

The initial CFX products addressed this longstanding problem [2]. The smallest (100 µm) index setting provides cutting speed and edge quality similar to conventional (fixed-beam) fiber lasers with standard 100 µm feeding fiber, maintaining the expected benefits of fiber lasers. The larger and ring-shaped CFX beams, not available in legacy fiber lasers, provide a dramatic improvement in O_2 cutting performance for mild steel, achieving cutting speed and edge quality that equal CO_2 lasers. Furthermore, the intermediate CFX Index settings (Fig. 1) can provide better edge quality for stainless steel and aluminum than that obtained with conventional fiber lasers, even those at higher power. CFX fiber lasers have thus enabled highly versatile metal-cutting tools. End-users can now have a single tool that performs optimum cutting for a range of materials and thicknesses rather than tolerating poor performance for some jobs or supporting multiple tools.

Having addressed the problem of thick mild steel cutting with the large ring-shaped CFX beams, we next considered fiber designs to optimize N_2 cutting performance for thin sheet metal (another large application). It is known that smaller beams provide faster N_2 cutting speeds, and some tools employ a 50 µm rather than a 100 µm feeding fibers, although the maximum thickness is then further restricted. We redesigned the CFX feeding fiber to provide a 50 µm Index 0 beam for faster N_2 cutting while maintaining the 330 µm annular guiding region for O_2 cutting of mild steel, in a product known as Mach Ultra.

We validated the cutting performance of Mach Ultra for both N_2 and O_2 cutting [1]. Fig. 3 shows the N_2 cutting speed for 3 mm stainless steel for a conventional 100 µm fiber laser at powers of 4 – 8 kW (grey bars). The green bar shows the cutting speed for 5 kW Mach Ultra (Index 0). The Mach Ultra cutting speed at 5 kW is equivalent to that of a conventional fiber laser at 8 kW, illustrating the dramatic benefits of delivering the laser power in an optimized format. The ability to

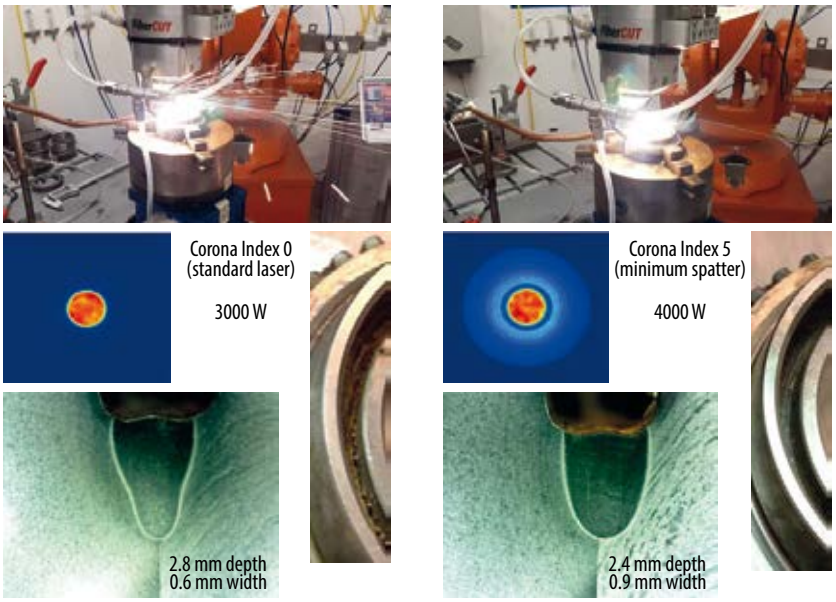


Fig. 4 Powertrain weld tests performed at the same speed, showing significant spatter reduction when using CFX. Spatter particles are visible both during the welding process (top photos) and in photos of the finished parts. (Source: Optoprim / nLight, first published in: Industrial Laser Solutions, p. 9, Sept./Oct. 2019)

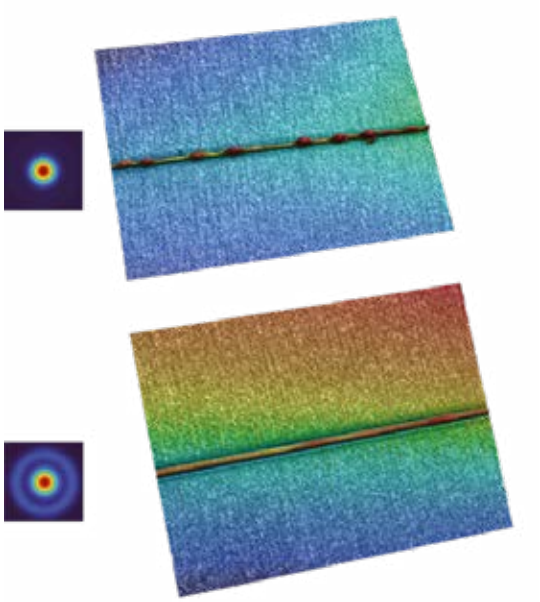


Fig. 5 Welding of 50 µm stainless steel bipolar plates for fuel cells. Both welds were performed at 1.3 m/s and 1 kW laser power, and the images show 3.4 mm of weld seam. The humping defect is evident in the SM weld (upper) and has been eliminated in the AFX weld (lower). (Source: D. Bartels, BLZ).

use a lower laser power while maintaining the same cutting speed and edge quality provides a lower cost per manufactured part by reducing both the up-front cost (laser and chiller) and the operating costs (electricity, downtime for cleaning or replacing optics in the cutting head). As expected, Mach Ultra maintains excellent performance for O_2 cutting of mild steel using the 330 µm donut beam.

Metal welding

Metal welding is the second-largest industrial market for high-power lasers, with significant growth driven by automotive applications. Lasers provide substantially higher throughput than conventional welding processes and can generate precise, low-heat-input welds, resulting in increased productivity and part quality. The high power and beam quality of fiber lasers enables 'keyhole welding' (so called because of the creation of a high-aspect-ratio vapor channel), which provides high speed and minimal distortion or heat-affected zone. Use of a larger spot size results in a shallower conduction weld, which is advantageous for aesthetic reasons and to minimize post-processing steps. Different beam properties at the workpiece are required to transition between these two welding modes and to optimize the weld quality for different materials and joint designs. CFX's tunable beam shape (Fig. 1) allows the weld depth and width to be tailored, providing the best performance for each weld.

In keyhole welding, spatter is a well known problem that can cause contamination of the finished part (requiring post processing and causing latent failures), a reduction in weld quality, and contamination of the tooling (increasing consumables and maintenance). To reduce spatter, the keyhole stability must be improved and the collapse of the vapor channel prevented. The Corona beam shape directs laser power where it is needed to open the keyhole, and the beam tunability provides minimum spatter for a wide range of materials and welding speeds. For example, Fig. 4 compares spatter generation when welding medium-carbon steel parts representative of an automotive powertrain using a standard beam shape and an optimized CFX beam shape.

Welding of thin metal (~50 µm – 2 mm) is becoming increasingly important for e-mobility applications, including the production of batteries and fuel cells, with high volumes demanding high welding productivity and quality. These applications require lower powers and smaller beams than the welding examples above, and SM lasers are usually used.

A typical fuel cell for an electric vehicle requires >1 km of weld seam in the bipolar plates within the fuel cell. Using an SM laser, the weld speed is limited to <1 m/s by potential humping defects, and increasing the laser power does not allow faster weld speeds. Work at both the Bavarian Laser Center (BLZ) and the Edison Welding Institute (EWI) has shown that AFX can increase the welding speed on stainless steel foil to at least 1.3 m/s without humping and while maintaining a narrow weld seam (Fig. 5). Similarly, AFX welding of high-strength aluminum stabilizes the melt pool depth and width, reduces hot cracking, decreases surface roughness and humping, and increases the process window [3].

EWI researchers showed that AFX can be used to control the weld penetration depth and interface width when welding 250 µm foils of aluminum to copper in a battery cell welding application. They also demonstrated that AFX can significantly reduce the spatter when welding aluminum and copper (key materials employed in battery production), similar to the CFX results shown in Fig. 4.

In the AFX welding examples above, the optimum beam shape depended on the material and the welding speed, highlighting the unique Corona benefit of maintaining full power for all beam shapes, thereby maximizing the versatility of the tool.

Additive manufacturing

In contrast to cutting and welding, additive manufacturing (AM), and specifically laser powder-bed fusion (LPBF), represents a smaller but rapidly growing market. The ability to fabricate parts that are lightweight, high in complexity, and easily customizable is essential for applications such as aerospace, medical, dental, and industrial. Since its inception in 1995, LPBF has emerged as the leading candidate for high-volume production of additively manufactured parts. CO_2 lasers were used in early LPBF machines, but fiber lasers were quickly adopted due to their higher power density and reliability.

To date, the accepted standard in LPBF tools has been an SM fiber laser, although this approach has several disadvantages. At power densities that ensure complete melting across the melt pool,

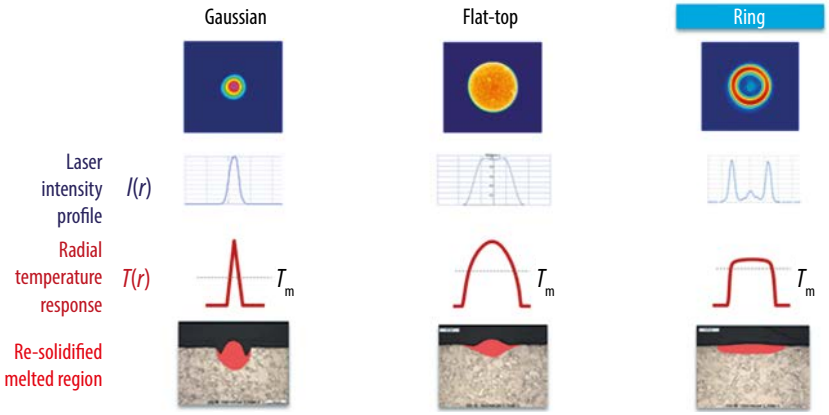


Fig. 6 The effect of beam shape on the melt-pool temperature profile and resultant material cross section (aluminum alloy). T_m denotes the melting point of the material.

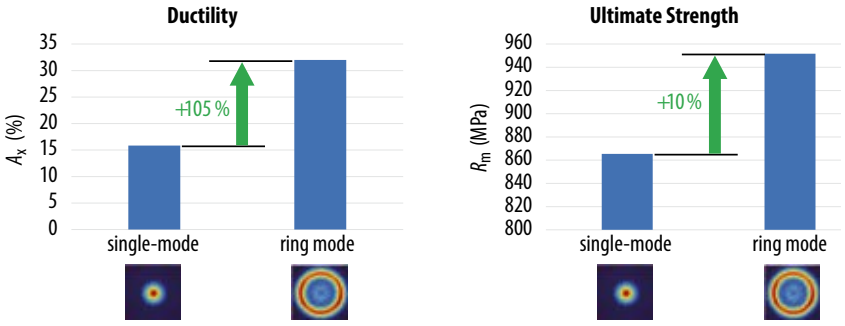


Fig. 7 Mechanical properties of Inconel 718 fabricated using an LPBF tool equipped with AFX (Source: M. Bechers & F. Eibl, Aconity3D)

the high intensity peak in the center of the Gaussian beam translates to a heat input and corresponding temperature profile that is above the boiling point, causing melt-pool instability. When depositing alloys, the non-uniform temperature profile causes vaporization of the lighter, lower-boiling-point elements, such as magnesium and zinc, causing compositional variance in the fabricated part. Additionally, the melt pool experiences a Marangoni effect with the central downwards force of the Gaussian beam, leading to ejection of material from the melt pool into the gaseous processing environment. This material, observed as soot and spatter, is the leading cause of porosity and other defects in LPBF-fabricated components (similar to the effects discussed in welding above).

Modifying the beam shape changes the temperature response within the melt pool and thus the cross section of the solidified LPBF track, as illustrated in Fig. 6. An SM beam shape results in a strongly peaked temperature profile, which can result in material 'balling' or 'humping' (as well as porosity, soot, spatter, and compositional variability) [4]. The situation is improved using a flat-top beam shape, but the temperature profile still exhibits a central peak. Transferring power from the center of the beam to the periphery allows the temperature profile to be flattened, as shown for the ring beam [5]. The ideal beam shape is material dependent, and the ability of AFX to vary the power distribution between the central SM spot and the ring (Fig. 2) is essential for optimizing the temperature profile and thus the LPBF process and material quality.

A higher melt-pool stability expands the LPBF process window, allowing the laser power (i.e. heat input) to be increased, which in turn provides higher productivity by enabling faster scan speeds and larger layer thicknesses without compromising quality. Using AFX, a material density of >99.5 % has been reported in parts made up to 7× faster than is possible with an SM beam, vastly improving the economics of additively manufactured parts [4, 6].

In addition to addressing longstanding LPBF limitations, AFX introduces an entirely new capability to AM. Multiple groups have shown that controlling the thermal profile in the melt pool leads directly to control of the microstructure and thus the local material properties, opening the possibility to achieve previously unattainable performance and functionality in LPBF-fabricated parts. For example, Fig. 7 shows the measured ductility and ultimate strength of Inconel 718, fabricated with a standard SM beam and with the AFX ring beam. In addition to being able to tune these important properties locally, AFX allows both to be increased simultaneously, in contrast to bulk materials, in which they are often anticorrelated.

Conclusions

All-fiber beam shaping is revolutionizing laser-based manufacturing in both established and emerging applications. This capability is a commercially accessible reality in CFX- and AFX-based tools released by leading integrators.

DOI: 10.1002/phvs.202400012

[1] *D.A.V. Kliner* et al.: Proc. of SPIE 11981, p. 119810C (2022), and references therein.
[2] *D.A.V. Kliner and B. Victor:* Industrial Laser Solutions, p. 23 (Sept./Oct. 2018).
[3] *F. Nahr* et al.: J. Manuf. Mater. Process. 7, p. 93 (2023).
[4] *J. Grünewald* et al.: Metals 11, 1989 (2021); J. Laser Appl. 35, 042009 (2023).
[5] *A. Rudolf:* Photonics Views 20(1), p. 28 (2019); https://doi.org/10.1002/phvs.202300008
[6] *T. Lantzsch* et al.: Proc. of SPIE 11994, p. 1199405 (2022).

Authors

Dahv Kliner

is the vice president of fiber laser technology at nLight and has been developing fiber laser technology and products for more than 25 years. He obtained a PhD from Stanford University. Dahv joined nLight in 2012 to start the industrial fiber lasers business unit, whose high-power fiber lasers provide industry-leading performance, productivity, and reliability. These lasers have garnered several innovation awards, including a Prism Award and two Laser Focus World Gold Innovators Awards. Dahv has co-authored more than 100 publications and 67 issued patents.

Alex Kingsbury

is the AM market development manager at nLight. She has worked in metal AM in technical, leadership, and advisory roles for 13 years. Prior to joining nLight, she held leadership positions at CSIRO and RMIT University, both in Melbourne, Australia. She also maintained a private consultancy, Additive Economics, to provide expert, strategic advice to investment firms, company boards, and government agencies on the commercialization of and investment in advanced manufacturing technologies. Alex is a graduate of the Australian Institute of Company Directors and holds a bachelor of engineering from RMIT University.

Dahv Kliner, nLIGHT, 5408 NE 88th St Bldg. E, Vancouver, WA 98665, USA; e-mail: dahv.kliner@nlight.net, Web: www.nlight.net, dahv-kliner-0655146 nlight

Lasers – smart tools with a bright future

Whether in energy, mobility, environmental or production technology, lasers have many advantages as measurement instruments or as production tools

Source: Fh. ILT

The social challenges we are facing with energy, the environment, mobility and health require innovative solutions. Intelligent and economic measurement and production processes are needed for these. The laser can provide them – today and also tomorrow.

It was a scientific race that was won on 16 May 1960 by Theodore Maiman: the development of the laser. Since then, this optical tool has continued its triumphal progress in industry over the following decades. It would be hard to imagine many different production processes today without lasers: they are always used when it comes down to precision, versatility, and focused energy. But how much future potential do lasers still have? Experts at the Fraunhofer Institute for Laser Technology ILT and its partner companies are certain that it is considerable.

Energy technology without laser technology? Unthinkable

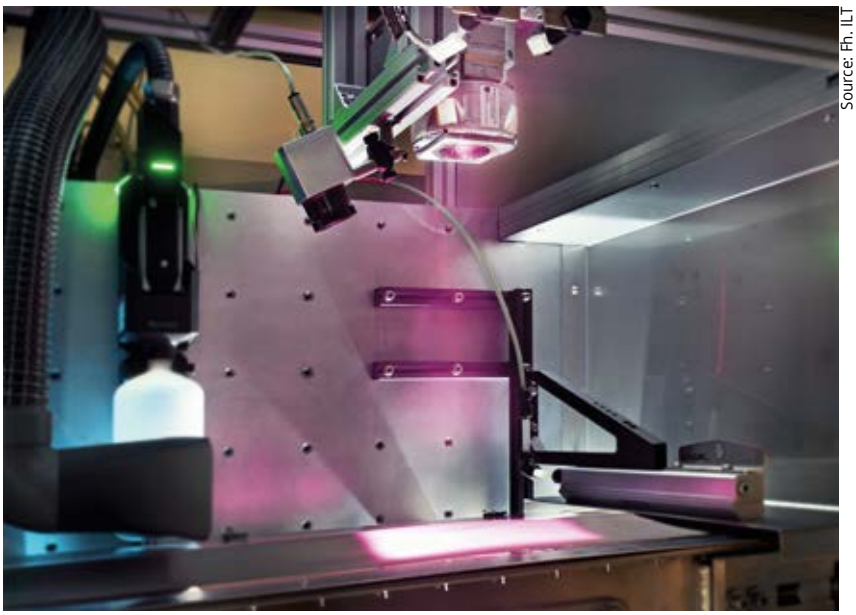
Innovations are necessary to counter climate change, also in energy technology: away from fossil energy sources, over to renewable energy. Lasers play an important role in this. Solar cells, for example, would not be possible without them: they are needed to make the contacts of the PERC and perovskite cells on the rear as well as for the connection of thin film cells and for laser coatings that ensure high efficiency. Lasers are also the first choice for classic cutting tasks and the removal of layers in multi-layer systems in organic solar technology. With regard to the further optimization of photovoltaics, the laser is not slowing the flow: the bottleneck is in the development of new, more efficient materials.

▲ 3D printing of a Fraunhofer ILT lettering made of three different powder materials as a demonstrator component for the new, highly productive EHLA 3D process.

It is another picture in the world of electromobility however, in particular in battery manufacture or when fabricating electric motors and the

power electronics. "The costs in electromobility are the decisive factor", says Reiner Ramsayer of Robert Bosch, Renningen. "Ultimately, German industry is in competition with other countries around the world – we can only win if we have higher productivity and efficiency, that is, with innovations that can only be realized with lasers." Lasers have advantages for joining tasks, and with new product features that are either more expensive or otherwise impossible. "On the one hand it is not really sensible to replace state-of-the-art processes with lasers, but near the physical limits, a laser can often go that one step further", Ramsayer stresses. One example of this is customized beamforming that the researchers at Fraunhofer ILT are developing. "Multibeam applications when drilling are made possible as are depletion processes with nanometer accuracy, or process-adapted dynamic changes in the melt pool when welding", says Prof Arnold Gillner, head of the business development department at Fraunhofer ILT. "We really do have an extremely versatile tool in the laser that we are currently only using to a fraction of its capability."

The Fraunhofer ILT provides customers an overview of the manufacturing process in its battery laboratory, including the various laser stages. Innovation arises ultimately not from an individual process, but out of the optimizing of a complete process. There is a fundamental question here: how can costs be reduced by using lasers, and efficiency increased? There is a lot of potential in the drying of electrodes after the wet coating process. The hot ovens that have been used to date not only take up a lot of space but are also real energy guzzlers. "The process can be a lot more efficient using a combination of an oven and a laser", explains Gillner. The electrodes are then pressed firmly together to ensure good conductivity – without the use of a laser. But the laser is the star in the next step of the production process: it generates a surface structure on the electrode that improves the quick charging ability and long-term stability of the battery. The following notching stage with a laser cuts the electrodes, a step in their production that has a direct effect on the quality and the life of the battery cell. The laser has the advantage over stamping here in that it never becomes blunt. The joining of different laid out layers and the joining of many cells together to form a battery pack are also jobs for the laser.


Source: Fh. ILT

Drying the electrodes with a diode laser: thanks to the special optics, the laser irradiates a larger area of the copper foil coated with graphite paste. The interaction of the graphite particles with the light energy generates heat and the liquid evaporates.

Not only new forms of energy generation are on the market; also old methods such as turbines will continue to be used. In future, they will not be working so much in gas-powered power stations but rather in hydrogen-driven generators to produce electricity. "High-current DC power lines to transport energy in which high-temperature superconductors are used that show no electrical resistance at minus 77 degrees Celsius – the first applications of superconducting cable are already in use. Lasers are needed here to provide pulsed laser deposition for the precise composition of the functional superconductor layers", says Gillner. Does it make sense for young people to get involved in laser technology? "Definitely!" says Ramsayer. "We need young people to maintain our lead in manufacturing and hardware." Gillner agrees with him: "It will never be boring with laser technology. We are always finding new applications, such as weed-killing by laser."

Additive manufacturing with lasers

If surfaces are to be coated or repaired, laser deposition has established itself as an ideal method, and it could soon be even more in demand. The clever use of lasers is not only efficient but also sustainable. They enable savings in the use of valuable materials, and the creation of characteristics at the edges of tools that could otherwise only be achieved


Robert Bosch

Reiner Ramsayer
Robert Bosch


Fh. ILT

Prof. Dr. Arnold Gillner
Fraunhofer ILT

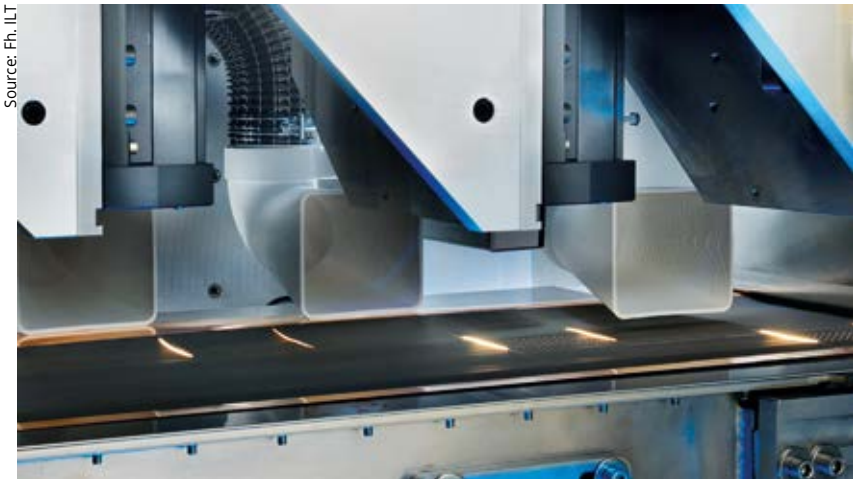

Voestalpine

Dr. Stefan Leuders
Voestalpine additive manufacturing center


Fh. ILT

Dr. Thomas Schopphoven
Fraunhofer ILT

Source: Fh. ILT



When creating the hole structures in the battery electrode, the ultrashort pulse laser works with four scanner modules, each equipped with six partial emitters.

with expensive alloys. The Austrian company Stahl- und Technologiekonzern Voestalpine also uses laser deposition – especially for tool and form construction. "We specialize in wear protection coatings and the repair of tools, for example for applications in heat forming and pressure casting", says Dr Stefan Leuders, head of technology and innovation at the Voestalpine additive manufacturing center. He sees a need for further development to provide an efficient laser deposition manufacturing process, amongst other aspects in the CAD/CAM programming to automatically create a tracking plan based on a digitized tool, which is very important for small production runs.

The researchers at Fraunhofer are also working on raising the further potential of laser deposition. "We want to better understand the processes, optimize them and save resources through digitalization – in particular by process simulation and the use of artificial intelligence such as machine learning", explains Dr Thomas Schopphoven, department head at Fraunhofer ILT. "We are also developing the processes for new materials and alloy types for brand new applications, such as hard chrome replacement." With regard to system technology, the researchers are investigating hybrid manufacturing whereby the laser-deposited coating layer and the machine finishing can be combined into one manufacturing step. "This enables a production time saving of fifty percent and also to deposit formerly unsuitable materials", says Schopphoven.

A core element of research in the department is the patented high-speed laser deposition process, known as EHLA, which was developed jointly by the Fraunhofer ILT and the RWTH in Aachen. "EHLA allows us to deposit tenth of a millimeter thick layers on large areas in a very short time, economically and using resources efficiently", says Dr Wilhelm Meiners, chief scientist for additive manufacturing at Fraunhofer ILT. "The productivity and resolution are improved so much in this way that they are way above those of normal laser deposition methods." Hundreds of EHLA systems are already on the market. The new method shows its strength above all in the coating of rotation-symmetric components. The researchers are currently optimizing the method for the processing of free-form areas and for the complete construction of complex new parts.

Until now, such complete manufacturing was achieved mostly with laser powder bed fusion (LPBF), material deposition in a powder bed within an enclosed process cabinet. "The biggest challenge for the industry is reducing the cost per part", Tim Lantzsch, department head at Fraunhofer ILT, is sure. Opportunities for cost reduction can be found in beam shaping or adjusting the process so that less support structures and postprocessing are necessary. Besides the requirement for high productivity, reproducibility and robustness are factors that concern both researchers and users. "As a laser institute, we want to solve them with knowledge of laser technology and mastery of processes. How can we make the melting process more efficient? How can we convert higher laser power into higher build rates?" explains Meiners.

The researchers of the Fraunhofer ILT are also looking at the broad fields of digitalization and life cycle assessment, with a concentration above all on quality assurance. How can wrong or defective parts be recognized as early as possible by appropriate monitoring systems or AI-based classic data processing? Sustainability and saving energy and CO_2 emissions are at the center of life cycle assessment: tools produced with LPBF offer much potential, in particular during their use, for example in aluminum die casting. "Just by using additively manufactured tool elements, we were able to demonstrably save sixty tonnes of CO_2 a year and casting cells in a foundry because the scrappage sank by three percent points through thermal optimization of the process, whereby less aluminum was in circulation that had to be re-melted", says Leuders. "Further savings in the CO_2 calculation arose

Fh. ILT

Dr. Wilhelm Meiners
Fraunhofer ILT

Fh. ILT

Tim Lantzsch
Fraunhofer ILT

Adlares

Matthias Ulbricht
Adlares

Fh. ILT

Hans-Dieter Hoffmann
Fraunhofer ILT

Source 3 images: Adlares

As part of the BMBF-funded project "CHARM – CH_4 Airborne Remote Monitoring", the Adlares helicopter (top right) with a lidar system on board (right) flies at a speed of 300 km/h along a gas pipeline several 10,000 km long to detect gas leaks (left)

directly for the additive manufacturing compared to the conventional machining route, although the biggest advantages are definitely in the usage phase of thermally optimized tools."

Lasers for lidar applications

Lasers are also used for light detection and ranging – lidar – optical distance and speed measurement similarly to radar. We see lidar applications ever more often in mobility applications, but they are also important for security and environmental technology as well as in meteorology, for example as used by the Teltow-based company Adlares. They have already been checking long-distance gas pipelines for leaks for many years. This is typically done by walking along the lines with a gas detector. However, while the original motivation to find leaks using airborne detection was security, in the meantime it has become the reduction of climate-damaging gases, in particular methane. "The new EU methane regulations present additional challenges in pipeline monitoring, and airborne-supported checks are the most sensible approach in many cases", states Matthias Ulbricht, CEO of Adlares. The technological challenges lie above all in obtaining the necessary sensitivity of the lidar systems to be able to detect even the smallest amounts of gas, coupled with the inhospitable environment of a helicopter for a laser. "The measurement frequency of 1,000 Hertz enables us to detect gas leaks of 150 liters an hour and less while travelling at up to 180 kilometers an hour – we can even detect the gas emitted by a single ruminating cow", Ulbricht confirms.

The cooperation between Adlares and the Fraunhofer ILT led to the measurement frequency being raised to 1,000 instead of the previous 100 Hertz, making the method much more economic. The researchers use Innoslab technology for airborne gas detection that enables powerful and economic laser amplifiers. "Fiber lasers cannot achieve the high pulse power with the necessary narrow bandwidth, disk lasers are too large, and lasers with cylindrical laser rods are limited to medium power. In contrast, Innoslab lasers are ideal for this range of operating parameters: they can run 24/7 and reach high pulse repetition rates", says Hans-Dieter Hoffmann, head of the laser and optical systems department at the Fraunhofer ILT.

Lidar systems not only make sense for airborne gas detection but also for satellite-based systems. "The Innoslab technology was already loved at Airbus in 2006", Hoffmann remembers. It made the jump into space with the Merlin and Aeolus projects in which both Airbus and Fraunhofer ILT were involved." The aim of the German-French demonstrator Merlin mission was to measure the local methane concentration in the atmosphere", explains Lucía Pérez-Prieto, project manager for optical

Airbus

Lucía Pérez-Prieto
Airbus Defence and Space

Fh. ILT

Prof. Carlo Holly
Fraunhofer ILT

Fh. ILT

Peter Abels
Fraunhofer ILT

Trumpf

Dr. Volker Rominger
Trumpf

Source: Fh. ILT

Life cycle assessment: Fraunhofer ILT is investigating how sustainable the LPBF process is in the development of process and system technology

instruments at Airbus Defence and Space. "Merlin is a flagship project for Germany: we can show for the first time that our lidar systems for the forthcoming space missions have a resolution that is much better than before." While Merlin is watching the climate change, Aeolus concentrates on weather forecasting. "Aeolus was the first attempt to measure the wind speed globally from space – this was so successful that an operational mission is being planned", says Pérez-Prieto. According to the plan, Airbus and Fraunhofer ILT will develop the lidar system for Aeolus 2. The main challenge will be that the laser must work reliably under the inhospitable conditions of space for seven years – maintenance-free of course. The experience gained will be fed into other R&D projects, in particular the management of large projects and quality assurance. "We have learnt a lot about these aspects from Airbus", confirms Hoffmann.

Artificial intelligence meets laser technology

An unparalleled future technology that has a lot of potential is artificial intelligence. It is therefore not surprising that it is not being ignored in the world of lasers. The combination of AI and laser technology only begins to make sense for the development of optical systems. It can quickly deliver a set of ten to more than twenty degrees of freedom – trial and error and iterative processes are the usual method of optical system design. Automated methods of optics design can simplify these procedures. "We use reinforcement learning here", explains Prof Carlo Holly, department head at Fraunhofer ILT and chair of 'Technologie Optischer Systeme TOS' at the RWTH Aachen University. "This approach is based on natural learning: was a decision good or bad? Certain behavioral structures are reinforced in this way." The researchers couple the virtual model of the agents with a classic optics ray tracing program – the agents then carry out the same actions that an optics designer would. They alter curvature radii, add or move lenses. The researchers are currently working with three or four lenses to understand the mechanisms.

Optical neuronal networks are closer to the application. These are not, as usual, part of a computer but consist of diffractive optical elements placed behind one another. Such optical neuronal networks are interesting, for example, for beam-shaping – they work, after all, in a similar way to holograms. "New degrees of freedom arise in this way, and a laser beam can demonstrate different levels of intensity – top hats or Gaussian distributions for example – along the direction of propagation. It is possible to form a 3D beam", enthuses Holly. And that is based on the same algorithms that are used for neuronal networks in computers.

Artificial intelligence also becomes exciting when analyzing process data – such as when various information about the process becomes available from numerous sensors. "This is a point at the birth of machine learning: it makes statements possible of a quality that was impossible ten years ago", Peter Abels, group leader at Fraunhofer ILT, is convinced. The visual monitoring of melting material or detection of breakthroughs when welding with laser beams – whether after the process, in real time or, in the future, allowing AI to regulate the process. "AI can more accurately distinguish between good and bad parts and find the causes", says Abels. The family-run company Trumpf has also discovered AI as a tool to address complex problems. An example is the 'TruLaser Center 7030' – a machine that cuts parts by laser and autonomously stacks them. "The complexity of the machine was too high to manage with conventional methods, so we used AI", explains Dr Volker Rominger, who has been working on laser technology for Trumpf for fifteen years. Artificial intelligence can also help with process control, for example with the quality-optimized welding of hairpins for e-vehicle batteries. While a human observer can easily recognize the end of a hairpin, this is a difficult task for conventional image processing – in particular when ambient conditions such as the light are constantly changing. "AI helps to find the unusual ones and instruct the machine to weld at the correct point under changing environmental conditions. AI has enabled us to reduce incorrect classification to a minimum", says Rominger. But what about a machine that controls the whole process itself using AI? "I think it is realistic in the long-term to have an expert machine where artificial intelligence makes the correct decisions in the background", says Rominger.

Carlo Holly and Peter Abels agree that the question of 'If' with regard to AI is obsolete. "It is much more a question of 'When?'. Those who do not use AI will lose out. Artificial intelligence will arrive – actually, it's already here." And with it come further exciting and future-oriented applications for lasers.

*

Text: Dr. Janine van Ackeren, freelance science journalist, Duisburg, Germany

Further Reading

T. Schopphoven, J. H. Schleifenbaum, S. Tharmakulasingam, O. Schulte: Setting Sights on a 3D Process, PhotonicsViews **16** (5), first published: 09 October 2019; https://doi.org/10.1002/phvs.201900041

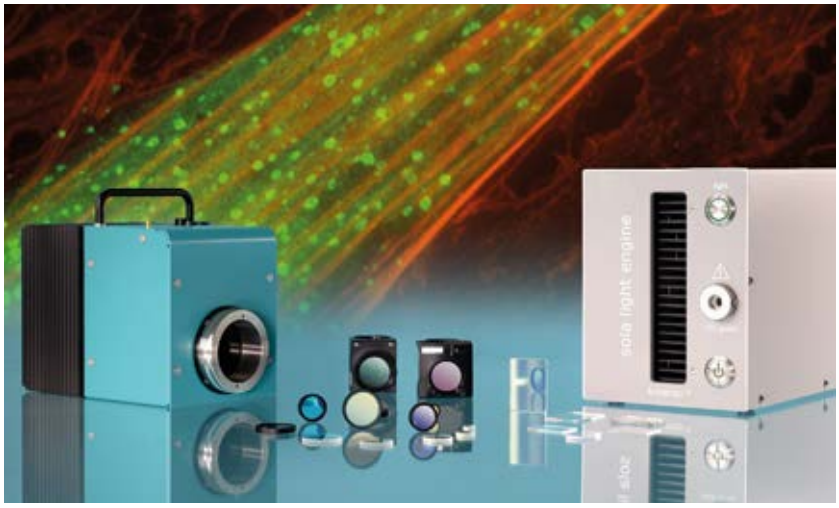
M. Grolms & V. Glushych: SMaC sets new standards in coating and surface finishing, PhotonicsView **20** (6) December 2023 https://doi.org/10.1002/phvs.202300042

New lasers for climate research, PhotonicsViews **20** (4), 60-63, first published: 15 June 2023; https://doi.org/10.1002/phvs.202300024

Expertise in spectral analysis and photonics

AHF analysentechnik is your expert partner in optical filter designs and microscope accessories for industry and research laboratories. AHF offers products which have proved their quality in many fields of applications, such as fluorescence microscopy, multiphoton spectroscopy, cell analysis, laser and Raman spectroscopy also including super-resolution techniques with optical resolution beyond the Abbe limit (TIRF, STED, PALM, STORM, etc.).

The range of products covers hard-coated singleband, multiband and interference filters, beamsplitters, dichroics and mirrors from prestigious manufacturers available as single filter or filter sets completely mounted in microscope-specific cubes. Customized filter designs, prototyping and OEM solutions can also be provided. Powerful LED light sources, image splitters and tools for quality monitoring of fluorescence imaging systems are part of the portfolio as well.



AHF started in 1981 and has grown over the years. Its customers benefit from long-term and interdisciplinary expertise. The team of AHF gives manufacturer-independent product advice and helps the customer to find the right optical filter design or accessory equipment for his specific application and instrument. In many cases, optical filters and LED light sources can be provided for testing.

AHF analysentechnik AG

Kohlplattenweg 18
72074 Tübingen, Germany
phone: +49 7071 53952-00
e-mail: info@ahf.de
Web: www.ahf.de

analytica, Booth A1.402

Edmund Optics – supporting its customers through two distinct service offerings!

Edmund Optics is a leading global provider of optical technology solutions that has been serving a variety of markets since 1942. The company employs more than 1,250 people across eighteen global locations and continues to expand.

Edmund Optics services its customers through two distinct offerings: its **marketplace** and **optical manufacturing services**! Learn here how Edmund Optics can best support you!

The **Edmund Optics' marketplace** is a one-stop shop for the best brands and products in optics and photonics with off-the-shelf products available for immediate shipping. Sporting over 34,000 products from the world's top optics, imaging, and photonics brands, the **Edmund Optics' marketplace** has one of the world's largest selections of optical components and has been voted the #1 preferred supplier of optical components for fourteen years in a row.

Edmund Optics' optical manufacturing services include custom design, prototyping, and volume manufacturing of high-quality optical and imaging components and systems. From design to prototype to production, Edmund Optics manufactures over two million optical components and over 175,000 optical assemblies every year. With in-house design, manufacturing, and metrology expertise and resources across our four design centers and eight specialized factories across the globe, Edmund Optics is supporting your scale volume or custom manufacturing requirements. Our expert team of Edmund Optics' optical and optomechanical designers, project managers, and manufacturing engineers will seamlessly support you from the ground-up and at each step of your project journey.

Edmund Optics, your partner for customized optics.

Edmund Optics GmbH

Isaac-Fulda-Allee 5
55124 Mainz, Germany
phone: +49 6131 57 00-0
e-mail: sales@edmundoptics.de
Web: www.edmundoptics.de

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 and spectrometers

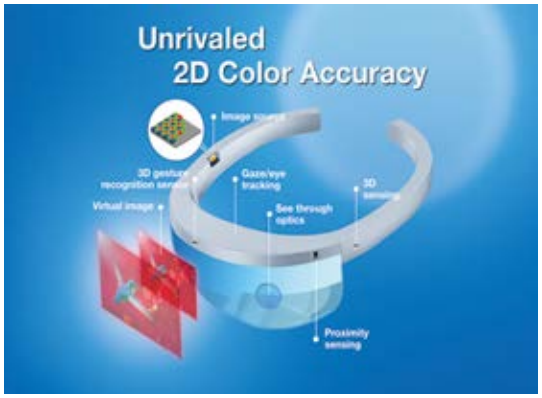
Through continuous technology development, customer orientation and an ISO certified quality management system, Hübner Photonics has become a preferred supplier of lasers to major instrument manufacturers and leading research labs for cutting-edge applications in the areas of fluorescence microscopy, 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.

HÜBNER Photonics GmbH
Wilhelmine-Reichard-Str. 6
34123 Kassel
Germany
phone: +49 6251 770 6686
fax: +49 6251 860 9917
general enquiries:
e-mail: info.de@hubner-photonics.com
sales enquiries:
e-mail: sales@hubner-photonics.com
Web: www.hubner-photonics.com

Your experts for light measurement solutions

Instrument Systems fosters innovative product ideas with high-end light measurement technology. Our solutions are indispensable for producers of VCSEL/laser-based systems, consumer electronics, displays, exterior automotive lighting, and LED/SSL modules. They all benefit from the high-precision CAS series of spectroradiometers: widely used as reference instruments, which measure precise and accurate from UV to IR. In combination with 2D imaging cameras, integrating spheres, and goniometer systems, our flexible light measurement systems cover all testing needs from lab to production.



At SPIE.AR|VR|MR 2024 in San Francisco, Instrument Systems launched its new LumiTop 5300. The 2D luminance and color measurement camera has a high resolution and a straight lens. It was specifically developed for 2D testing of AR/VR display modules prior to installation in the headset, and complements the LumiTop 4000 with a periscope lens that has been tried and tested over many years. The new TOP 300 is also celebrating its premiere. The coupling optics provide an optical system modeled on the human eye, and can be connected to a CAS series spectroradiometer via a fiber connection. It was especially designed for simple optical tests along the production line of AR/VR modules. The VTC infrared cameras for near and far field analyses of VCSELs, such as 3D gesture recognition sensors or lidar systems, round off our portfolio for the optical quality assurance of AR/VR devices along the entire production chain.

Instrument Systems GmbH
Kastenbauerstr. 2
81677 Munich
Germany
phone: +49 89 454943-0
e-mail: sales@instrumentsystems.com
Web: www.instrumentsystems.com

Enabling technologies that transform our world

MKS Instruments is a global provider of instruments and solutions to measure, monitor, deliver, analyze, power and control critical parameters in advanced manufacturing and research applications. 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 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 CO_2 and high-power fiber laser material processing. Newport provides a full range of solutions including motion control, optical tables and vibration isolation systems, photonic instruments, optical and opto-mechanical components. MKS Photonics Solutions enhance our customers' capabilities and productivity in the semiconductor, industrial technologies, life and health sciences, research and defense markets. Our solutions support our Surround the Workpiece offerings, in which we deliver leading products and services in the lasers, photonics, and optics markets.

MKS Instruments
Newport Spectra-Physics GmbH
Guerickeweg 7
64291 Darmstadt, Germany
phone: +49 6151 708-0
e-mail: germany@newport.com
Web: www.mks.com
AKL'24, Booth 59

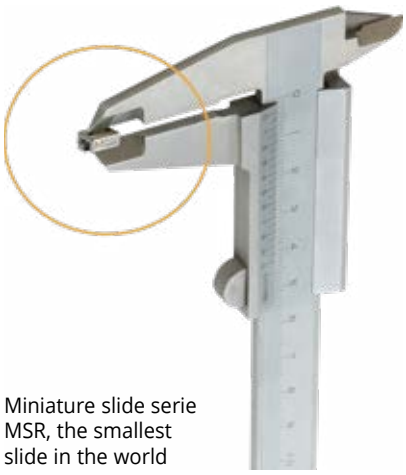
Precision linear guides and positioning stages

PM, a family-owned company based in the Netherlands, is a leading European manufacturer specializing in standard and customized precision linear guides, linear slides, miniature slides, rotation bearings, sub-assemblies, and engineered-to-spec motion systems.

With over 50 years of manufacturing experience, PM is a trusted partner for numerous global players across various industries such as semiconductor, optical, metrology, medical technology, industrial automation, space, and defense. Employing more than 200 people, PM's in-house production capabilities allow them to deliver a wide range of products, from extremely small-sized components to large machined products like vacuum chambers, accurate machine elements, and frames.

The linear bearings product lineup consists of ball, cross roller, and needle roller linear bearings. In addition to these, PM specializes in linear slides and provides a range of miniature slides. One of the latest innovations is the MSR cross roller linear slides, which are extremely compact and feature anti-cage creep technology. These slides offer highly accurate movement at high speeds.

Other notable products include the compact and flat rotary table bearing, designed for precise rotary motion, and the gonio bearings, which offer precision and low friction curved motion.


Miniature slide serie MSR, the smallest slide in the world

Originally developed for optical lenses applications, these bearings have proven their worth.

Moreover, the portfolio encompasses customized xy-stages, positioning systems, and advanced motion systems with sub-micron level accuracies. With our extensive expertise, tailored solutions can be designed to meet the specific requirements of various industries.

To ensure the highest quality, all products are assembled in conditioned low-dust assembly rooms. For semiconductor and medical customers, we offer ultrasonic cleaning, assembly, and qualification in cleanroom classes 6 and 7.

PM B.V.
Galileistraat 2
7701 SK Dedemsvaart
The Netherlands
phone: +31 523 612 258
e-mail: info@pm.nl
Web: www.pm.nl

JPT Opto-Electronics

Registered in 2006, Shenzhen JPT Opto-Electronics focuses on the R&D, production, sales, and technical services of laser technology. Based on laser technologies, JPT integrates leading technologies such as laser and optics, test and measurement, motion control and automation, machine vision. The company highly values intellectual property and has applied for more than 600 patents and software copyrights. In 2019, JPT went public in the STAR Market of Shanghai Stock Exchange.

Leading manufacturer of MOPA pulsed fiber lasers

In the past 16 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 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.

JPT STOCK CODE: 688025

Shenzhen JPT Opto-electronics Co., Ltd.
1201, Bldg A, Kemron S&T Park, Guanlan Hi-tech Ind. Area, Longhua Dist.
Shenzhen, China, 518110
phone: +86 755 29528181
fax: +86 755 29528185
e-mail: sales@jptoe.com
Web: www.jptoe.com

Toptica Photonics

Toptica has been developing and manufacturing high-end laser systems for scientific and industrial applications for twenty 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.

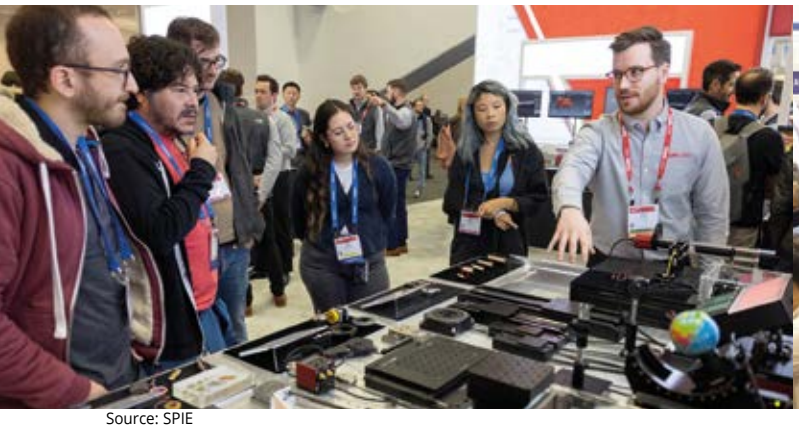
Toptica's 490 employees take pride in developing customized systems. In close collaboration with several universities and institutes, latest scientific discoveries are frequently incorporated into commercial products. With a global distribution network, Toptica provides exceptional service worldwide.

Short profile Toptica Photonics

Founded: 1998
Employees: 490 (2023)
Revenues: 130 Mio. €
Legal form: Aktiengesellschaft (AG), private ownership
Presidents: Dr. Wilhelm Kaenders, Dr. Thomas Renner
Chairman: Dr. Dieter Schenk

TOPTICA

TOPTICA Photonics AG
Lochhamer Schlag 19
82166 Graefelfing / Munich
Germany
phone: +49 89 85837-0
e-mail: sales@toptica.com
Web: www.toptica.com



Source: SPIE

Source: Informa Markets

April 07 – 11, 2024

SPIE Photonics Europe

Strasbourg, France

https://spie.org/conferences-and-exhibitions/photonics-europe

April 17 – 19, 2024

AKL'24

Aachen, Germany

www.lasercongress.org

April 22 – 26, 2024

Hannover Messe

Hanover, Germany

www.hannovermesse.de

April 23 – 26, 2024

Control

Stuttgart, Germany

www.control-messe.de

May 05 – 10, 2024

CLEO

Charlotte, NC, USA

www.cleoconference.org

May 14 – 16, 2024

Optatec

Frankfurt, Germany

www.optatec-messe.de

May 14 – 16, 2024

Rapid.Tech 3D

Erfurt, Germany

www.rapidtech-3d.de

June 04 – 06, 2024

SLT 2024

Stuttgart, Germany

www.slt.uni-stuttgart.de

June 11, 2024

Photonics Germany Future Summit

Photonics & Quantum Technologies

Berlin, Germany

https://photonics-germany.de

June 11 – 13, 2024

Sensor + Test

Nuremberg, Germany

www.sensor-test.de

June 11 – 14, 2024

EPHJ

Geneva, Switzerland

https://ephj.ch

July 17 – 18, 2024

LaserEMobility Workshop 2024

Garching, Germany

https://laseremobility.com

August 18 – 22, 2024

SPIE Optics + Photonics

San Diego, CA, USA

https://spie.org

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

Showcasing a robust and expanding industry

Review: SPIE Photonics West Conference & Exhibition, 27 January – 1 February 2024, San Francisco, USA

Source: SPIE

The largest annual optics and photonics event of the year, which includes the rapidly growing Quantum West conference and the co-located SPIE AR|VR|MR, encompassed more than 1,500 exhibitors and over 5,000 technical presentations.

SPIE held an impactful and vibrant Photonics West last week at San Francisco's Moscone Center, with 24,000-plus technical professionals registered from more than 70 countries across the international optics and photonics community. The largest annual photonics conference, which ran from 27 January to 1 February, hosted over 1,500 exhibitors, and featured over 5,000 technical presentations across an interactive and engaging week that included BiOS, LASE, OPTO, Quantum West, the BiOS Expo, the Photonics West exhibition, the Quantum West Expo, and the co-located AR|VR|MR conference and exhibition.

SPIE CEO Kent Rochford said: "The invigorating energy and high levels of enthusiasm throughout the Moscone Center characterized a truly exciting week. AR|VR|MR continues to grow by leaps and bounds, and the addition of a standalone exhibit to the Quantum West program reflects the growing impact of the technology. We were also delighted by the success of our brand-new SPIE Global Business Forum, a packed event that drew top industry executives together for high-level presentations and conversation. Altogether it was a pleasure to be part of the networking, research-sharing, and collaborative discussions among world-leading scientists, engineers, students, and businesspeople."

As always, the dynamic week showcased the latest innovative technologies and discoveries stemming from a diverse and thriving optics and photonics community, bringing together researchers, innovators, engineers, entrepreneurs, and business leaders. Over a hundred distinct technical conferences paired perfectly with the four exhibitions held during the week, bringing researchers and companies together to further science, technology, and applications. The week also included a wide range of live product demonstrations on the exhibition floors and a job fair.

The inaugural SPIE Global Business Forum was a resounding, sold-out success. With the 16th annual Prism Awards honoring the top new optics and photonics products, and the fast-paced Startup Challenge pitch competition, Photonics West recognized the best optics and photonics technologies, trends, and entrepreneurial opportunities, while the Quantum West Business Summit featured talks and panels that provided key insights into that expanding commercial ecosystem.

In addition, a program of 56 educational courses offered expert-led technical training and learning, which complemented the dozens of professional development and networking sessions. From Lunch and Learn programming focused on EDI, to networking and social events that provided many opportunities for in-person conversations and possible future collaborations.

SPIE Photonics West 2025 will take place 25 – 30 January at the Moscone Center in San Francisco. The call for papers will open in spring of 2024.

https://spie.org

Bringing the photonics community together

Review: Asia Photonics Expo (APE) 2024, March 6 – 8, Singapore

Organized by Informa Markets, the inaugural Asia Photonics Expo (APE) was successfully held at Sands Expo and Convention Centre in Singapore. With an exhibition area of 15,000 square meters, APE 2024 attracted 350 international exhibitors showcasing a wide range of sectors including optical communication, optics, lasers, infrared, sensing, and displays. It provided a comprehensive platform for business, technology exchange, and networking, enabling industry professionals to engage in meaningful discussions with leading companies and experts.

Source: Informa Markets

Inauguration ceremony for the Asia Photonics Expo

APE promoted in-depth communication and business collaboration between professionals in the photonics ecosystem. More than 4,400 visitors from 76 countries or regions filled the exhibition area, and twenty delegations were present, attending two dozen concurrent conferences and activities.

The first ever Asia Photonics Expo concluded on March 8, 2024, setting a solid foundation for APE 2025. Visitors can explore innovations and advancements in photonics again on March 5 – 7, 2025, at Sands Expo & Convention Centre – Marina Bay Sands, Level 1, Singapore.

www.asiaphotonicsexpo.com

Preview: 36th Control

23 – 26 April 2024, Stuttgart, Germany

The latest products and solutions in vision technology, image processing, sensors, measurement, and testing will be shown at the 36th Control exhibition in Stuttgart. Developments and future concepts in automation and digitalization will also be presented.

Quality assurance has become increasingly important in many industries and sectors. QA solutions are used in industrial production, in many operational processes, in non-industrial fields of application, in medical technology as well as in defense applications.

Control brings QA experts from all over the world together on an equal footing and is regarded worldwide as a unique meeting place for QA professionals. An intensive exchange of expertise takes place at the event, which is highly valued by exhibitors and expert visitors alike. Solution suppliers come together directly with quality managers, engineers and production experts involved in routine daily operations. The trade fair showcases various types of measuring technology and is relevant for all industries.

As part of Control 2024, the Fraunhofer Vision Business Unit will organize its special show "Contactless Measuring Technology" for the 18th time. The show will feature a cvariety of innovative technologies, applications and system components from the fields of contactless measuring and test technology on roughly 300 square meters of exhibition floor space.

An exciting startup area will be included once again in order to enhance the fields of measuring technology and quality assurance with new ideas and perspectives from young companies.

www.control-messe.de

Preview: CLEO

5 – 10 May 2024, Charlotte, North Carolina, USA

For more than forty years, CLEO has served as the proving ground for innovators and breakthrough technologies. It is the global stage where next-generation innovations reach the marketplace.

Now more than ever, it is essential to stay connected with your customers and to develop new relationships. Participating in CLEO enables you to reach a global audience of buyers and industry leaders while connecting with innovative professionals looking for opportunities to forge a career in the industry.

The CLEO Hub from May 7 – 9 is the destination for product information, industry and market-based programs and networking. The exhibition is not just a location to meet exhibiting companies. It is an energetic and thriving location that offers poster sessions and a theater hosting two plenary sessions and industry and market-focused programs. Coffee breaks provide a platform for lively scientific discussion and collegial networking opportunities.

With more than eighty participating companies, The CLEO Hub offers a vibrant and comprehensive show floor with the essential product information you need to advance and facilitate your research.

The technical conference emphasizes significant recent advances in the application of photonics technology to address current real world problems. Presentations by leaders in their fields highlight how important advances are being realized. Special symposia are comprised of invited and contributed papers on areas deemed to be topical and of special interest to conference attendees. Special sessions provide convivial, interactive, open fora to address topics not covered by traditional presentations, but that are of interest and importance to the CLEO community. Workshops offer an informal format to enable open discussion between moderators and panels of specialists and the audience to address technical or strategic questions that may lack clear consensus.

www.cleoconference.org

Preview: SLT 2024

4 – 6 June 2024, Stuttgart, Germany

The Institut für Strahlwerkzeuge (IFSW) at the University of Stuttgart cordially invites laser experts to participate in the 12th Stuttgart Laser Technology Forum (SLT). The conference in the English language will take place for the first time over three days, June 4 – 6, 2024, in the Kursaal Stuttgart-Bad Cannstatt.

The traditional invited talks will be supplemented by 'contributed' presentations. Experts from science, research and industry will talk about current and future developments in areas such as laser material processing, laser beam sources, laser optics, quantum technologies and artificial intelligence in production.

An accompanying exhibition will enrich the conference program.

The mission of the SLT is to address laser technology for materials processing in a fundamentally scientific and yet comprehensible manner with a strong contribution by international and German research institutions and exemplify the scientific conclusions by presentations on corresponding industrial implementations.

Invited plenary speakers on 4 June will be Prof Jens Anders, University of Stuttgart, and Dr Michael Förtsch, Qant GmbH; on the second day, apl Prof Benno Willke, Leibniz University Hannover and MPI for Gravitational Physics, and Eric Mottay, Amplitude Laser. On 6 June, Dr Ben Mills, Optoelectronics Research Centre, University of Southampton, and Dr Christian Daniel, Robert Bosch GmbH, will give plenary talks.

Early bird discounts are available until 28 April.

www.slt.uni-stuttgart.de

Preview: 22nd EPHJ

11 – 14 June 2024, Geneva, Switzerland

This year's EPHJ, taking place in June again, is a long-awaited annual gathering for the high-precision market where professionals can explore and discover the latest trends and technological innovations.For twenty years, the unique EPHJ show has been bringing together professionals from the high-precision industry, featuring watchmaking, jewellery, microtechnologies and medtech.

EPHJ is an international hub for innovation and business professionals. An annual get-together highly anticipated by the high-precision market, it is where professionals come to explore and discover the latest trends and technological innovations.

More than three quarters of the 800 exhibitors report doing business at the show. This success is also due to the excellent quality and professionalism of the 20,000 trade visitors whose quality is praised by 96 % of exhibitors.

The EPHJ trade fair, which is also appreciated for its relaxed and friendly atmosphere, is an innovation platform for the high-precision technology sectors and a place for debates and high-profile guests to analyse the market, progress and challenges in the high-precision industry.

EPHJ is a cluster of promising start-ups thanks to which the technological future of the market is taking shape. Visitors have the opportunity to meet customers or suppliers, make personal contacts and expand their network.

https://ephj.ch

Save the Date: Photonics Germany Future Summit Photonics & Quantum Technologies

Photonics Germany, the alliance of Spectaris and OptecNet Deutschland, cordially invites experts to be a part of the second Photonics Germany Future Summit in Berlin on June 11, 2024. The aim of the event is to bring together representatives from business, research, and politics to present and discuss current trends and needs for action. The program with top-class lectures and a panel discussion will be published online.

On June 10, 2024, an evening event will take place above the rooftops of Berlin – an excellent opportunity for intensive networking in a relaxed atmosphere.

https://photonics-germany.de

Preview: Sensor+Test 2024

11 – 13 June 2024, Nuremberg, Germany

The international trade fair for sensor, measuring and testing technology takes place in Nuremberg, June 11 – 13, 2024. The new calibration area presents the key topic of the event.

According to the organizers, strong exhibitor numbers from neighboring Switzerland, and especially British and US companies have confirmed their participation. "After the abolition of entry restrictions, we are expecting more exhibitors from China than ever before," says a delighted Elena Schultz, managing director of AMA Service. "As things stand at present, we are expecting 400 exhibitors in Halls 1 and 2 this year," says Elena Schultz.

In order to support the online participation and to increase the added value of the leading trade fair for visitors and exhibitors, there will be 90-minute professionally guided technology and application guided tours.

The supporting program will once again be accompanied by a lecture forum. At the forum in Hall 1, which is centrally integrated into a meeting marketplace, exhibitors will be presenting new developments, products and applications on all three days. Admission is free for visitors.

On Thursday, the Job Lounge will be part of the Young Engineers Day.

www.sensor-test.de

Components and accessories

Cooling systems

KKT chillers
Industriestraße 3 • 95359 Kasendorf
T +49 9228 9977 0
F +49 9228 9977 149
E info@kkt-chillers.com
W www.kkt-chillers.com

technotrans systems GmbH
Gottlieb-Daimler-Str. 3-9
76532 Baden-Baden
Tel.: +49 7221 9711-0 Fax.: -111
www.technotrans.de
info@technotrans.de

Extraction systems, AIR PuriFication

Fuchs Umwelttechnik P+V GmbH
Gassenäcker 35-39
89195 Steinberg
Tel.: +49 (0) 7346 / 9614-0
Fax: +49 (0) 7346 / 8422
E-Mail: info@fuchs-umwelttechnik.com
www.fuchs-umwelttechnik.com

TEKA Absaug- und Entsorgungstechnologie GmbH
Millenkamp 9
48653 Coesfeld
Tel.: +49 2541 84 84 1-0
info@teka.eu | www.teka.eu
Social Media: www.teka.eu/socialmedia

Laser beam sources: Solid-state lasers

Diode lasers, for material processing

Laserline GmbH
56218 Mülheim-Kärlich
Tel. 02630/964-0, Fax 02630/964-1018
www.laserline.com, info@laserline.com

Fiber lasers up to 100 W

PHOTON ENERGY GMBH
Bräunleinsberg 10, 91242 Ottensoos
Tel. +49(0)9123-99034-0, Fax. –22
info@photon-energy.de, www.photon-energy.de

Nd:YAG lasers, diode-pumped

PHOTON ENERGY GMBH
Bräunleinsberg 10, 91242 Ottensoos
Tel. +49(0)9123-99034-0, Fax. –22
info@photon-energy.de, www.photon-energy.de

Nd:YAG lasers, pulsed

PHOTON ENERGY GMBH
Bräunleinsberg 10, 91242 Ottensoos
Tel. +49(0)9123-99034-0, Fax –22
info@photon-energy.de, www.photon-energy.de

Nd:YAG lasers, up to 500 W

PHOTON ENERGY GMBH
Bräunleinsberg 10, 91242 Ottensoos
Tel. +49(0)9123-99034-0, Fax. –22
info@photon-energy.de, www.photon-energy.de

Short-pulse lasers

PHOTON ENERGY GMBH
Bräunleinsberg 10, 91242 Ottensoos
Tel. +49(0)9123-99034-0, Fax –22
info@photon-energy.de, www.photon-energy.de

Laser optics and components

Beam splitters

Optics Balzers AG
Balzers, Liechtenstein
Phone +423 388 92 00
info.mbo@materion.com
www.materion.com/balzersoptics

Filters, optical

Optics Balzers AG
Balzers, Liechtenstein
Phone +423 388 92 00
info.mbo@materion.com
www.materion.com/balzersoptics

Free-form optics

Trionplas Technologies GmbH
Permoserstr. 15
D-04318 Leipzig
Tel. +49(0)3412352234
info@trionplas.de
www.trionplas.de

LOGO?

Galvanometer Scanning Systems

SCANLAB GmbH
Siemensstr. 2 a
82178 Puchheim
Tel. +49 (0) 89 800 746-0
info@scanlab.de
www.scanlab.de

Microoptics

Zünd precision Optics ltd
Prismastr. 5
CH-9444 Diepoldsau
Tel. +41(0)71 737 74 00
Fax +41(0)71 737 74 10
info@zuendoptics.com
www.zuendoptics.com

Mirror coatings

Optics Balzers AG
Balzers, Liechtenstein
Phone +423 388 92 00
info.mbo@materion.com
www.materion.com/balzersoptics

Mirrors

B&M Optik GmbH
Am Fleckenberg 20, 65549 Limburg
+49 (0) 6431 9860 – 0
info@bm-optik.de / www.bm-optik.de

Optics Balzers AG
Balzers, Liechtenstein
Phone +423 388 92 00
info.mbo@materion.com
www.materion.com/balzersoptics

Mirros, UV

Optics Balzers AG
Balzers, Liechtenstein
Phone +423 388 92 00
info.mbo@materion.com
www.materion.com/balzersoptics

Optical Components

B&M Optik GmbH
Am Fleckenberg 20, 65549 Limburg
+49 (0) 6431 9860 – 0
info@bm-optik.de / www.bm-optik.de

Optics Balzers AG
Balzers, Liechtenstein
Phone +423 388 92 00
info.mbo@materion.com
www.materion.com/balzersoptics

Prisms

B&M Optik GmbH
Am Fleckenberg 20, 65549 Limburg
+49 (0) 6431 9860 – 0
info@bm-optik.de / www.bm-optik.de

Optics Balzers AG
Balzers, Liechtenstein
Phone +423 388 92 00
info.mbo@materion.com
www.materion.com/balzersoptics

Windows, optical

B&M Optik GmbH
Am Fleckenberg 20, 65549 Limburg
+49 (0) 6431 9860 – 0
info@bm-optik.de / www.bm-optik.de

Material processing systems

Laser welding

Evosys Laser GmbH
Erlangen, Tel. +49 9131-4088-0
www.evosys-laser.com
sales@evosys-laser.com

LPKF WeldingQuipment GmbH
Tel. +49-911-669859-0, Fax: -77
www.lpkf-laserwelding.de

Marking systems

PHOTON ENERGY GMBH
Bräunleinsberg 10, 91242 Ottensoos
Tel. +49(0)9123-99034-0, Fax. –22
info@photon-energy.de, www.photon-energy.de

Optical components

3D Anti-Glare-Spray

Helling GmbH, 25436 Heidgraben
3D-Laserscanning-Entspiegelungsspray
Tel.: 04122/922-0, Fax: 922-201
info@helling.de

Optical metrology

Acceleration sensors

POLYTEC GmbH
76337 Waldbronn
www.polytec.de
info@polytec.de

Dimensional gauging

POLYTEC GmbH
76337 Waldbronn
www.polytec.de
info@polytec.de

Film thickness measurements

POLYTEC GmbH
76337 Waldbronn
www.polytec.de
info@polytec.de

Interferometric measurements

POLYTEC GmbH
76337 Waldbronn
www.polytec.de
info@polytec.de

Surface quality measurements

POLYTEC GmbH
76337 Waldbronn
www.polytec.de
info@polytec.de

Transmission/reflection measurement of thin films

ESSENT OPTICS
Spectrophotometers for Coaters

EssentOptics Europe UAB
Mokslininkų g. 2A
Vilnius LT-08412, Lithuania
Tel. +370 616 19961
E-mail: office@essentoptics.com
www.essentoptics.com

Velocity measurement

POLYTEC GmbH
76337 Waldbronn
www.polytec.de
info@polytec.de

Vibration measurement

POLYTEC GmbH
76337 Waldbronn
www.polytec.de
info@polytec.de

Services

Application development/ Application laboratories

Fraunhofer-Institut für Lasertechnik
Steinbachstraße 15, 52074 Aachen
Tel: 0241/8906-0, Fax: 0241/8906-121
www.ilt.fraunhofer.de

Optical development and engineering companies

Fraunhofer-Institut für Lasertechnik
Steinbachstraße 15, 52074 Aachen
Tel: 0241/8906-0 Fax: 0241/8906-121
www.ilt.fraunhofer.de

System consulting

Fraunhofer-Institut für Lasertechnik
Steinbachstraße 15, 52074 Aachen
Tel: 0241/8906-0, Fax: 0241/8906-121
www.ilt.fraunhofer.de

PhotonicsViews

OPTICS • PHOTONICS • LASER TECHNOLOGY

PhotonicsViews is published with five international issues per year.

Don't miss any issue

subscribe at an annual fee of 454 Euros per year*).

Or apply for a qualified subscription and receive individual issues **for free.**

*) including national/intl. shipping

I wish to receive all print issues of the chosen publication as a regular subscriber for 454.00 Euro per year

☐ PhotonicsViews

I wish to receive chosen issues free of charge as a qualified subscriber

☐ PhotonicsViews

Your principal job function

- ☐ Corporate Management
- ☐ Design & Development Engineering
- ☐ Engineering Management
- ☐ Manufacturing Production Engineering
- ☐ Marketing/Sales
- ☐ Purchasing/Procurement
- ☐ Quality Control
- ☐ Research and Development
- ☐ Technical Service
- ☐ Other: _____

What industry do you work for?

- ☐ Aerospace
- ☐ Automotive
- ☐ Chemical
- ☐ Consulting
- ☐ Electronics
- ☐ General Manufacturing
- ☐ Government/Organization
- ☐ Industrial R&D
- ☐ Medical Equipment
- ☐ Military/Defense
- ☐ Optics/Precision Engineering
- ☐ Printing
- ☐ Scientific R&D
- ☐ Semiconductor
- ☐ Other: _____

Please submit this form via telefax to +49 6123 9238 244 or send a scan as e-mail to WileyGIT@vuservice.de

☐ I agree to receive further electronic information from Wiley.

www.photonicsviews.com

Your Contact Details / Billing Address:

Title/First Name/Last Name

Company/Organization

Address

Country/City/Zip-Code

E-Mail

Phone/Fax

Date/Signature

WILEY

Company Index

published in media partnership with

publishing medium of

PhotonicsViews
OPTICS • PHOTONICS • LASER TECHNOLOGY

Wiley-VCH GmbH
Boschstraße 12, 69469 Weinheim, Germany
ISSN 2626-1294

Editorial:
Dr. Oliver Dreissigacker (od; responsible), Sybille Lepper (sl), Stephanie Nickl (sn)
Phone: +49 (0)6201 606-181 / -105

Boschstr. 12, 69469 Weinheim, Germany
Fax: +49 (0)6201 606-328
e-mail: photonicsviews@wiley.com
www.photonicsviews.com

Contributing Editors:
Dr. Christel Budzinski (cb)
Carsten Heinisch
Jan Oliver Löfken

Copy editing: Matthias Erler, David Jayne

Subscriptions:
Wiley GIT Reader Service
65341 Eltville, Germany
Phone: +49 (0)6123 9238 246
Fax: +49 (0)6123 9238 244
e-mail: WileyGIT@vuservice.de
Our service is available for you from Monday to Friday 8 am – 5 pm (CEST)

Advertising:
Änne Anders (responsible)
Boschstraße 12, 69469 Weinheim, Germany
Phone: +49 (0)62 01 60 65 52
Fax: +49 (0)62 01 60 65 50
e-mail: aanders@wiley.com

Nicole Schramm (Executive)
Boschstraße 12, 69469 Weinheim, Germany
Phone: +49 (0)62 01 60 65 59
Fax: +49 (0)62 01 60 65 50
e-mail: nschramm@wiley.com

Valid advertising price list: 01 October 2023

Banking account:
JP Morgan AG, Frankfurt, Germany
Account number: 6161517443
BLZ: 50110800
BIC: CHASDEFX
IBAN: DE55550110800616151744 3

Production and Layout:
Marita Beyer, Anja Hauck

Commercial Manager: Jörg Wüllner
Publishing Director: Steffen Ebert

Printed in Germany by westermann DRUCK I pva

Per media partnership or publishing co-operation, members of the European Photonics Industry Consortium EPIC, Photonics Germany – through OptecNet Deutschland e.V. and SPECTARIS Deutscher Industrieverband für Optik, Photonik, Analysen- und Medizintechnik e.V. – and European Optical Society (EOS) with its national optical societies, especially the Deutsche Gesellschaft für angewandte Optik DGaO, receive PhotonicsViews with currently six issues per year.

University of Stuttgart
Germany

CONFERENCE
ANNOUNCEMENT

SLT 2024

04 June – 06 June

STUTTGART LASER TECHNOLOGY FORUM

SLT 2024

04 June – 06 June

New format

- Invited and contributed presentations!
- Extended duration: 3 days
- The conference language is English.

Early bird discounts until 28 April!

For more information please visit
www.slt.uni-stuttgart.de

Register now
www.conftool.org/slt2024

IFSW