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5

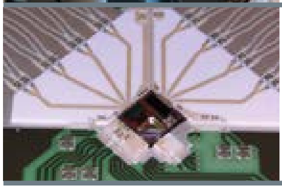
PhotonicsViews

OPTICS • PHOTONICS • LASER TECHNOLOGY

Focus:

Laser Welding

Machine Vision
Light field technology for lean automation processes



Technology Report
European manufacturing capabilities for photonics

published in media partnership with
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DAY OF PHOTONICS

21 OCTOBER 2021

Every company, school, organization, association, university, and individual is invited to participate!

Organise an activity for Day of Photonics!

www.day-of-photonics.org

DAY OF PHOTONICS disseminates "photonics" towards the general public. It is an initiative of EPIC, the industry association that promotes the sustainable development of organisations working in the field of photonics. EPIC fosters a vibrant photonics ecosystem by maintaining a strong network and acting as a catalyst and facilitator for technological and commercial advancement.

EPIC
European Photonics Industry Consortium

Improve our visibiliy

PhotonicSweden increases the awareness of the values created by photonics, and the importance of investing in the industry

Sweden has a long history of leadership in high-tech industries. Companies such as Ericsson, SKF, Ikea, Volvo and Atlas Copco have a long history and continue to lead their fields. Younger companies such as Spotify and Klarna renew the industry with new technologies for the internet era. Huge industrial investments towards battery production and fossil-free steel are opening new opportunities.

Photonics remains an area of strength. Veoneer (auto safety), Mycronic (precision manufacturing), Tobii (eye tracking), Coherent-Optoskand (laser delivery), Senseair (gas sensing), FLIR Sweden (IR cameras), Silex (MEMS foundry) and Hübner-Cobolt (lasers) are just a few examples of companies in Sweden with photonics at their core, and with world leading technologies and unique products in their respective fields.

In academia, groups at KTH, Chalmers, and the universities of Lund, Umeå, Luleå, and Linköping ensure that new photonics experts are being trained. Universities and the Swerim and RISE institutes ensure that new technologies are being developed, and that photonics research is being implemented industrially, in Sweden and abroad.

As a high-tech photonics startup in Sweden, you will immediately need to face an international market with all the challenges involved. National and international funding opportunities and other support structures for SMEs are indispensable for the establishment and growth of these companies, and it is an area where PhotonicSweden, a nonprofit industrial association in Sweden, tries to make an impact. However, despite its importance, photonics often remains hidden inside other products, an essential key enabler but often invisible to non-experts. This invisibility is a challenge when trying to promote photonics and strengthen the area as a whole by increasing its visibility towards decision and policy makers. Here, our joint efforts in the European photonics sector are extremely important, to increase the awareness of the values created by photonics, and the importance of investing in the industry.

As chair of the board of directors in PhotonicSweden, I have the privilege to see firsthand some of the amazing photonics businesses and the research that is done in Sweden, and I encourage you to do the same.

Åsa Claesson

Source: Philippe Rendu

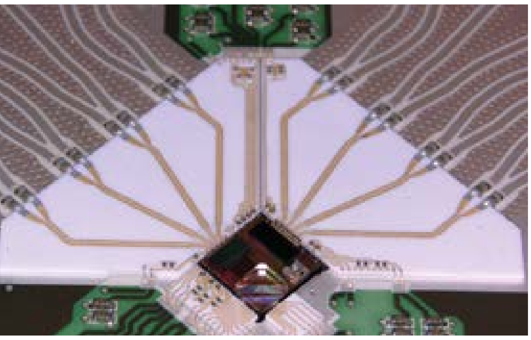
Åsa Claesson

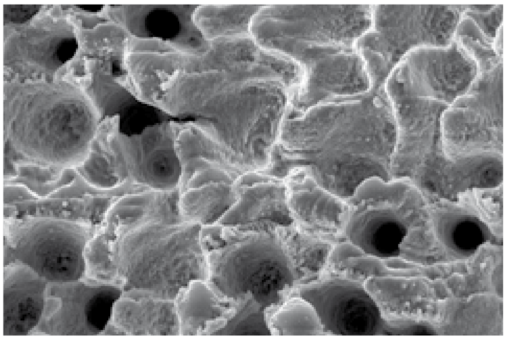
Senior Scientist at RISE Research Institutes of Sweden
Chair of the board of directors of PhotonicSweden

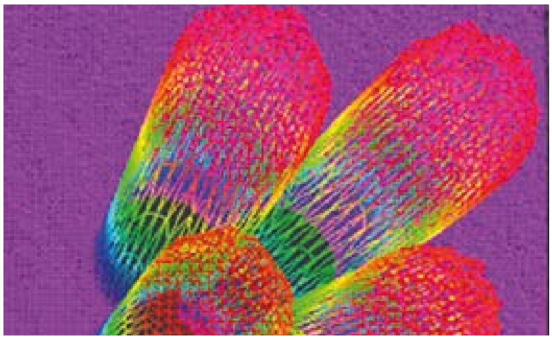
PhotonicSweden
The Swedish Technology Platform in Optics and Photonics

PhotonicsViews

OPTICS • PHOTONICS • LASER TECHNOLOGY







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Cover:
"The Future Depends on Optics"
With a broad range of optical components and imaging products, Edmund Optics enables solutions addressing the challenges of our future and adopts its portfolio always reflecting customer and market needs.
Source: Edmund Optics

LiDAR adoption: technology choices and supply chain management are key enablers

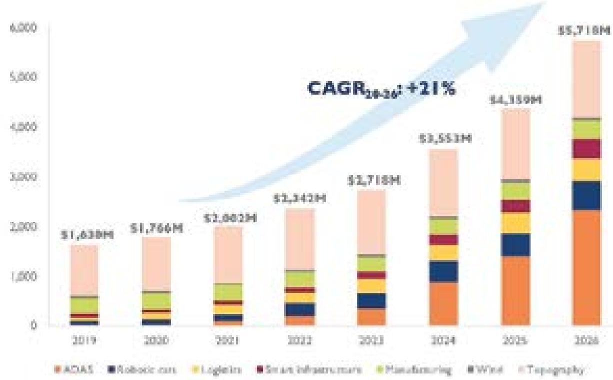
"The market for lidar in automotive and industrial applications is expected to reach $ 5.7 B in 2026, showing a significant 21 % CAGR between 2020 and 2026", asserts Dr Alexis Debray, senior technology and market analyst, photonic, sensing, and semiconductor at Yole Développement (Yole). "In 2020, the lidar in ADAS represented only 1.5 % of the automotive and industrial lidar market. But the ADAS proportion is expected to reach 41 % in 2026."

Therefore, Yole forecasts an impressive 111 % CAGR during the 2020 – 2026 period, for this market segment. In that context, it will reach a market size of $ 2.3 B.

In parallel, the growth in robotic cars, including robotaxis and autonomous shuttles, is expected to be less impressive but still important. This segment is expected to reach $ 575 M in 2026 with a 33 % CAGR over the same period.

In the industrial market, smart infrastructure and logistics are expected to see higher growth. The smart infrastructure lidar market will reach $ 395 M in 2026 with a 35 % CAGR between 2020 and 2026. The logistics lidar market will reach $ 466 M in 2026 with a 23 % CAGR. In smart infrastructure, smart city applications are expected to be the most important segment to look at.

Security, highway monitoring and autonomous checkout are other important applications. In logistics, autonomous trucks and delivery robots are expected to have the most significant growth.



LiDAR market overview – breakdown by application ($M) (Source: LiDAR for Automotive and Industrial Applications 2021 report, Yole Développement 2021)

With the 2021 edition of its annual lidar technology and market report, Yole's analysts propose an update of their market analysis by adding new focus on the supply chain, industrial applications, software and computing for ADAS, key lidar companies as well as additional reverse costing analyses. The report aims to deliver valuable market metrics and dynamics and offer an application-oriented focus on key existing markets and the most promising emerging ones. The analysts took a step back to analyze the major technology trends and their impact on the industry.

Since the invention of 3D real-time lidar by David Hall from Velodyne in 2005, more than eighty lidar companies have been established.

www.yole.fr

VMT and Cadkon become partners

Following their successful co-operation in numerous automation projects, Vision Machine Technic Bildverarbeitungssysteme (VMT) and the special machine manufacturer Cadkon are joining forces in the form of a partnership. The companies will now co-ordinate their automation solutions for laboratory automation as well as pharmaceutical and medical technology more closely.

Since automation solutions require increasing expertise in various technical disciplines that can hardly be covered by a single company, VMT and Cadkon are now joining forces to jointly cover customer requirements by dovetailing subsystems and processes, which at the same time reduces effort and thus costs in automation projects.

The two companies have known each other for over ten years, during which time numerous customer solutions have been created. The partnership will optimize task areas in accordance with the partners' expertise and define interfaces in such a way that smooth processes result.

"Through the partnership, we bring together the strengths of both companies in machine vision, robotics, mechanical engineering and automation. This results in optimally integrated overall solutions for our customers," explains Dr Stefan Gehlen, managing director of VMT.

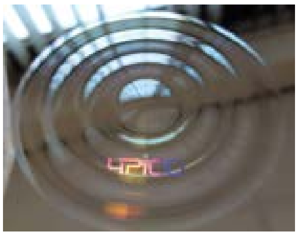
vmt-vision-technology.com

From left to right: Peter Fischer (VMT), Volkmar Adler (Cadkon) and Dr Stefan Gehlen (VMT) (Source: VMT)

Raith acquires 4pico Litho

The German company Raith expands its nanofabrication portfolio with laser beam lithography from the Netherlands. 4pico Litho, located near Eindhoven, serves the high-resolution R&D lithography and holography origination markets with its well-known PicoMaster and MicroMaster product range. In future, its mature products will benefit from synergies with Raith in market access and support. Moreover, key advantages are expected from the connectivity between electron beam (EBL) and laser beam lithography (LBL).

"This add-on acquisition and integration of 4pico Litho into Raith's portfolio now enables us to offer the perfect complement to electron beam lithography and focused ion beam nanofabrication. Furthermore, it will drive Raith's continued profitable growth worldwide," says Dr Ralf Jede,



Fresnel lens (Source: 4pico)

CEO of the Raith group. "Customers using both technologies will benefit from direct write lithography at sub-µm resolution and the throughput advantages of optical lithography."

"We are very pleased to merge our long-standing expertise in UV laser technology for micropatterning with Raith's leadership in nanofabrication markets. By combining our strengths with Raith's competencies in sales, marketing, production, and services, we will make the PicoMaster into the top choice," says Jacco Houter, CEO of 4pico Litho.

www.raith.com

Nano Dimension expands its reach beyond additive manufacturing electronics

Nano Dimension, an additively manufactured electronics (AME) and printed electronics (PE) manufacturing system provider has renamed Nanofabrica Ltd – and its 3D additively manufacturing (AM) printing system the Tera 250 – following the acquisition by Nano Dimension in April 2021. The company is now known as Nano Dimension's Fabrica Group, and its micro-AM technology printing system the Tera 250 is now the Fabrica 2.0 3D Additive Micro Manufacturing Machine.

Since commercializing the Fabrica 2.0 machine, the Fabrica group has been making significant headway positioning micro-3D printing as a viable alternative to traditional micro plastic fabrication technologies. It is used in the areas of medical devices, micro-optics, semi-conductors, micro-electronics, micro-electro-mechanical systems (MEMS), micro fluidics, and life sciences, making products such as casings for micro-electronics, micro springs, micro actuators and micro sensors, and numerous medical components such as micro valves, micro syringes, and surgical devices.

Jon Donner, general manager and head of Fabrica's sales team stated, "The acquisition by Nano Dimension allows Fabrica to accelerate its commercialization in all relevant vertical markets across all geographies."


Source: Fabrica

Nanofabrica's EVP global sales Avi Cohen

www.nano-fabrica.com

Lumibird purchases Areva's stake in Cilas

Lumibird, a European provider of laser technologies, has finalized the acquisition of Areva's 37 % stake in Cilas after obtaining the necessary administrative authorizations.

The complementary nature of the Cilas and Lumibird technology portfolios will enable them to benefit from dual (civil and military) technological synergies and constitute an offer and development capacity in laser subsystems and components that is unrivaled in Europe, with the human, technical and industrial resources to best meet the expectations of industry players.

For Marc Le Flohic, CEO and founder of Lumibird, "the acquisition of Areva's stake in Cilas is a decisive strategic step in our merger project. It reinforces our vision of a sovereign industry in the field of lasers, based on agile industrial players capable of developing their technologies for the defense and space markets, as well as for many civil markets – aeronautics, industrial, medical, and so forth. This acquisition will allow the emergence of a new player of sufficient critical size to effectively serve the interests of the major French integrators as well as those of the European states. The completion of this transaction will pave the way for the acquisition of other European tech champions that could enrich and accelerate this development model."

www.lumibird.com

Jenoptik is focusing in the metrology biz

The company sells non-optical process metrology business for grinding machines to Marposs, which takes over all Jenoptik employees at the main site in Peseux, Switzerland, as well as in Ratingen and Ludwigsburg, Germany; forty people in total. In 2020, Jenoptik generated revenue of around € 7 M with process metrology for grinding machines.

With the sale, Jenoptik is focusing more strongly on those metrology areas in which the group is well positioned on the global market, and is divesting smaller, highly specialized, non-optical activities in its light and production division. "We have found a partner and new 'best owner' for the process metrology business in the Marposs group. As a global supplier and metrology specialist, Marposs offers very good development opportunities for this unit," said Jenoptik's president and CEO Stefan Traeger.


Source: Jenoptik, H. Mueller-Elsner

Industrial Metrology Jena

The process measurement technology sold by Jenoptik specifically addresses production optimization and quality assurance in grinding processes, particularly in the automotive industry.

www.jenoptik.de

Balluff: groundbreaking ceremony for the expansion of the headquarters

The sensor and automation manufacturer Balluff is building another office and administration building at its headquarters in Neuhausen a. d. F., Germany, which will accommodate 530 employees. The groundbreaking ceremony was held recently, and the building is scheduled to be ready for occupancy in summer 2023.

The planned new building on the existing company site between Zabergäustrasse and Schurwaldstrasse will provide office workplaces for more than 530 people and a company restaurant with more than 280 seats. If everything goes according to plan, the shell will be completed by July 2022 and the building should be ready for occupation the following summer. With an investment volume of almost 60 million euros, the construction project is one of the largest single investments in Balluff's history. "We are very pleased that construction work is starting now," said Balluff managing director Katrin Stegmaier-Hermle at the groundbreaking ceremony on July 28, 2021.

Groundbreaking ceremony at the company site in Neuhausen a. d. F. (Source: Balluff)

www.balluff.de

Construction of new headquarters begins

More than three decades ago, Isra Vision was founded as a spin-off of TU Darmstadt and developed into a world-leading machine vision technology company in the subsequent years. The founder and CEO, Enis Ersü, stepped back from active professional life at

Source: Isra Vision

Ground-breaking ceremony for the new headquarters in Darmstadt

the end of June 2021. As part of the company's succession planning, Isra Vision entered into a strategic partnership with the Swedish industrial group Atlas Copco, forming the heart of the new Machine Vision Solutions division. With a strong new management team (cf. p. 9), the foundations are now being laid for the successful future development of the company. There was also a traditional groundbreaking ceremony to mark the start of construction of its new headquarters building in Darmstadt, located on a property measuring around 15,000 square meters in the city's 'Knell' development district with its historic water tower in Frankfurter Straße. Set to be constructed in two stages, it will consist of three connected buildings housing offices and development laboratories, as well as demonstration and assembly halls.

The project provides space for future development and a constantly growing workforce. Designed to the latest energy standards, the building will grow over time and will offer space for around 960 employees.

www.isravision.com

20 years of photons in focus

"How do you build a practical camera for industrial applications?" That was the question that guided Dr. Peter Schwider out of research and into the practical arena – and motivated him to found Photonfocus. The company, part of Isra Vision since 2019, has now celebrated the 20th anniversary of its founding.

The first CMOS sensor with a global shutter and trigger formed the basis for the success of Photonfocus. With this product, the company proved that CMOS sensors were fully competitive against the then dominant CCD sensors. The A1024 sensor is still sold today and, with its very high full well capacity, is still regarded as a benchmark in the market. This laid the groundwork for the triumph of CMOS technology for industrial use, making it a real milestone for Photonfocus and CMOS sensors alike.

Source: Photonfocus

Peter Schwider with the A1024

On the basis of this and numerous other groundbreaking proprietary technologies, such as LinLog for high-contrast images with high dynamic range, the company develops and produces sensors and cameras for many different applications. Individual components such as sensors, processors and interfaces can quickly be adapted to standard Photonfocus cameras.

www.photonfocus.com

UV-C calibration standards with accredited test procedure

Instrument Systems has been accredited for tests in lighting technology to DIN EN ISO / IEC 17025 since 2009 and is now offering accredited testing of radiant flux and luminous flux with the "Goniospectroradiometry of optical radiation sources" procedure. This procedure has enabled the development of UVC-LED reference sources with traceable reference values of maximum precision for radiant flux and irradiance. These reference sources are used to monitor and calibrate UV measuring equipment such as the ISP-PTFE series.

Source: Instrument Systems

Laboratory setting

The accreditation of test labs is extremely important for photometry customers. With it they receive the assurance that their measuring equipment delivers reliable and traceable results. At the same time, the accredited testing of the measuring instruments often used in production guarantees the high quality of the final products and instills a high level of confidence for the final customer.

Instrument Systems developed a test procedure that is conformant with standard CIE 239:2020 and accredited for the production of high-precision UV-LED reference sources. The traceable reference values for radiant flux are determined by the measurement of UV-LED sources with a goniospectroradiometer.

www.instrumentsystems.com

Lasers cutting blanks for the Porsche Smart Press Shop

At the beginning of June, Porsche and Schuler started the operation of a fully-connected press shop in East German Halle (Saale). Apart from a servo press line with an output of up to twenty strokes per minute, the Smart Press Shop also features a state-of-the-art blanking line: a Laser Blanking Line 2.18 equipped with two cutting heads for processing strip material with a width of up to 1,880 mm.

Blanking lines with lasers do not require expensive and heavy blanking dies, which is why they are particularly suitable for the production of new parts or small batch sizes with frequent product changes. The continuously moving coil material is processed into blanks at high cutting speeds. Thanks to tooling-free scrap separation, a high output is also achieved. The gentle trans-

Source: Schuler

Laser Blanking Line 2.18

port of sensitive materials such as aluminum is ensured too.

The Laser Blanking Line is the ideal solution for the 'Smart Press Shop' in Halle, which focuses on the production of aluminum outer skin parts in small batch sizes. The line which supplies the blanks for the servo press line forms the point of departure for a 'track and trace' system.

www.schulergroup.com

ASTM awards contract to Fraunhofer ILT

Optical system of a multiscanner LB-PBF system. (Source: Fh. ILT)

The Fraunhofer Institute for Laser Technology ILT has received an award for decades of development in the field of additive manufacturing: the institute won a competition conducted by ASTM International and is now working on a project towards the standardization of machine condition monitoring in laser beam powder bed fusion (LB-PBF). It is focusing on selecting and qualifying imaging sensor technology that can be used to specifically monitor the condition of LB-PBF systems. Finally, the institute will derive cost-reducing recommendations for end users from these data.

Since 2009, ASTM International has been leading the standardization of additive manufacturing in Committee F42. Additionally, it formed the Additive Manufacturing Center of Excellence (AM CoE) in 2018, which aims to accelerate AM standardization by conducting short-term and targeted R&D projects, as well as providing education and workforce development, certification, and advisory services.

With the standardization, the Aachen engineers want to enable end users to easily and correctly classify and interpret their data.

www.ilt.fraunhofer.de

PhotonicLEAP awarded over € 5 M funding

Source: PhotonicLEAP

The European Horizon 2020 collaborative research project PhotonicLEAP has been awarded over five million euros in funding from the European Commission to develop disruptive technologies that will drive down the cost of integrated photonic packaging and test processes.

So far, existing photonics integrated circuits (PICs) manufacturing processes have been difficult to automate, have limited manufacturing capacity, and are costly, with packaging and testing typically accounting for over 75 % of the total manufacturing cost. As a result, existing PIC manufacturing processes greatly impede the uptake of PIC technologies across many mass markets.

To address this challenge, PhotonicLEAP will develop disruptive wafer-level PIC module integration, packaging and test technologies that will reduce the costs of PIC production by over ten times, revolutionizing existing applications and creating completely new markets.

PhotonicLEAP will be delivered by a highly experienced consortium that consists of six leading research organizations and companies, including Tyndall National Institute, Fraunhofer IZM & HHI, Ficontec, LPKF, Suss MicroOptics, Bosch, Eindhoven University of Technology and Interuniversitair Micro-Electronica Centrum Imec.

www.tyndall.ie

Photonics Center opens in Joensuu

Business Joensuu Oy decided in spring to establish a new company called Photonics Center Oy. Its service package will be a key element in implementing the Joensuu region's business strategy. It will strongly support the creation of businesses and jobs in the growing photonics sector and attract new businesses to the region. The service package is made possible by strong research, educational competence and international networks. It has been built in a large co-operation project which is now moving on to the next phase.

The Photonics Center will help companies shorten research and product development time and bring products to the market faster. Photonics Center is a unique center of expertise and service in the photonics industry, even on a global scale. Companies and other actors in the industry will receive services including expert advice and training, shared access to equipment and services, and diverse facilities. The Photonics Center will focus on equipment services such as a unique service in Finland that offers active alignment, assembly and testing of camera modules and lidar systems.

www.photonics.fi

Photonics Center visio image (Source: Aihio Arkkitehdit / Business Joensuu)

Generation change at Mahr

After almost thirty years at Mahr, Stephan Gais, chief executive officer and shareholder, left the management board at the end of June. He thus ended his operational activities for the family-owned company. Gais summarized when he said goodbye to the employees at a staff meeting in mid-June: "Together, we have achieved a lot: Mahr has an excellent name with customers all over the world and our portfolio is positioned for the future."

L. t. r.: Udo Erath, Manuel Huesken, Lutz Aschke (Source: Mahr)

A new phase of life awaits the great-great-grandson of company founder Carl Mahr, in which he expects to have "more time for family". Nevertheless, he does not want to call it retirement and assures with a smile: "I'm not going to sit back and grow orchids." Gais will remain a member of the advisory board. He will continue to be the face of the Mahr family for the employees and for the management. In his new role, Gais wants to ensure that the values of the founding family continue to be lived.

The new chief executive officer of the Mahr group, Manual Huesken, took over in July. He leads the company together with his management colleagues Udo Erath (COO) and Dr Lutz Aschke (CFO / CIO) on an equal footing and acts as spokesman for the management board. The three company heads now have the task of implementing the newly-developed strategy of the group.

Stephan Gais (Source: Mahr)

www.mahr.de

IDS expands its management

Effective August 1, Alexander Lewinsky became managing director of camera manufacturer IDS. The engineer takes over the operational management of the Obersulm-based company alongside Jan Hartmann. Company founder and shareholder Jürgen Hartmann remains responsible for development and product management.

From left: Alexander Lewinsky, Jan Hartmann, Jürgen Hartmann (Source: IDS)

Lewinsky has been part of the IDS team since 2012, first as product manager, then as purchasing manager and division manager for production/logistics and quality assurance. In his new position, he will continue to be primarily responsible for purchasing, production, logistics, quality assurance, and infrastructure.

"With Alexander Lewinsky, IDS is getting someone with experience in the industry as managing director, who has accompanied the development of the company for nine years and has had a significant influence on the entire operations division, not least through structuring and optimization measures," says Jürgen Hartmann. At the same time, his son Jan will be responsible for administration, sales, system consulting and marketing.

IDS was founded in 1997 and today employs over 330 people in many parts of the world.

https://ids-imaging.com

Lumibird appoints a CSR officer

The Lumibird Group, a European provider of laser technologies, has appointed Frédéric Chiquet to take on the newly-created position of chief corporate social responsibility (CSR) officer from June 29, 2021, to build an objective framework and drive progress with its contributions in terms of social responsibility and sustainable development.

Frédéric Chiquet has a degree in material physics and a master's in business administration from IGR-IAE Rennes, and has held various senior program management roles over the past 14 years with the Lumibird group.

His primary mission will be to coordinate the policy defined by the board of directors with a view to promoting and consolidating a business model that incorporates the expectations of all the various stakeholders. To transform this into a real growth driver, he will be working to meet four key challenges: developing a relationship with clients that is built around confidence and trust, enabling the sustainable development of the ecosystem and markets for the most innovative technologies; building loyalty, motivating and positively engaging staff in the strategy and supporting their development; establishing robust, long-term partnerships with suppliers that can progress and grow with the group; and aligning the group with a global approach focused on social responsibility (ensuring a high threshold for requirements in terms of business ethics) and environmental responsibility (ensuring the preservation of the ecosystem).

www.lumibird.com

Zeiss IQS France appoints new managing director

On September 1, 2021, Mustapha El Bouchouafi will succeed Cyril Aujard as managing director of Zeiss Industrial Quality Solutions France. Born in the Netherlands in 1979, El Bouchouafi has an engineering degree from Germany and an MBA from the United States. After working as a consultant in the telecommunications sector in Germany, he moved to the automotive industry in 2005. In this sector, he progressed from quality manager of a supplier company to its general manager.

Six years later, he was appointed product manager for Leitz's high-precision range in the US and South America before joining the management team of Hexagon Metrology in Germany. In 2016, he took over the management of Hexagon Manufacturing Intelligence France.

In 2018, he became president of Symop's measurement, vision, and control group, before working as a consultant for SME restructuring projects in Germany.

www.zeiss.de

New head of space projects at Asphericon


Source: Asphericon

Matthieu Frambourg

Asphericon, a leading manufacturer of aspheric optics systems, is expanding its sales team. Matthieu Frambourg, who has already been working for the Jena-based optics specialist since April 2020, has been recruited for the head of space projects.

In his new role, he will be responsible for the management and organization of all sales activities with a focus on space. A particular role in his work will be to maintain and expand direct customer contacts. In addition, he will control project management and support the global sales team in an advisory function.

"I am pleased to be able to contribute my extensive expertise in optics and space to demanding customer projects while working for Asphericon," Frambourg says of his new position.

In his position on a freelance basis, he reports directly to head of sales Sebastian Henkel.

The graduated optical engineer looks back on more than twenty years of experience in the photonics and aerospace industry. In leading positions, he managed projects for adaptive optics for telescopes, instrument design at the European Southern Observatory and the development of a ground-based test system for satellites, among others. In parallel with his involvement with a world leader in space instrumentation, Frambourg has been a freelance optical engineering manager since 2010.

www.asphericon.com

New department head at LZH

Dr Andreas Wienke (Source: LZH)

As of June 1, 2021, Dr Andreas Wienke has taken over as head of the optical components department at Laser Zentrum Hannover e.V. (LZH) from Dr Lars Jensen, who has moved to industry.

Dr Wienke started at the LZH in 2011 as a scientific employee in the laser development department. In 2016, he moved to industry as a development engineer, returned to LZH in 2017, and took over first as head of the optical systems group in 2018 and then as head of the ultrafast photonics group in 2020.

He had studied physics at the Westfälische Wilhelms Universitaet Muenster and received his PhD in physics from the Leibniz Universitaet Hannover in 2016.

Dr Wienke is looking forward to the new challenge and will contribute his extensive experience in all areas of laser development – from cw fiber lasers to ultrashort-pulse fiber and solid-state lasers to additively manufactured optical systems – to advance the optical components department, which was restructured earlier in 2021.

www.lzh.de

Isra Vision with new management team


Source: Isra Vision

(l. t. r.) Enis Ersü, Dr Johannes Giet, Tomas Lundin, Hans Jürgen Christ

More than three decades ago, Isra Vision was founded as a spin-off of the Technical University of Darmstadt and subsequently developed into a leading global machine vision technology company. The founder and CEO of Isra Vision, Enis Ersü, retired at the end of June 2021. In the course of his succession planning, Isra has entered into a strategic partnership with the Swedish industry group Atlas Copco and forms the nucleus of the new machine vision solutions division. With a new, powerful management team, the course is now being set for further successful business development.

The new three-member management team consists of Hans Jürgen Christ and Dr Johannes Giet and the new speaker of the executive board, Tomas Lundin.

Lundin worked for the Atlas Copco group for over twenty years in various management positions. With his many years of market and management experience, he brings with him the best qualifications for the future growth tasks at Isra Vision. In the last four years, he has gained experience in the Asian market as the general manager industrial technology in China. He has already been on site at Isra's headquarters in Darmstadt since August 2020 and is active as a member of the management board. Lundin will lead the new division as president of machine vision solutions from the headquarters in Darmstadt.

Hans Jürgen Christ has been with the company for 25 years. Dr Johannes Giet came to Isra in 2001 via the acquisition of Rheinmetall Machine Vision, where he was the transaction manager.

www.isravision.com

Michail Klimkovic is new CEO of Ximea sro.

Michail Klimkovic (Source: Ximea)

With immediate effect, Michail Klimkovic becomes managing director of Ximea s.r.o., based in Marianka, Slovakia.

Michail Klimkovic, comments on the promotion: "It is a huge pleasure to lead a fantastic team of highly skilled, gifted, and motivated engineers and I am looking forward to discussing solutions with our customers and prospects that considerably contribute to the innovation and performance of their products. We will move XIMEA into the next phase, offering superb products, always with leading-edge properties. With an advanced development architecture, XIMEA will be able to provide the best-in-class performance for time to market and fit to need for our customer's projects. I am looking forward to this trip!"

Michail Klimkovic's ideas and innovations as chief engineer, as well as his leadership style, have already had a strong impact on the company in recent years.

www.ximea.com

Product of the Month

High performance laser for wafer surface analysis

Manufacturer: Laser Quantum.
Product: High power, air-cooled laser "axiom LE" delivering 12 W of power @ 532 nm without the need for liquid cooling. It is designed specifically for the inspection of semiconductors for defects during every part of the manufacturing process.
Features: The properties can be leveraged in such a way as to balance high throughput with accuracy and can be rapidly scanned whilst ensuring absolute compliance to clean operating environments. Designed with the semiconductor system builder in mind, the laser is designed specifically to address the requirements

of wafer inspection. The manufacturer offers to OEMs a series of features that are unique to this application. Thanks to its novel cavity design, the laser can be supplied with a customized bandwidth profile, to deliver a speckle pattern dedicated to the specifics of the inspection application, along with exceptional beam quality and active noise suppression. Thanks to the strong focus on OEM integration, it offers hands-free, remote maintenance and service and every laser can be securely accessed from any location on the globe to optimize performance or troubleshoot.

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New high power laser illuminators

Manufacturer: Frankfurt Laser Company.
Product: New "FLTT" series of high-power laser illuminators based on high quality VCSEL chips with an excellent optic design.
Features: With an optical output power of up to 25 W it is possible to achieve an illumination range of more than 5000 m. The illuminators have a large dynamic beam angle zooming range and match the field view angle of most standard cameras. The customer can choose between RS232, RS422; RS485 and TTL interface and they are compatible with major lens and cameras, integrated with the protocols of Pelco D. The illuminators are easily implementen in optical systems. Simultaneously, position can be pre-set via serial port, and users can call the instruction to operate conveniently in use. Due to uniform power intensity of the beam, users can obtain high quality videos and easily recognize gestures.

Applications: Security surveillance, automobile night vision (ADAS), machine vision, gesture recognition, display applications, medical applications, military applications, port terminal monitoring, border and coastal defense monitoring, forest fire monitoring, commanding height monitoring, highway monitoring.

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Terahertz spectrometer with a separate handheld probe head

Manufacturer: Hamamatsu.
Product: Attenuated total reflection (ATR) terahertz spectrometer "C16356" that allows separation of the probe head from the main unit, which until now has never been possible. It can measure even large samples, solids, and living organisms.
Background: Terahertz wave spectroscopy mostly applies a light transmission method that utilizes terahertz waves transmitting through samples. However, this method has limitations such as difficulty in measuring liquids because terahertz waves are easily absorbed by water. In addition, this method also requires a step to prepare special pellets when measuring powders. The new ATR spectrometer is compatible with liquid and powder measurements.

Features: The optical design of previous products was reviewed from scratch and terahertz wave measurement was shifted from the traditional electrical method to an optical method. The spectrometer's optical system is made up of optical fibers and optical communication devices. These efforts made the measurement unit (probe head) much more compact and connectable to the main unit by an optical fiber. In previous products, the samples had to be set within a measurement chamber inside the spectrometer. The new device, however, has a handheld probe head that can be flexibly moved to match the sample size and position. By reducing the number of optical components and electrical wiring and by optimizing the housing design, the main unit is downsized making it around 60 % the cubic size and 40 % the weight of the previous products. Thanks to its enhanced ruggedness against vibration, the user can easily take it to various kinds of locations in a carry case.

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GaN crystal evaluation system using ODPL spectroscopy

Manufacturer: Hamamatsu.
Product: GaN (gallium nitride) crystal evaluation system "ODPL (omnidirectional photoluminescence) measurement system C15993-01" that quantitatively evaluates the quality of GaN crystals. These crystals are currently drawing vast attention as a material for next-generation power semiconductors.
Background: ODPL spectroscopy, developed by Hamamatsu and a research group of Tohoku University, is a novel technique for quantifying and accurately evaluating the quality of compound semiconductor crystals such as GaN by quantifying structural defects and impurities within the crystal. Other than in traditional measurement methods utilizing photoluminescence, it enables highly reproducible measurements of the PL intensity emitted in all directions from a GaN crystal by using an integrating sphere. With a unique calculation method, the internal quantum efficiency of GaN crystals can be calculated from the measurement results. Thus, ODPL spectroscopy measurement allows quantitatively evaluating the crystal quality.
Features: The PL measurement wavelength ranges from 300 nm to 950 nm. The multichannel spectrum analyzer is a photodetector (back-thinned CCD linear image sensor) with 1024 channels, a measurement wavelength range from 200 nm to 950 nm and a spectral resolution < 2 nm. The AD resolution is 16 bits. The integrating sphere is made of Spectralon with a size of 3.3 inches, the sample holder allows substrates from 6 mm × 6 mm × 1 mm to 17 mm × 17 mm × 1 mm. The illumination light source is a white LED, a color CMOS camera serves as observation camera with a field-of-view of approx. 6 mm diameter. The dimensions (W×D×H) are 725 mm × 380 mm × 417 mm.

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Compact laser diode line modules with ultra-thin lines

Manufacturer: Frankfurt Laser Company.
Product: New "HSML-E" series of very compact laser diode line modules which deliver an ultra-thin line.
Features: Laser head and laser driver are separated which allows a very compact size of the laser head of just Ø12.6 mm × 44 mm. The laser driver is 200 mm away from the laser head with dimensions of Ø12.6 mm × 40 mm and can be operated at 24 V. The beam line can be focused to e.g. a thickness of just 10 µm at 40 mm distance. Standard fan angles are 10° to 90°. The wavelength range is from 405 nm to 1060 nm with output powers up to 50 mW. The power stability is typically <±5 % over 8 hours at an operating temperature range from 10 °C to 50° C. As an option these modules are offered with potentiometer for power adjustment, external TTL modulation up to 1 MHz and analogue modulation up to 100 kHz. The housing is electrically isolated and satisfies the protection class IP67 which makes these modules ideal for the use in industrial applications with harsh environmental conditions.
Applications: The major applications are machine vision, scanning, profiling and laser triangulation.

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Polarization analyzer for fiber optic and free beam applications

Manufacturer: Schäfter+Kirchhoff.
Product: Polarization analyzers of the "SK010PA" series, a comprehensive universal measurement and test systems for free beam applications and fiber-coupled laser radiation. They are available for various wavelength ranges (UV+: 350–450 nm, UV: 375–450 nm, UVIS: 400–700 nm, VIS: 450–800 nm, NIR: 700–1100 nm, IR: 1100–1660 nm).
Features: As Plug-n-Play devices, they connect to the USB port of a standard computer. Alignments and measurements are performed rapidly. A real-time interactive display shows the state of polarization on a Poincaré sphere and on a polarization ellipse as well as the degree of polarization. Special routines that determine the polarization extinction ratio of fiber-coupled sources allow the evaluation of the alignment of polarization-maintaining fibers for sources with high coherence. In free beam applications, a particular state of polarization can be adjusted by means of the polarization analyzer, for example in circularly polarized beams, which can be generated with a fiber collimator with a manually adjustable, integrated quarter wave plate. The polarization analyzer is compatible with the microbench/cage system. The standard delivery includes the software as well as a fiber adapter for FC-APC connectors. Other connector adapters and/or microbench adapters for different diameter optics can also be supplied. The compact design with the communication and power supply via USB 2.0 and full remote control via DLL support enables its easy integration within existing systems.
An article on the polarization analyzer can be found in Photonics Views, Volume 18, Issue 3, pages 74–78 (June/July 2021) or https://onlinelibrary.wiley.com/doi/10.1002/phvs.202100042.

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XY Galvanometer sets for high-speed imaging applications

Manufacturer: Cambridge Technology.
Product: Fast and accurate XY galvanometer sets for high-speed imaging applications like OCT (optical coherence Tomography). Available is a broad a range of product offerings from high-performance to cost-effective.
Background: OCT requires a fast and accurate scanning source for the delivery of the light beam and subsequent acquisition of the reflected wave. It relies heavily on XY galvanometers' repeatability excellence at high speeds to achieve high imaging quality. An OCT instrument under daily use could see a billion scanning cycles over its lifetime. That's the reason why the scanning motors in OCT require premium construction components designed for long life that can maintain the highest quality images. OCT-based devices come in many configurations from desktop instruments to hand-held devices and surgical device aids. For this reason, a critical factor for OCT products requires the scanning engine to be compact and flexible in its interface with the optical beam train.
Features: The galvanometer XY sets provide a footprint of compact models to ensure integration in small spaces, coupled with reliable, high-performance to achieve high-speed scanning. Some key specifications include the fastest motor speeds in the industry, delivering low drift and long-term stability; superior precision and accuracy that ensure high-quality scanning output; and an extensive range of aperture sizes and mirror coating. Compact models with small footprint ensure easy integration for small spaces.

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How Apple balanced cost and performance with the iPad Pro's miniLEDs

System Plus Consulting reveals the device's backlight secrets

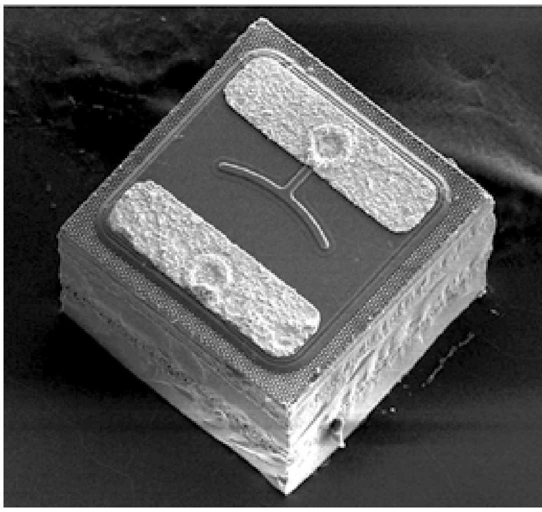
"After more than three years of hype, excitement, and unfulfilled promises, miniLED backlights are finally ready for prime time," asserts Taha Ayari, technology and cost analyst at System Plus Consulting part of Yole Développement (Yole). And he explains: "MiniLED monitors and laptops have been available since late 2020. Most leading TV brands are adopting miniLED backlights in their 2021 flagship models. The highly anticipated miniLED Apple iPad Pro was officially announced in April 2021."

In this context, the reverse engineering and costing company System Plus Consulting announced an in-depth analysis of the miniLEDs and their assembly in the display's backlight unit of the 12.9-inch iPad Pro 2021 edition. The company provides a full reverse costing study of the miniLEDs and their assembly in the backlight unit of the display.

Properly designed miniLED backlights allow LCD displays to reach contrast performance close to that of OLEDs while maintaining the high brightness characteristics of LCDs. All of this while offering reduced power consumption, a very thin form factor (thickness), and cost/price competitiveness with OLED. "With this newest iPad Pro, Apple is really bringing this newer display technology to the consumer", comments Dr Youssef El Gmili, director laboratory department at System Plus Consulting. "As many different supply chain and technology choices are not settled yet, this tear down report provides great insights into the choices Apple is bringing to the table."

The new backlighting system is composed of 10,384 miniLEDs divided into 2,596 local dimming zones. The miniLEDs, which are GaN-based dies on patterned sapphire substrate, have an engineered light-emission pattern using dedicated top and back dielectric reflectors. "At System Plus Consulting, we think that they are manufactured by Epistar in Taiwan", announces Ayari … This foundry was built in 2017 in Taiwan. Its capacity is mainly focused on discrete LEDs, on 100 mm wafer size.

The report presents the detailed process flow of the miniLEDs and proposes a key cost analysis. This front-end analysis combines the following costs: wafer, equipment, consumable, labor, clean room, and yield losses. The die cost analysis is a combination of front-end cost, probe test and dicing cost, and yield losses.


Source: Yole Group

SEM image of the LED die, front side

The COB assembly of the more than 10,000 miniLEDS is believed to be done by TSMT in Taiwan. The miniLEDs are mounted in flip-chip configuration. They are driven by nine drivers from STMicroelectronics. These drivers are wafer-level chip-scale packaged. The System Plus Consulting report also delivers a detailed cost analysis of the drivers. Youssef El Gmili confirms: "The main part of the backlight unit cost is due to the miniLEDs at 37 % …". The backlight unit is also part of the System Plus Consulting cost analysis.

Eric Virey, Dr Zine Bouhamri, and analysts at Yole have supported the System Plus Consulting team during its investigation.

www.yole.fr

Acquiring 3D images at over 1,000 frames per second

BitFlow CoaXPress frame grabber used in groundbreaking new 3D imaging system

Researchers with the Energy Materials Telecommunications Center, National Institute for Scientific Research in Quebec, Canada, have developed a groundbreaking technique to acquire 3D images at over one thousand frames per second with resolution as high as 1180 × 860 – far beyond the capabilities of available systems today – by eliminating information redundancy in data acquisition. Certain to open new opportunities for 3D applications, the dual-view band-limited illumination profilometry (BLIP) with temporally interlaced acquisition (TIA) system or simply BLIP-TIA, relies upon the BitFlow Cyton-CXP CoaXPress frame grabber to transmit images from two CMOS cameras to a computer for processing at rates surpassing 12.5 Gb/s.

Existing 3D systems based on fringe projection profilometry (FPP) have two main limitations. First, each camera captures the full sequence of fringe patterns, therefore imposing redundancy in data acquisition that ultimately clamps the system's imaging speed. Second, the cameras are placed on different sides of a projector.

To overcome the limitations, the scientists developed BLIP-TIA with a new algorithm for coordinate-based 3D point matching from different views. Implemented with two cameras from Optronis placed side-by-side and the BitFlow Cyton-CXP frame grabber, it allows each camera to capture half of the sequence of the phase-shifted patterns, reducing the individual camera's data transfer load by fifty percent, and freeing up capacity to transfer data from more pixels on each camera's sensor or to support higher frame rates.

Besides its high-speed data transfer, the Cyton-CXP two-channel frame grabber incorporates the Gen 2.0 x8 PCI Express bus interface on its back-end.

Reference: *Ch. Jiang et al.:* High-speed dual-view band-limited illumination profilometry using temporally interlaced acquisition, Photon. Res. **8**, 1808-1817 (2020); DOI: 10.1364/prj.399492

www.bitflow.com

LIPSS for metal forming tools

A laser process chain to produce functionalized tool surfaces

From ecological and economic points of view, alternatives to conventional lubricants in metal forming are of great interest. The focus is on tools' surface functionalization by laser-induced periodic surface structures (LIPSS). These structures must be protected due to their loss when in direct tribological contact. So a laser-based process chain has been developed using pulsed and continuous laser processes to create dimples and retain the hydrophilic properties of the LIPSS, as contact angles of 14° prove.

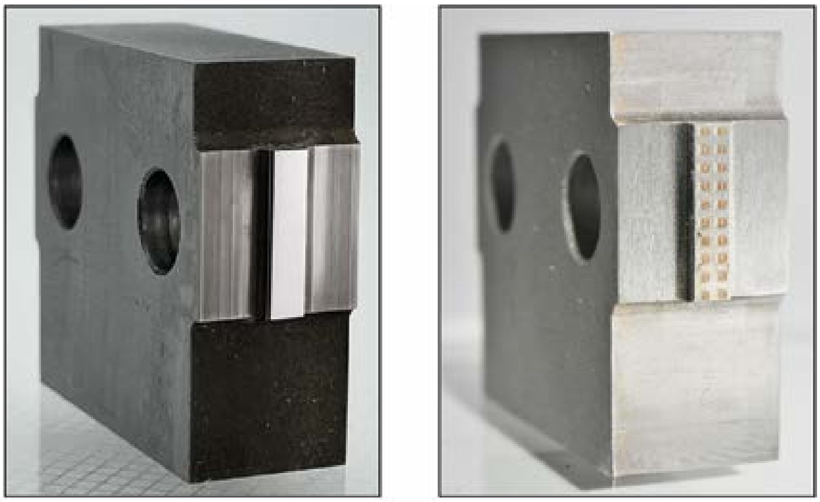


Fig. 1 Initial state (left) and final tool (right) after laser processing with LIPSS on the bottom of dimples. (Source: BIAS (Klett) 2021; BIAS ID 210338)

The use of water as a lubricant during sheet metal forming instead of conventional oil lubricants is extremely attractive from resource conservation and environmental protection points of view. However, the insufficient film thickness, for example due to its low viscosity, is major obstacle when using water as a lubricant. In order to counteract the low viscosity of water, the functionalization of tool surfaces is coming to the fore. This can be achieved by using microstructures, such as microdimples or by applying nanostructures, for example, laser-induced periodic surface structures (LIPSS). To allow LIPSS to develop their hydrophilic properties in sheet metal forming processes, they must be protected from direct mechanical contact, as LIPSS otherwise wear out. The LIPSS are therefore applied in dimples and, consequently, have no direct mechanical contact. The use of LIPSS and dimples at the same time requires a process chain tailored to the preservation of these structures and their hydrophilic properties. Moreover, hardening of the contact surface must be ensured, which keeps the deformation of the tool within narrow tolerances.

The laser-based process chain begins with the laser ablation of microdimples on the contact surface of the tools. Ultrashort-pulsed lasers, such as the ps-lasers with pulse durations of about 6 ps, are particularly suitable for this purpose. At pulse energies of 75 µJ, repetition rates of 50 kHz and scanning velocities of 500 mm/s, dimples with an area of 500 µm × 523 µm and a depth of 29 µm can be created in several passes, as Fig. 2a left depicts. LIPSS-like structures can already be observed on the bottom of the dimples after this step (Fig. 2a right). However, contact angle measurements investigating the wetting behavior show that dimple bottoms with contact angles of 101° exhibit hydrophobic behavior.

The existing structures and the asperities of the bottoms are removed in a second step by laser polishing. This is done using a cw-laser at a laser power of 17 W, a scanning speed of 100 mm/s and a scan trajectory composed of par-

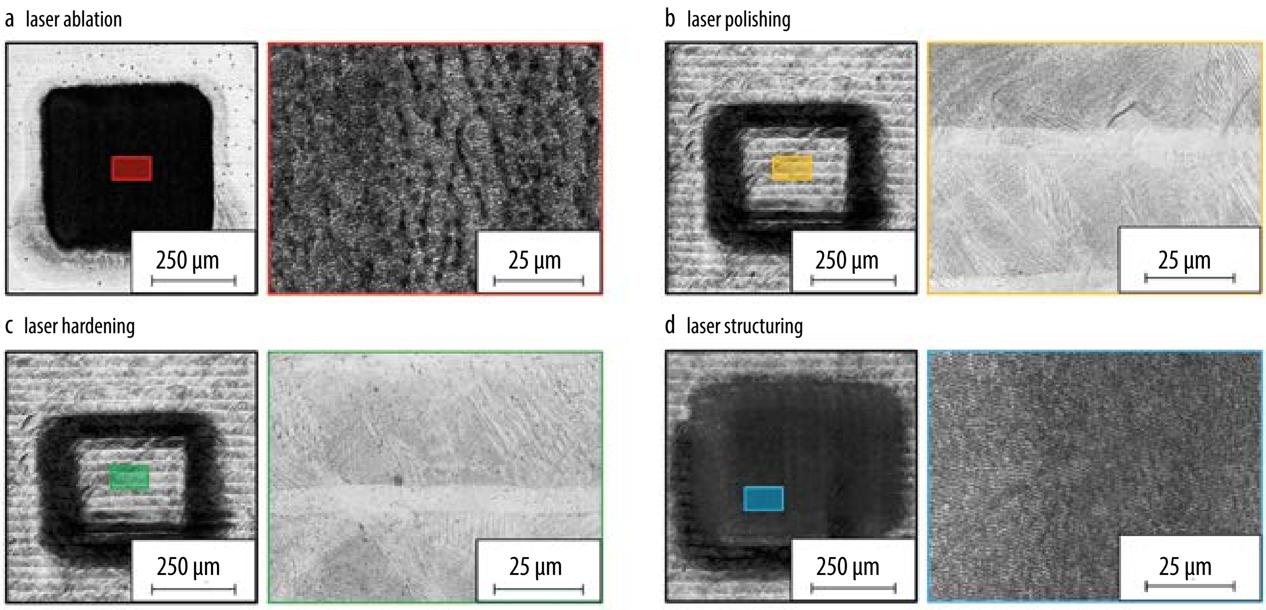


Fig. 2 Resulting dimple shapes and bottom surfaces after each laser based process step. (Source: Rathmann 2021; BIAS ID 210565)

allel paths. These paths have a spacing of 81 µm from each other. After a single pass, the dimple bases have an arithmetic mean roughness of $Sa = 0.95$ µm, as shown in Fig. 2b. The wetting angle in this state is 74° and thus similar to that of the initial tool surface.

Finally, the tools need to be both hardened and structured. The question of sequence is answered by the influence of laser radiation on existing LIPSS. The influence is such that the nanostructures change both their periodicity and aspect ratio, and the wetting property deteriorates. The wetting angle is then in the range of 62°. Consequently, the tools are firstly hardened and then structured. The cw-based laser hardening process has no further influence on the surface roughness (see Fig. 2c) but the initial tool hardness of 250 HV1 is increased to 550 HV1. In addition, hardening by laser also results in minimal distortion. The geometry of the dimples and contact surface is thus preserved.

In order to minimize the influence of heat during structuring on the set and present hardness in the contact zone, the LIPSS are only applied to the bottoms of the dimples (see Fig. 2d, laser structuring) using a ps-laser. With a pulse energy of 200 µJ, a repetition rate of 50 kHz and a scanning velocity of 1,840 mm/s, uniform LIPSS are formed perpendicular to the scanning direction. This maintains the hardness in the bars surrounding the dimples and protects the contact area from mechanical wear. The wetting behavior of the final bottoms is maximized due to the LIPSS. The measured contact angle is 14° and therefore the surface shows a super hydrophilic behavior.

Fig. 1 shows the final tool on the right. The orange-like shimmering on the right of Fig. 1 are the LIPSS, which also change the optical properties of a surface and therefore glow orange at a certain viewing angle. The process steps described here have resulted in a laser-based process chain whose outcome is a hardened and functionalized contact surface, combining the advantages of dimples and hydrophilic LIPSS to be able to use deionized water as a lubricant in metal forming with lubricated, sliding contact.

*

Funding by the Deutsche Forschungsgemeinschaft DFG (project 416530419 “Wasser als Schmierstoff für die Hochgeschwindigkeitsumformung mithilfe von LIPSS”) is gratefully acknowledged.

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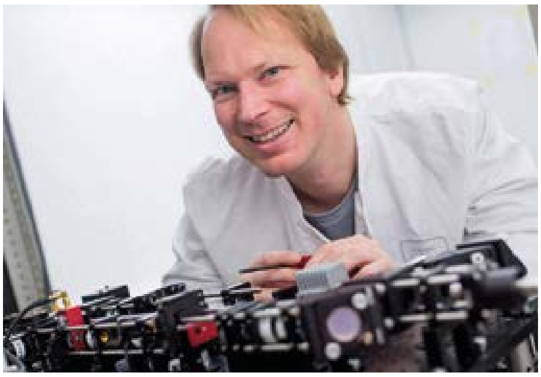
High-resolution microscope built from Lego

The understanding of microscopy increases significantly after working with the new device

Microscopy is an essential tool in many fields of science and medicine. However, many groups have limited access to this technology due to its cost and fragility. Now, researchers from the Universities of Göttingen and Münster have succeeded in building a high-resolution microscope using nothing more than children's plastic building bricks and affordable parts from a mobile phone.



Researchers around Timo Betz built a high-resolution microscope using just children's plastic building bricks and bits from a mobile phone. They showed that children aged 9 – 13 increased their understanding of microscopy by building it. (Source: T. Betz)

They then went on to show that children aged 9 to 13 had significantly increased understanding of microscopy after constructing and working with the Lego microscope.

The researchers designed a fully functional, high-resolution microscope with capabilities close to a modern research microscope. Apart from the optics, all parts were from the toy brick system. The team realized that the lenses in modern smartphone cameras, which cost around four euros each, are of such high quality that they can make it possible to resolve even individual cells. The scientists produced instructions for building the microscope as well as a step-by-step tutorial to guide people through the construction process whilst learning about the relevant optical characteristics.

The researchers measured childrens' understanding through questionnaires given to a group of 9 to 13 year olds. They found that children given the parts and plans to construct the microscope themselves significantly increased their knowledge of microscopy. For this particular study, the researchers, whose day-to-day research focusses on fundamental biophysical processes, benefitted from the input and enthusiasm of their 10-year-old co-author.

The researchers stayed in contact with the children and monitored their progress: after they had constructed the main parts, they discovered that the lenses can act as magnifying glasses. After exploring this, and realizing that a good light source was important, they initially found it tricky to align two magnifying glasses. However, once they had achieved this, the lenses generated tremendous magnification. This enabled the children to literally play with the microscope, make their own adaptations, explore how the magnification works, and discover the exciting world of the micro-cosmos for themselves.

Reference: *B. E. Vos* et al.: Designing a High-Resolution, LEGO-Based Microscope for an Educational Setting, Biophys., online 22 June 2021; DOI: 10.35459/tbp.2021.000191

https://github.com/tobetz/LegoMicroscope

In-house rapid prototyping at PTB in Berlin

The lab's LPKF ProtoLaser U4 processes a wide variety of materials, even HF

The Physikalisch-Technische Bundesanstalt (PTB), as the National Metrology Institute of Germany, enjoys an excellent reputation throughout the world. For its scientific and metrological development work, it often needs special electronic devices that are not available on the market. The corresponding solutions are designed by the scientists and development engineers at PTB and then manufactured by the department "Nutzerunterstützung" (user support), an internal service provider, as single-sided or double-sided PCBs. For this, the institute uses in-house prototyping equipment from LPKF.

Prototyping lab at PTB Berlin with the ProtoMat H60 and the LPKF ProtoLaser U4 (Source: LPKF)

For rapid manufacturing of the PCB prototypes, the lab has an LPKF ProtoMat H60 circuit board plotter, an LPKF ProtoLaser U4 laser system, and the LPKF Contac S4 through-hole plating system. A process for creating solder masks with LPKF ProMask as well as additional devices such as a programmable oven for drying and curing, a UV exposure unit for polymerization, a measuring device for the PCB copper thickness – including the copper in the vias – and a stereo microscope are also used in the lab.

Speed is of the essence due to the large number of PCBs produced by the service provider. If drilling and structuring must both be performed by the same machine, the LPKF ProtoLaser U4 is used. This laser system can process a wide variety of materials, even HF materials. That is important because at PTB, many different materials – even new materials – are used. With the lab equipment, employees process, for example, FR4 material with a thickness of 1.0 mm or 1.55 mm and a copper layer of thickness 18 µm or 35 µm or Rogers RO4003 or TMM10i. Flex materials and ceramics can be processed reliably with the ProtoLaser. Processing of aluminum oxide of thickness 1.0 mm with 35 µm copper for applications with higher current intensities and accordingly stronger heat generation also works very well. Demands on processing speed have increased dramatically over the last few years – especially for structures smaller than 100 µm. Through its capacity to drill and structure, the ProtoLaser U4, which is considered an 'all-around genius' at PTB, makes it possible to meet the high requirements.

www.lpkf.de
www.ptb.de

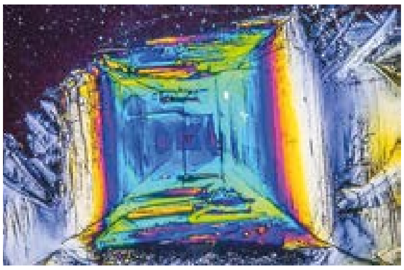
Pyroelectricity: detecting the infrared

100 years and very much alive and kicking

A century ago, Joseph Valasek discovered the phenomenon of ferroelectricity in potassium-sodium tartrate-tetrahydrate, also known as Rochelle or Seignette salt. He initially observed hysteresis curves of the dielectric polarization under the influence of an electric field. Valasek formulated that the "dielectric displacement *D*, the electrical field *E* and the polarization behave analogue to the magnetic values *B*, *H* and *I*". Piezoelectric and pyroelectric characteristics had been investigated on crystals such as tourmaline and quartz long before Valasek. He followed these investigations and paved the way to the exploration of ferroelectric crystals. These can, like pyroelectric crystals, exhibit a 'natural' polarization, however, the polarity can be reversed by an electric field. Further ferroelectrics were found during the following years and rapidly applied in ultrasonic transducers as a result of their outstanding characteristics. Today ferroelectrics can be found in many everyday devices, e.g. as non-volatile memories in electronic systems, as piezoelements in loudspeakers and lighters and also as pyroelectric detectors in gas and flame sensors.

The scientific journal APL Materials dedicated a special edition "100 Years of Ferroelectricity – a Celebration" to the discovery of ferroelectricity. Dr Neumann and two other experts from the research and development department of InfraTec Infrarotsensorik und Messtechnik have participated in this special edition with the specialist article "Advantages and limitation of Mn-doped PIN–PMN–PT single crystals in pyroelectric detectors". Although lithium tantalate is the customary material for InfraTec detectors, further pyroelectric materials are being researched with the objective of improving the performance and producing more cost-effectively and also with high process safety. The publication compares lithium tantalate and lead-magnesium niobate-based monocrystals as materials in pyroelectric detectors. In addition to relaxor ferroelectrics based on lead-indium niobate – lead-magnesium niobate – lead titanate (PIN-PMN-PT) the team also researched on composites from the ferroelectric polymer PVDF and PZT thin films.

The pyroelectric effect is the basis for the infrared detectors of InfraTec and a broad field for the continuous investigation of pyroelectric materials and processing technologies. One person who has always been involved in the further development and optimization is Dr Norbert Neumann. Together with Drs Matthias Heinze and Matthias Krauss he founded InfraTec GmbH Infrarotsensorik and Messtechnik in 1991 and became head of development in the sensor technology division some time later. At the beginning of the 2000s, he and his team developed a new class of pyroelectric detector with integrated transimpedance amplifier for current operation, e.g. the LME-336 (single channel) and the LMM-244 (4-channel), followed by the generation of tunable detectors (microspectrometers), which are equipped with the Fabry-Pérot filter that has received numerous awards. A patented solution for the installation of the pyroelectric elements, which arms the detector against vibrations or mechanical shocks, also came out of the InfraTec research laboratories in the last few years as the LME or LMM series.


Polarization-microscopic image of crystallized Rochelle salt (Source: InfraTec)

The development of new and stable technologies for the processing of the $LiTaO_3$ wafers, e. g. for the application of the absorption and electrode layers, has been accompanied by the sensor development department since the beginning of production. The automatic measuring systems with which the sensitivity and the murmurs of the detectors are measured are an essential prerequisite and building block of our quality philosophy.

The intentions of the advanced development to ferroelectric materials included increasingly extensive investigations into the feasibility and risks for serial production alongside the technical enthusiasm. This laid the foundation for a well-equipped development laboratory.

www.infratec.de

"Tested with photon precision"

Fully automated measuring station guarantees highest quality

With a fully automated measuring station from Swabian Instruments, Laser Components can now test up to twelve

Count measuring station (Source: Laser Components)

Count photon detectors simultaneously for all crucial values. With this new technology and continuous process optimization, the company has not only succeeded in accelerating the quality control of Count modules, but measurement accuracy has also been further improved as well. Customers can be sure that the photon counters operate with the highest precision and the lowest possible error tolerance.

The measuring station was tailored precisely to the requirements of the Olching-based company. At its core is a Time Tagger Ultra from Swabian Instruments. A proprietary data processing architecture makes this technology particularly well suited for time-correlated single photon counting (TCSPC), time interval counting, and coincidence counting. Laser Components uses it in conjunction with ultrashort-pulsed diode lasers, high-precision reference power meters, and computer-controlled moving tables. At four wavelengths (405 nm, 505 nm, 670 nm, and 804 nm), performance parameters such as jitter, dark count rate, afterpulsing, dead time, and detection efficiency are determined. Count modules can be tested with and without fiber coupling. The results are digitally logged for later access – for example, as part of a trend analysis.

"Through the close cooperation with Swabian Instruments, we obtained a measuring station that is optimally adapted to our processes," explains Dr Lars Mechold, CTO at Laser Components. "This not only allowed us to further improve the quality control of our products but the optimized manufacturing process means shorter delivery times and better availability for our customers."

www.lasercomponents.com
www.swabianinstruments.com

"Revolutionizing augmented reality"

Infineon's new MEMS scanner for eyeglasses and head-up displays

What if your everyday eyeglasses became the next media for augmented reality applications? What if every car could display valuable data on the whole windshield to securely guide you through the traffic? The new MEMS scanner solution from Infineon Technologies, comprising a MEMS mirror and MEMS driver, allows completely new product

Infineon's MEMS scanner chipset enables AR-HUD systems with minimum optical volume. (Source: Infineon)

designs. Its miniature size and low power consumption are the basis for making augmented reality (AR) solutions more widely available for consumer applications such as wearables and for automotive head-up displays.

Charles Chan, head of Infineon's automotive MEMS product line, explains "Maps, infotainment or messages projected on everyday glasses guide people to the nearest supermarket or shared car park around the corner. Overlaying valuable information, from route navigation to driver assistance systems, over the car's complete windshield, instead of just over a small area in front of the driver, is a major step ahead for improving driving safety and convenience."

Infineon's MEMS scanner chipset features an innovative tilting mirror which lays the foundation for a new generation of laser beam scanner (LBS) projectors. Compared to alternative system designs and competitive MEMS scanner solutions, Infineon's new chipset stands out in terms of performance, size, energy consumption and competitive system costs. A major challenge when developing AR-HUDs is integrating the system into the dashboard, due to space restrictions. Conventional HUD systems can be more than thirty liters in optical volume, yet still offer only a very modest field of view. By contrast, laser beam scanners based on Infineon's MEMS scanner chipsets enable HUD systems with minimum optical volume, so they can be integrated into even the smallest dashboard. Easy integration together with a competitive bill of material also bring AR-HUDs with a large field of view to small cars and compact classes.

Information in constant view

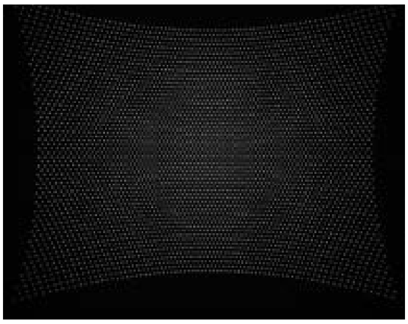
The Infineon MEMS scanner chipset enables the design of an AR micro-projector which is light in weight and can be aesthetically integrated into all-day-wear eyeglasses and sports glasses. Thanks to the chipset's low power consumption, small batteries can easily be integrated into the frame, allowing the glasses to be worn conveniently throughout the day without the need to frequently recharge the batteries.

To advance the development of AR smart glasses' systems for the consumer market, Infineon is collaborating with TriLite Technologies, a Vienna-based start-up. While Infineon looks after the MEMS scanner chipset, TriLite is responsible for system integration and control algorithms that enhance the optical performance of the system. Both companies combine several years of research in optical MEMS and mass manufacturing capabilities.

www.infineon.com · www.trilite-tech.com

Flat, multifunctional optics platform for 3D sensing and LiDAR

DOE platform by NILT is ready for mass production



Proven dot pattern of 940 nm VCSEL array project through a DOE collimator and 3 × 3 fan-out DOE. (Source: NILT)

Advanced optical solutions provider NIL Technology (NILT) has launched a highly advanced flat optics technology platform for near-infrared (NIR) for use in 3D sensing and lidar. The technology could become a game changer for smartphones, automotive, and other applications, due to its multifunctionality, compactness, and unprecedented optical performance.

Since its first introduction for face recognition, 3D sensing has become a highly valued feature for several applications in smartphones, augmented, virtual, and mixed reality (AR/VR/MR), automotive (ADAS adaptation), and robotics. All these applications require a compact system with high optical efficiency that can be mass produced with consistent quality, a well-known challenge in the optics industry.

NILT is ready for mass production of its diffractive optical elements (DOE) platform that is both flat, thin, and multifunctional. The platform provides better optical performance than any existing solutions on the market and has several advantages: compactness, high efficiency, and mass production ability.

NILT's optical solutions include diffusers, fan-outs (also known as dot projectors, beam splitters or structured light) and collimators based on the same technology platform allowing multi-functionality. In other words, one module can be made with multiple optical functions in a single process. This gives an overall size reduction, shortened optical path, simpler integration, and overall a need for fewer optical modules. Traditionally, flood illuminators and dot pattern illuminators require separate modules with a different supply chain. NILT is the first supplier that can provide collimation, flood illumination and dot patterns into one single optical element.

The company developed proprietary design algorithms to optimize optical efficiency and maximize performance. Full control of zero-order transmission is enabled. Fan-outs for dot illuminators are designed and fabricated for highly consistent dot uniformity with high contrast having no stitch effects. Diffusers for flood illuminators have an unmatched sharp transition at the edge of the illumination field to increase the amount of light within the target scene. This gives more precise, less energy consuming and faster 3D images.

Optical components based on NILT's solutions are already used in global, flagship smartphones. Now, using its validated, reliable, and proven methodology, the company has developed a unique in-house platform that is based on more than a decade of global customer engagements. The result is a mobile proven solution that is ready for mass production in new flagship mobile phones.

"We foresee a lot of business opportunities for the 3D sensing market," asserts Dr Zine Bouhamri, team lead analyst imaging and display from Yole Développement. "It is not a chimera, for sure. We expect a 15-billion dollar market in 2026, with a 14.5 % CAGR between 2020 and 2026. The mobile, consumer and automotive segments will drive the 3D sensing development with existing and emerging applications."

Theodor Nielsen, CEO of NILT says: "We have worked closely with selected partners and customers for the last year to develop and fine-tune our DOE technology. We have built full in-house capabilities from design to mass production, which ensures fast and efficient turnaround time on products."

NILT solutions for 3D sensing are available now. Besides DOEs, the product portfolio of advanced optical elements, components and modules also include solutions based on metalenses / metaoptical components (MOE), as well as AR displays.

www.nilt.com

Jennifer Barton elected into SPIE presidential chain

Society's next vice president is also co-chair of SPIE Photonics West BiOS conference

Jennifer Kehlet Barton, professor of biomedical engineering and optical sciences, and director of the BIO5 Institute at the University of Arizona, has been elected to serve as the 2022 vice president of SPIE, the international society for optics and photonics. With her election, Barton joins the presidential chain, and will serve as president-elect in 2023 and as the society's president in 2024.

2021 president David Andrews, a professor at the University of East Anglia, made the announcement along with other SPIE election results at this year's annual general meeting of the society on 2 August during SPIE Optics + Photonics. Terms begin on 1 January 2022.

Top row, left to right: Jennifer Barton, Audrey Bowden, Gong-Ru Lin; bottom row, left to right: Jason Mulliner, Allison Barto, Rebecca Fahrig (Source: SPIE)

Barton is known for her development of miniature endoscopes that combine multiple optical imaging techniques, particularly optical coherence tomography and fluorescence spectroscopy. Her research into light-tissue interaction and dynamic optical properties of blood laid the groundwork for a novel therapeutic laser to treat disorders of the skin's blood vessels. She has published over 120 peer-reviewed journal papers in these research areas.

Barton has a long history with SPIE, including serving on its board of directors and on various committees including the Engineering, Science, and Technology Policy Committee and the Membership & Communities Committee. She serves as symposium co-chair of SPIE Photonics West BiOS, and as session chair for the European Conferences on Biomedical Optics. Barton's awards include the 1997 DJ Lovell Scholarship and the 2016 SPIE President's Award.

"I am honored and enthusiastic to serve as SPIE's next vice president, and to enter the presidential chain," said Barton. "SPIE has been vital to my career in industry and academia and is a tremendous source of inspiration and collaboration for myself and my trainees. I look forward to helping SPIE become even more inclusive as we leverage the lessons learned from a year of remote content delivery and continue to provide outstanding value to constituents with exciting events, great services, and cutting-edge digital content."

Alongside Barton, Anita Mahadevan-Jansen, a professor at Vanderbilt University, will serve as the 2022 SPIE president.

Jason Mulliner, chief financial officer at Alluxa Inc, was elected to serve as the 2022 SPIE secretary/treasurer.

Four newly elected society directors will serve three-year terms from 2022 to 2024: Audrey Bowden from Vanderbilt University, Gong-Ru Lin from National Taiwan University, Allison Barto, director at Ball Aerospace, and Rebecca Fahrig from Siemens Healthcare.

https://spie.org

EMVA: The newly elected board's first meeting

Constituent meeting of the EMVA Board of Directors

At last, pandemic rules made it possible for the elected board members to gather for a constituent meeting on August 4 and 5, 2021, at the EMVA member Zeiss Automated Inspection Systems' facilities. Of course, everyone is double-vaccinated, the EMVA emphasizes.

Already on June 1, 2021, the EMVA General Assembly elected the new board of directors for the upcoming three-year term, namely: Arnaud Destruels, Sony Europe (Image Sensing Solutions); Arndt Bake, Basler; Prof Dr Bernd Jähne, Heidelberg University; Dr Chris Yates, Vision Ventures; Dr Christoph Garbe, HD Vision Systems; Dr Dirk Berndt, Fraunhofer IFF; Dr Kai-Udo Modrich, Zeiss Inline Inspection & Metrology; Dr Marco Diani, iMAGE S; Dr Ronald Mueller, Vision Markets. The board members were finally able to meet at the beginning of August to allocate the board roles, among other tasks.

The newly elected Board of Directors of the EMVA met for the first time. Of course, all members are double-vaccinated, emphasizes the EVMA. (Source: EMVA)

Dr Yates continues to lead the EMVA as president, Prof Jähne serves as vice president, and Arndt Bake oversees the finances as treasurer.

www.emva.org

New Photonics Finland board

Juha Toivonen from University of Tampere succeeds Timo Vuorenpää from Senop as chairman

On 24 August, the Photonics Finland spring meeting elected the new board for forthcoming two years, including a new chairman and deputy chairman. The position of chairman changes between academia and industry every two years to ensure consistent and smooth decisionmaking. Previous chairman Timo Vuorenpää from Senop has now handed over the position to Juha Toivonen from the University of Tampere.

Photonics is currently developing at speed in Finland – many companies are recruiting and growing significantly. Based on a 2020 survey the whole photonics industry in Finland grows 38 % annually. The biggest markets are in industry solutions and in health sector.

In global business, Finland is a small but agile player that has solutions for many upcoming challenges, from achieving the European Green Deal or tackling climate change. Key for success in Finland is the close collaboration between academia and industry, coordinated by Photonics Finland.

Photonics Finland board:

- Chairman of the board Juha Toivonen, University of Tampere
- Deputy chairman Kim Grundström, Kimmy Photonics

Photonics Finland board members – deputy members:

Petri Stenberg, Dispelix, Joensuu – Ulla Haapanen, Modulight, Tampere
Timo Vuorenpää, Senop, Jyväskylä – Kimmo Solehmainen, Oplatek Group, Leppävirta
Niklas Saxen, Edmund Optics, Helsinki – Jouko Korppi-Tommola, Jyväskylä University
Antti Isomäki, University of Helsinki – Mikko Huttunen, University of Tampere
Heidi Piili, University of Turku – Pekka Hänninen, University of Turku, Sanna Uusitalo, VTT, Oulu – Harri Lipsanen, Aalto University, Espoo

Juha Toivonen (left), Kim Grundström (Source: photonics.fi / WIN)

Members that are retiring from board: Jyrki Huttunen (Oplatek Group), Veli-Pekka Leppänen (Nanocomp), Lasse Orsila (Modulight) and Pertti Ikäläinen (Huawei)

www.photonics.fi

Advanced UV for Life e.V. Association founded

Communication platform, cooperation exchange and interest group

UV technologies can be used in a wide variety of ways and open up possibilities for innovative and environmentally friendly solutions. In times of the Corona pandemic, it has become particularly clear what contribution they can make. The association 'Advanced UV for Life e.V. – Association for the Promotion of UV Semiconductor Technologies' is therefore committed to the goal of rapidly advancing such technological solutions and transferring them from research to application.

Advanced UV for Life e.V. founding members (Source: Adv. UV for Life)

Although UV LEDs are already used in many applications, there is still a considerable need for research and technology development. Close coordination between the developers of the components and the end users in the various areas of application is a prerequisite for innovative ideas to be implemented quickly. Decisive for market access are legal regulations and standards for the use of the new components and technologies.

The newly-founded 'Advanced UV for Life' association bundles the competencies from industry and science along the entire value chain – from the concept to the UV semiconductor to its application. This is also reflected in the list of founding members. The association builds on the eight years of experience of the consortium of the same name, which was funded by the German Federal Ministry of Education and Research as part of the 'Zwanzig20' program. "The goal is to promote and accelerate the technical advancement of UV radiation sources and UV sensors, in particular LEDs, photodiodes and laser diodes, and accelerate their deployment and use," says Prof Michael Kneissl. He is chairman of the association, whose office is located at the Ferdinand Braun Institute in Berlin. The association forms the communication and cooperation platform to discuss technological and scientific issues and to initiate development and research projects.

In addition to Prof Kneissl (Technical University of Berlin and Ferdinand Braun Institute) as chairman, Prof Michael Heuken (Aixtron SE), Dr Martin Straßburg (Osram Opto Semiconductors), Thomas Westerhoff (Fraunhofer Gesellschaft) and Dr Olaf Brodersen (CiS Forschungsinstitut für Mikrosensorik) were also voted onto the board, being supported by an internal advisory board of nine members.

www.advanced-uv.de/verein

Let us promote photonics together!

Day of Photonics 2021 – EPIC is calling for your contribution

The European Photonics Industry Consortium (EPIC) is encouraging businesses across Europe and the UK that have products and services associated with photonics in any capacity to join them in celebrating the Day of Photonics, 21 October 2021.

The commemoration day of photonics was established in 1983 by the General Conference on Weights and Measures to call attention to the important role that photonic devices, circuits and the entire photonics/optical device supply chain plays in so many aspects of daily life.

Photonics – a key enabling technology

Photonics is a key enabling technology within many fields and products including: LED lighting, photovoltaic (PV) solar energy, photonic integrated circuits (PICs), optical components, lasers, sensors, imaging, displays, projectors, optical fiber, and other photonic-related technologies that have myriad applications in health, security, agriculture, food, communication, transportation, and many other areas.

EPIC notes that on the occasion of this anniversary, hundreds of activities are being organized around the world by members of the photonics supply chain to raise attention to the importance of their work and the contributions made that positively impact so many aspects of modern life. The purpose is to promote photonics (and companies building photonic devices) by informing the general public about what makes photonic technologies unique and valuable; why they are important to consumer, commercial and industrial products, combined with the fact that PICs and other integration technologies are creating opportunities to further miniaturize products, speed communication and reduce energy consumption.

Join hundreds of Day of Photonics activities around the world

"We encourage you to join us in the promotion of photonics and to organize an activity! View previous activities for inspiration at the web address that follows," noted Susette Germer, public relations manager for EPIC. She went on to note that Day of Photonics activities do not have to take place exactly on 21st October; some companies have their day the week before or the week after, but this anniversary is a good motivation to call attention to the positive role photonics plays across the globe at a time when everyone could use encouragement and good news. "Events or commemorative activities can be as small as sending your staff a piece of chocolate with the Day of Photonics logo or as big as asking your marketing team to organize an online conference or webinar," she noted.

Follow this link for information about past Day of Photonics activities: www.flickr.com/photos/epic-photonics/

Here is how to participate in the Day of Photonics 2021

EPIC suggests and requests that any promotional activities utilize the official Day of Photonics logo as part of a company's promotion along with their individual company logo; the Day of Photonics logo can be found at day-of-photonics.org. EPIC also suggests that persons organizing an event send the association a photo or a screen shot of how a company is recognizing photonics at their company; photos sent will be added to those of other companies in on-going EPIC promotions. Photos can be sent to: DAY-OF-PHOTONICS@epic-assoc.com and they can be directly shared via LinkedIn by tagging @DAY OF PHOTONICS and via Twitter @DayPhotonics.

Moreover, this year the activity with the most engagements (likes, comments, shares) on the Day of Photonics official LinkedIn page will win the "Best Day of Photonics Activity Award" – a virtual diploma and a virtual badge that can be displayed on the winner's website!

www.epic-assoc.com

Upcoming EPIC events:

- 11 October 2021, 15:00 CEST
  EPIC Online Technology Meeting on Laser Vision Correction
- 18 October 2021, 15:00 CEST
  EPIC Online Technology Meeting on Graphene Technology and Applications
- 25 October 2021, 15:00 CEST
  EPIC Online Technology Meeting on Low Light Cameras Technology and Applications
- 1 November 2021, 15:00 CET
  EPIC Online Technology Meeting on White Lasers and Supercontinuum Generation
- 3 November 2021, 15:00 CET
  EPIC Online Quantum Technology Meeting on Ion Traps, Gravitometers and other Quantum Sensors
- 8 November 2021, 15:00 CET
  EPIC Online Technology Meeting on New Developments for Microwave Photonics

www.epic-assoc.com/epic-events

“Find good managers”

EPIC interview: Jimena García-Romeu, CEO of Alcyon Photonics

Jose Pozo

Jose Pozo, EPIC’s CTO, talks to Jimena García-Romeu, CEO of Alcyon Photonics, a provider of photonic building blocks, PDKs and simulation software to aid PIC design and fabrication.

With a talent for maths and science and on a mission to change the world, in 1998, Jimena embarked on a degree in telecommunication and business administration at the Polytechnic University of Madrid. Aware that technology can only impact on society through companies, she chose the course because it had strong links with telecom companies. In her case, this involved practical training with ONO, a Spanish telecom operator, and Ericsson where she worked on developing new business opportunities for telecom apps.

On graduating in 2002, she joined Vodafone Spain, working initially on business marketing and followed by three years in business planning and strategy. Then in 2008, with a desire to gain multinational experience, she decided to change direction and for the next five years, worked as a consultant in business and marketing development/strategy for a range of international companies. These included the MMC Group, working on a submarine communication cable project, Microsoft, and Huawei.

In 2013, Jimena was headhunted by Telefónica to manage a vendor strategy to promote Windows Phone devices in various countries. As she explains, with each job change, she looked for technologically innovative companies, a multinational environment to gain a wider vision of the business and a teamwork ethos. During this period, she continued her education with an MBA Program and in 2015, she completed a management course at the UCLA in California on organizational leadership as part of their W50 Women’s Leadership Program.

Source all images: Alcyon Photonics

Jimena García-Romeu enjoying the surroundings of her company’s Madrid headquarters

Alcyon Photonics

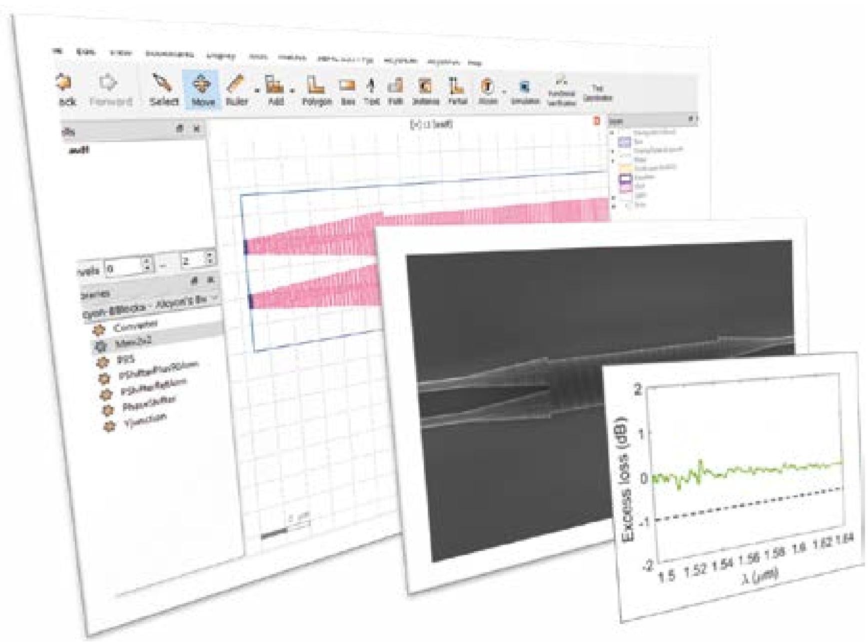
Alcyon had been set up in 2018 as a spin-off from the Spanish National Research Council (CSIC), to commercialize the PIC technology developed by Aitor Villafranca, namely, high-performance photonic IP building blocks from 1.2 to 4 µm bandwidth with integrated polarization capabilities. Also available were optical engines for industry applications, like coherent receivers, together with a PIC management and commercialization platform supported by layout and circuit simulation tools.

After spending the next eighteen months developing proof-of-concepts to show the technology could be fabricated in a scalable way, in 2019, Aitor and Alcyon partner and CTO Antonio Dias offered Jimena the position of CEO. Her mission was to develop a business and marketing strategy to push the technology to PIC designers in application areas ranging from optical communications, biochemical, sensing and spectrometry to quantum computing and quantum cryptography.

Despite knowing little about photonics, having very few contacts in the photonics industry, and being pregnant with her first child, Jimena accepted the position. As she explains, working with such innovative technology and building a company from scratch was irresistible. Although she had never worked in the photonics sector, she was confident that her experience in business development, problem solving skills and appetite for hard work would be a good combination to overcome any future challenges.

Company development

Over the last 18 months, Alcyon has grown to a workforce of eight and Jimena has focused on developing the business in three main areas: 1) a comprehensive library of IP photonic building blocks to enable PIC designers to design circuits based on their specific needs; 2) a library to facilitate integration with commercial software and enable optical engines for comms and sensor applications, for example optical receivers or



Alcyon SWG library & PDK for layout and simulation

microspectrometers; and 3) integration with circuit layout tools to ensure design compatibility with foundries and enable final fabrication and commercialization of the device.

During this period, Alcyon has accumulated several patents on photonic building blocks and become a NEOTEC and EC Seal of Excellence awarded company, which recognizes its contribution to bridge innovation and industrial development.

The future

As Jimena points out, while there are players already monetizing the gap between academia and industry by building end-to-end projects, photonics will not become massive and take over electronics unless PIC design is made simpler than at present. By providing a comprehensive set of IP building blocks, PDKs and optical engines together with layout tools to ensure design compatibility with foundries, Alcyon's fundamental aim is to make designers' lives as easy as possible, which will attract more companies and increase the number of applications created.

Because of their building blocks' wide range of both polarization capabilities and bandwidths, the initial focus will be on communication applications and the aim over the next five years is to have two or three success stories with partners that can be used to unlock other application fields in areas such as sensing or spectrometry.

A main part of the commercial strategy will be to leverage the IP aspect and comprehensive range of the company's portfolio because they believe that providing an all-in-one solution will accelerate adoption of the technology.

What would you do differently if you started again?
"One thing I would probably do differently is to join a strategy consultancy earlier because it took me many years to learn this the hard way on the job. Strategy consulting quickly provides you with a lot of tools that can accelerate your career. Also, something I always wanted to do was work abroad, not only for the work experience but also for the fun of working in a different culture. The problem was that each time I applied for a job in a foreign country, I received a better job offer in Spain."

"One of the hardest things I have had to learn is understanding the customer. I started having direct customer contact when I was at Vodafone and I think it would have helped if I had taken on a job in a retail store while I was at university. In this type of job, you learn a lot about people, and learning how to interact and understand their needs is invaluable for your career."

In view of your interest in women's leadership and the alarming scarcity of women in the photonics industry, particularly in senior management, what advice do you have for the next generation of female entrepreneurs?

"It is not just a women's conversation – both men and women need to be brilliant, work hard and strive for a work-life balance. It is not about maternity or having different hobbies. For me, it is much more about bias against women in the workplace and understanding how females grow up."

"Be bold: As a woman, I am not immune to the effects of this mindset. When I was offered my current position, I was pregnant with my first child and my first reaction was that I would not be able to handle the job. Then, with the support of my husband, I thought about the attraction of the technology, building something from scratch in an innovative environment, and I just went for it because I could not resist the opportunity."

"Speak up: Don't let your work speak for you, it is the worst thing you can do. When you want something, speak up and say what you want. If you want to be CEO, say so."

"Work hard: It is important to understand that great efforts lead to great accomplishments. Just doing good enough, will not take you to the top. Whenever you start with a new company, you need to be aware that the more impact you want to make, the harder you need to work. Just doing good enough is fine – it is what you're paid for, but if you are working to change the world, you will need to excel at what you do, and this will require hard work."

"Look for an employer who will enable you to achieve your chosen work-life balance: Work-life balance is very important, and a successful career is one that is compatible with your personal life, however you chose to live. I spend from two to three hours every afternoon with my child, but then I work until quite late at night. I don't expect everyone to work like me, but at least

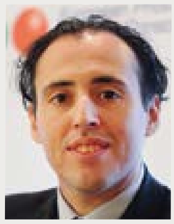
I have the possibility. Companies need to understand that women will be more attracted to work for them if they provide flexible working hours to enable female employees to fulfil family commitments".

"Volunteer: I have never missed the opportunity to learn by volunteering to take on new projects. No one will give you a leading position unless you have the required experience, and a good way to get this is by volunteering. When I was at Vodafone, I volunteered for anything that was offered and ended up managing five projects, whereas my colleagues ran two projects each. So be bold and volunteer for new projects because they will give you success stories, prove what you can do and increase your self-confidence".

"Work in a variety of industries and sectors: Make sure you get experience in more than one industry because working in a range of sectors with business, customers and developers broadens your mind for finding solutions for a business, and enriches you as a professional".

"Find good managers: I was really lucky in my early career to have good, empowering managers. This makes an enormous difference to your career path and is something you really need to look for when you start out".

Author



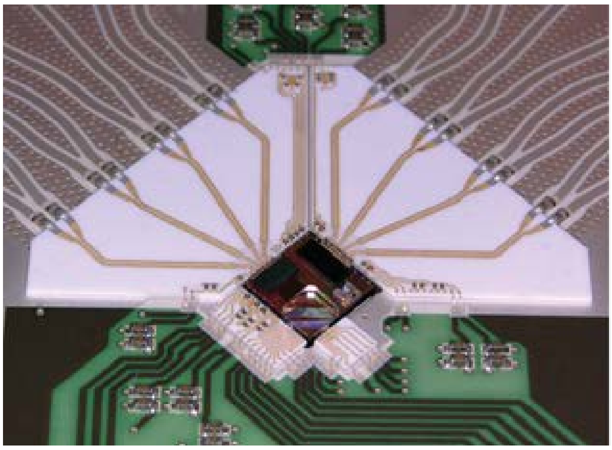
Jose Pozo is director of technology and innovation at EPIC, and as such he represents more than seven hundred leading corporate members active in the field of photonics. His work consists of actively engaging with them and providing them with the tools to strengthen their position in the supply chain. He has twenty years' background in photonics technology, market knowledge, and a large network within the industrial and academic photonics landscape. Jose holds a PhD in electrical engineering from the University of Bristol, UK, and an MSc and a BEng in telecom engineering from Spain and Belgium.

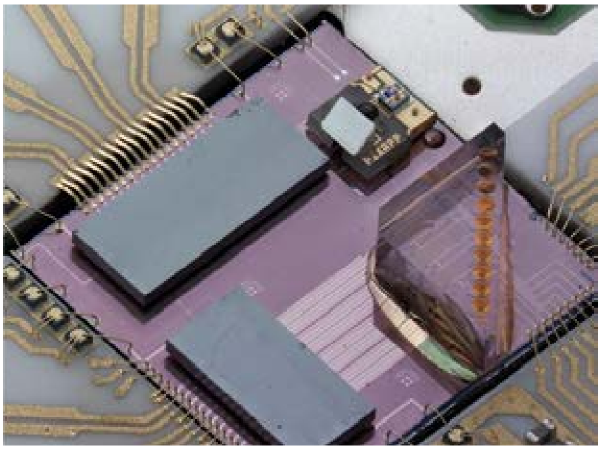
Dr. Jose Pozo, European Photonics Industry Consortium EPIC, 17 Rue Hamelin, Paris, France; e-mail: jose.pozo@epic-assoc.com, Web: www.epic-assoc.com

European manufacturing capabilities for photonics

How pilot lines enhance the continent's competitiveness

Ana González & Antonio Raspa





Since 2016, various European pilot lines have been created to scale up the manufacture of innovative photonics components and systems, with the twin aims of achieving self-sufficiency and enhancing European global competitiveness in the field of photonics. In this article, we take a brief look at the manufacturing capabilities set up by the European Commission to provide services for the pilot production of photonic devices to SMEs, focusing on achievements and challenges for the future.

Photonics has shown an enormous potential for solving many of the technological challenges of the 21st century, such as faster data transmission, advanced manufacturing and defense technology, and new imaging devices to enable keyhole surgery and the diagnosis and monitoring of cancer and other serious diseases. However, European SMEs face a number of hurdles to scaling up production, such as a lack of expertise or access to R&D facilities, difficulties with finding investment or obtaining access to global markets. In 2013, these concerns led the EU to commit 120 million euros over the following seven years to help fund various pilot lines (EPLs) with the aim of lowering the commercial and technological barriers to enable European SMEs to scale up the manufacture of key photonics technology.

There are also barriers relating to the photonics industry itself, such as the absence of an advanced, cost-intensive manufacturing infrastructure, a lack of manufacturing standards, and the fact that many photonics technologies are still relatively immature. Specifically, for prototyping, the technology readiness level (TRL) needs to increase from TRL 1–2 (experimental proof of concept) to TRL 5–6 (demonstration and validation in a relevant environment). Similarly, to achieve low-volume pilot production, TRL levels need to increase from TRL 5–6 to TRL 7–8, where system prototypes have been demonstrated, qualified and proven in an operational environment.

Since 2016, various the EU funded pilot lines have been set up to help SMEs overcome these barriers and "to take photonics technologies out of the lab and into the market". They include pilot lines for the development of photonics-based prototypes as well as projects to ramp up the manufacture of specific technology, such as miniaturized laser-based MIR-spectroscopic sensors, free-form micro-optical structures, and photonic integrated circuits, (PICs).

▲**Fig. 1** PIXAPP demonstrator package with silicon photonic chip, integrated laser, micro-optics, flipchip electronics, ball and ribbon wirebonding and high-speed electrical interposers (Source: Tyndall I. / Agrotech).

Common features: In order to achieve these aims, EPLs are composed of a consortium of up to fifteen partners with the necessary expertise and experience required to help SMEs ramp up production of their photonics components and systems. Although the technologies vary, the EPLs have a number of common aims, as follows:

To lower technological barriers by

- providing a single entry point to a range of advanced, easily accessed manufacturing services covering all stages from design, prototyping, testing and validation to packaging and scaling up production.
- developing engineering to opti-

mize the production process and new equipment to develop new products.
- focusing on an increasing technology readiness level; for prototypes from TRL1–2 up to TRL 5–6; and to enable low volume pilot production, from TRL 5–6 to TRL 7–8.
- creating a unified ecosystem and cost-intensive infrastructure to enable pilot line users, suppliers, and end-user manufacturers to start collaborating at an early stage of product development, and planning to agree and develop manufacturing standards.

To lower commercial barriers by
- sharing facilities to reduce R&D costs and avoiding the need for investment in new plant and equipment.
- providing analysis of technical and business viability of projects together with business and financial coaching to help ensure that projects are commercially focused and primed for market success.
- helping SME's navigate the fragmented regulatory structure, e.g. for the introduction of new medical devices.

To lower trade barriers by
- facilitating easy access to markets.
- providing opportunities for SMEs to partner with large industrial players to market their innovations on a global scale.

To communicate and disseminate the results and aims of the pilot line to all stakeholders, i.e. industry, policy makers, the general public, investors, and the wider research community in order to
- increase awareness of the importance of photonics technology for European economic growth and the generation of new jobs, career opportunities and further training.
- provide transparency on how EU citizen's taxes are being spent.
- attract more young people to study photonics and ensure a future, gender-balanced supply of expertise for the photonics industry.

To become sustainable after the duration of the project by leveraging private investment so that pilot line technologies and services can be provided on a commercial basis.

The EPLs can be grouped into four broad categories, as follows:

1. Prototyping

Actphast4.0: Running from November 2017 to October 2021, Actphast4.0 provides support to enable SMEs to develop photonics-based prototypes and to bridge the gap from TRL1–2 (experimental proof of concept) to TRL 5–6 (demonstration and validation in a relevant environment). The project has seven technology platforms: free-space optics, specialty fibers, polymer-based optics, MOEMS and three 'flavors' of photonic integrated circuits (PICs), namely, silicon (Si), indium phosphide (InP), and a combination of silicon nitride (Si_3N_4) and silicon dioxide (SiO_2) for the fabrication of passive waveguides. Over the last five years, more than 120 companies have used Actphast4.0 to develop photonics-based prototypes for applications in agrifood (e.g. soil monitoring and control of harvest); biomedicine (e.g. retinal implants); biotechnology (e.g. point-of-care diagnostics); connected mobility; Industry 4.0; information and communication; smart cities and smart living; sustainability.

2. Photonic integrated circuits (PICs)

PIX4Life: The first pilot line to ramp up production of PICs was PIX4Life, which was created in 2016 to accelerate the manufacture of optical life science systems based on silicon nitride (SiN) photonic integrated circuit technology for applications in the visible range (400 – 1000 nm). The advantage of silicon nitride is that it is transparent in visible and near-infrared wavelengths, which makes it possible to make SiN waveguides with very low propagation loss. This makes SiN PICs ideal for life science products such as biosensors, cytometers, DNA sequencers, gas sensors, microscopes and medical imagers. Other applications include lidar and quantum computing, and SiN PICs are also widely used in the fabrication of semiconductor devices as they are highly compatible with CMOS technology.

JePPIX: Launched in 2019, JePPIX provides SMEs with direct access to state-of-the-art manufacturing of photonic integrated circuits (PICs) based on indium phosphide (InP) from proof of concept to industrial prototyping and pre-production. Indium phosphide is used to produce lasers, photodetectors, and modulators because, as a compound semiconductor bandgap material, InP is the most effective material for the generation of laser signals and the detection and conversion of those signals back to electronic form. These advantages allow the integration of hundreds of optically active and passive functions on the same chip that can handle the high-speed transmission of very large volumes of data. Applications include fiber-optic communication, biomedical devices, next generation mobile and portable devices, astrobiology, and quantum computing.

PIXAPP: As a PIC integrates multiple photonic functions, such as lasers, detectors, modulators and splitters, integrating the PIC with other components and light sources can be problematic. These problems include coupling light into and out of the PIC and connecting and aligning other electrical and optical components. To overcome these problems, PIXAPP was created in 2017 to provide a range of standardized building blocks, to provide users with a clear menu of advanced packaging technologies that can be scaled to volume production. This standardized approach provides fast and easy access to packaging solutions, especially for emerging markets such as medical devices, diagnostics, and sensing.

3. Pilot lines focusing of a single technology for various markets

PI-SCALE: This was an open access pilot line, active between 2016 and 2019, to enable companies of all sizes to quickly and cost effectively test and scale up their flexible OLED lighting or signage concepts and bring them to mass production readiness. The basic aim was to bridge the gap between R&D and mass production, offering small-to-medium scale pre-production runs of customized flexible OLED devices with a volume of up to 5,000 m^2 of OLEDs/year. By working with the pilot line, companies have been able to make decisions about their final product design, test their concepts in up-scaled manufacturing processes, and have produced a large numbers of product prototypes for testing (TRL7).

Mirphab: Launched in 2016 as a four-year project, Mirphab aimed to scale up products based on miniaturized laser-based MIR-spectroscopic sensors. Mid-infrared (MIR) light in the 3 – 12 µm wavelength band interacts strongly with molecular vibrations that present unique adsorption spectrums that give superior detection capabil-

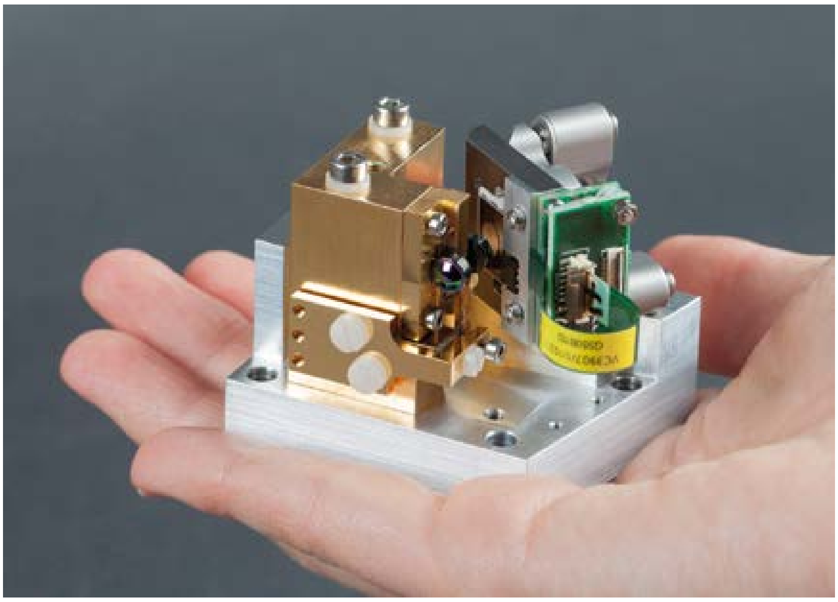


Fig. 2 Miniaturized quantum cascade laser (µEC-QCL) source covering up to 200 cm^{-1} wavelength band for various applications such as food safety control or environmental monitoring (Source: Fraunhofer IAF)

ities and unambiguous detection of chemicals in gas and liquids. In recent years, developments in laser sources and integrated photonic circuits have allowed the manufacture of miniaturized, compact, low cost and low power consumption mid-infraRed (IR) spectroscopy devices capable of highly sensitive, real-time detection. Applications (Fig. 2) include climate and environmental monitoring, point-of-care autonomous detection systems and rapid clinical diagnostics; process yield and food quality control; emission controls for the oil and gas industries.

Towards the end of the project, in May 2021, the Mirphab consortium launched the Mid IR Alliance[*]. The aim was to build on the success of Mirphab to ensure long-term commercial sustainability by creating an industrial alliance of companies dedicated to the continued success and advancement of mid-infrared technology. Participants are from all levels of the supply chain, including laser and detector manufacturers, developers of mid-infrared cameras and sensors, PIC manufacturers, and providers of modelling software and packaging services. The Mid IR Alliance will be the voice of mid-IR technology and a bridge between end-users and the companies providing systems, components and services.

Phabulous: Set up in 2020, Phabulous helps mature manufacturing processes and increase manufacturing readiness of free-form micro-optical structures and functionalities. Free-form micro-optics are micro-optical components that have no symmetry constraints, are enabled by innovative modelling and require ultra-precision machining. This technology offers new functionalities due to aberration reduction, non-symmetric illumination, system simplification and miniaturization and integration. Applications include high added-value devices such as micro displays for augmented reality and lighting systems for professional, automotive, transportation and luxury markets.

4. Focus on a single market using different technologies

MedPhab: Created in 2020, MedPhab marked a change of strategy as, instead of focusing on a single technology, the project was designed to ramp up the manufacture of devices for a particular application field, namely, medical diagnostics. The technologies include fiber optics, microfluidics, surface functionalization, instrumentation, opto-electronic integration, and miniaturization for micromodules and wearables. Applications range from IVD platforms for nucleic acid diagnostics, biosensing and reader units for immunoassay to biophotonics devices for surgical guidance, and mobile photonic readers for cardiovascular complications.

Evaluation of the EPLs

As most of the EPLs have only recently finished or are still running, it is too soon to evaluate their achievements. Ultimately, success will be measured by the extent to which they become commercially sustainable after the life of the project and, in this regard, the Mid-IR Alliance set up by the Mirphab consortium is a positive development. Notwithstanding the ultimate results, the EPLs have made an important first step in reducing the technological, commercial and trade barriers that have hitherto prevented European SME's from commercially exploiting photonics technology. They have also made inroads into two other areas. The first is the scarcity of talent resulting from the low numbers of young people studying STEM subjects and the fact that most of those who do study sciences tend to see photonics as a niche discipline. The EPLs are helping to address this problem by encouraging 'young minds' to consider photonics as a good career choice and by reaching out to the wider research community to stimulate interest in interdisciplinary collaborative research for both their own technology and for photonics in general.

The EPLs have also made progress in the field of standardization. Unlike the semiconductor industry, photonics has few, if any, globally agreed manufacturing standards. As a solution, most of the EPLs, and PIXAPP in particular, work with pre-configured standardized building blocks so that SME's can focus on designing products rather than worrying about the complexity of the technology.

JePPIX democratizes access to industrial prototyping and preproduction of high-performance InP photonic integrated circuits (PIC). The pilot line is enabled by the InPulse project. InPulse has the ambition to transform business

*) https://midiralliance.eu/

practices from vertical integration – where design, fabrication and product development are all in-house and inaccessible to new entrants – to horizontal where fabless and labless businesses share the same manufacturing infrastructure. InPulse provides low entry barrier access to low and medium production volumes of InP PICs.

PIXAPP is the world's first open-access pilot line for photonic integrated circuit assembly and packaging. Developing multiple standardized packaging and packaging building blocks, the PIXAPP pilot line aims to help leading companies and SMEs to exploit PIC technology to improve their current products and/or to transfer their PIC-related research into PIC-based products.

Mirphab is a pilot line for the prototyping and production of mid-IR chemical sensing devices, able to operate in both gas and liquid mediums. Mirphab provides a platform to ensure the bridging between technology and component development and the commercial availability of such components, avoiding the risks associated with the introduction of new disruptive technology. The aim of Mirphab is to become a commercially available prototyping line in 2020. The focus of the pilot line is to deploy mid-IR prototypes swiftly in the market at a minimum of capital investment.

Phabulous is available to strengthen Europe's leading position as a technology and machine provider for the production of micro-optics, based on a value selling model that retains the high-cost and high-value technology portfolio in Europe. It aims to develop easily accessible, world class manufacturing facilities to enable European companies to implement micro-optical components in their products and compete advantageously with their global competitors.

MedPhab is Europe's first pilot line dedicated to the manufacture, testing, validation, and up-scaling of new photonics technology for medical applications, ranging from diagnostics to surgical tools and therapeutics. The purpose of MedPhab pilot production line is to accelerate the commercialization of diagnostic devices and instruments for treatment based on photonics, and to reduce the R&D costs. The selected devices are intended for hospital use (to assist doctors), home care devices (monitoring patients) and equipment for chemical diagnostics (based on the use of serum, saliva, or a urine sample). MedPhab will also provide seamless transition from pilot line production to up-scaled production without needing to change service providers. Use-case companies have been selected for the validation of the pilot line services covering both in-vivo and in-vitro domains.

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MedPhab has received funding from the European Union's Horizon 2020 research and innovation program under grant agreement No 871345. (https://medphab.eu)

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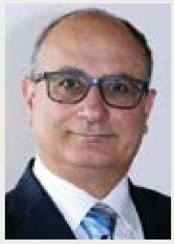
Ana González has been R&D manager at EPIC until recently. Her expertise relies on the development of systems based on integrated photonic circuits, packaging, and assembly, and the investigation of applications such as chemical / biological sensing and datacom. In addition, she has been involved in technology transfer and business development processes. She received her bachelor's degree in chemistry from the University Autonomous of Barcelona (UAB) and her PhD degree from the Catalan Institute of Nanoscience and Nanotechnology (ICN2).



Antonio Raspa is the innovation manager of EPIC and has a background in electrical engineering with a specialization in quantum electronics. Before joining EPIC, he worked at Quanta System as R&D manager, developing solid-state laser sources and customized photonic systems for industrial and scientific applications. During this period, he was also in charge as lidar specialist of the Italian research program in Antarctica. Later he worked at Trumpf and Rofin-Sinar as an industrial laser products and processes specialist. In 2009 he again joined Quanta System, organizing and managing a brand-new structure to produce sterile optical fibers for surgery.

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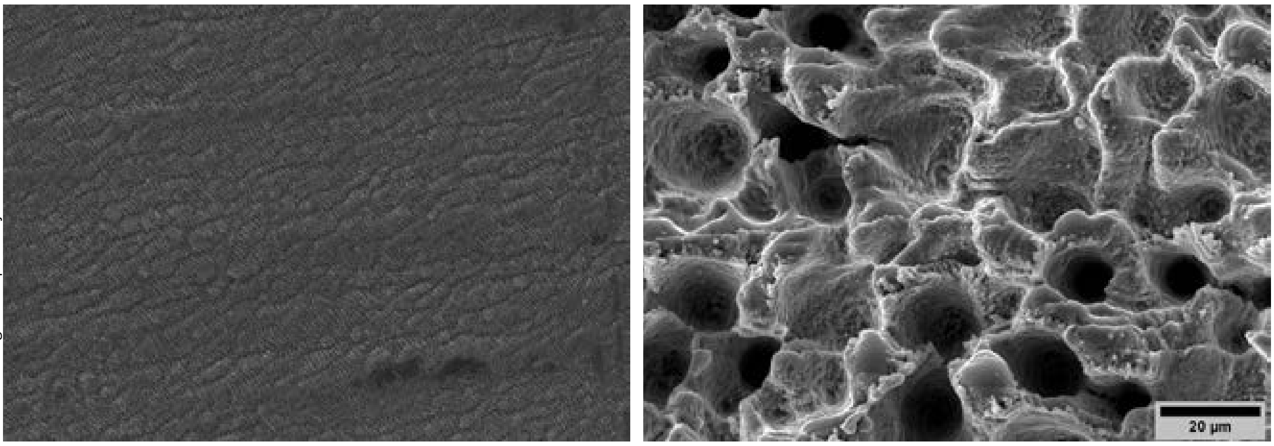
Heat accumulation in metals under femtosecond irradiation: simulation and experimentation

Research on predicting the quality of laser processing of metals using femtosecond lasers for industrial purposes

Liliana Cangueiro, David Bruneel, Thomas Kiedrowski, Nikolai Schroeder, Andrés Fabián Lasagni, and J. A. Ramos-de-Campos

Source all images: LAMpAS Project



▲ SEM images of stainless steel surfaces ablated with a femtosecond laser at 500 kHz, 1 m/s scanning speed and increasing fluences (left to right)

Ultrafast laser micromachining results depend on both the processing parameters and the material properties. The thermal effects are negligible if a good combination of processing parameters is chosen. However, optimizing the processing parameters to achieve the required surface quality on a given material can be quite complex and time consuming. Within the framework of the European LAMpAS project, we developed a model to estimate the heat accumulation on a surface as a function of the laser fluence, scanning speed and line pitch. The simulation results were correlated with experimental ones. The predictions of the model allow evaluation of the heat distribution on the surface, and optimize the ultrafast laser micromachining strategy, yielding negligible thermal damage.

It has been thoroughly demonstrated in recent years that ultrafast lasers are excellent tools for ablating and micromachining virtually all types of materials. They allow the cutting, milling, etching and texturing of surfaces with micrometer precision and the resulting thermal effects are negligible, provided that an optimal set of processing parameters is used. Depending on the material and its thermal properties, if the processing parameters used are not good, typically by combining high fluences with high repetition rates and/or low scanning speeds, the thermal damage can often jeopardize the laser application due to the accumulation of residual heat in the surface regions remaining after ablation.

Aiming at increasing the throughput of ultrashort laser patterning, a high-power (1.5 kW), ultrashort laser operating at a repetition rates up to 10 MHz was used for direct laser interference patterning of surfaces at high scanning speeds, within the framework of the European LAMpAS project (www.lampas.eu). The interferences were created using a DLIP module, and a polygon scanner yielded beam scanning speeds of tens to hundreds of meters per second. Such high speeds, combined with an unconventionally large spot size, help to achieve a surface texturing rate of up to 2 m^2/min, taking full advantage of a high-power ultrashort-pulsed laser. An infrared camera monitored the irradiation zone in real time, and the treated part was verified using an analysis system based on fast-Fourier transform (Fig. 1). This laser-based nano/micro-texturing setup allows surface functionalization with antibacterial, anti-fingerprint and easy-to-clean properties that may be used to generate new decoration finishes.

The deposition of energy at such a rate, combined with the complexity of

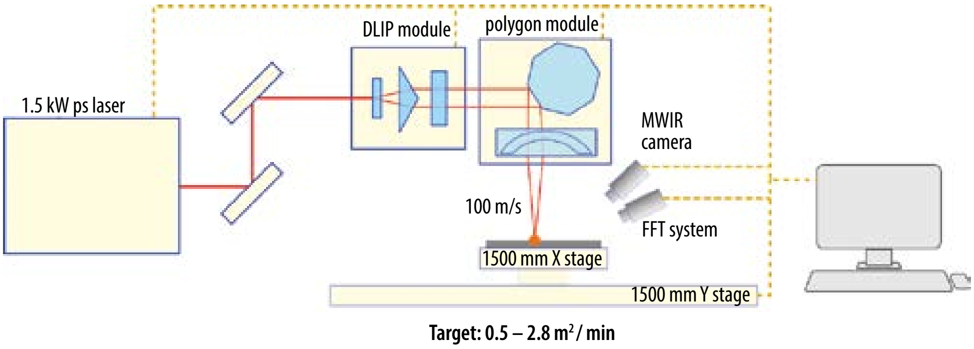


Fig. 1 Schematic illustration of the LAmpAS setup

the ultrashort-pulsed laser-material interaction, required careful management and optimization of the processing parameters to minimize the thermal damage. To this end, we developed a model to estimate the heat accumulation on a surface as a function of the laser energy deposition parameters and the way the beam moves throughout the surface.

Heat accumulation model

The extent of the thermal effects obtained under laser irradiation depend on the processing parameters and the thermal properties of the material. An approach to estimate the heat accumulation at the ablation surface consists of assuming that part of the deposited energy is not used in ablation or the vaporization/sublimation of the material, but remains in the target in the form of heat that then diffuses into the bulk (Fig. 2). This residual thermal energy can be quantified using a calorimetric setup, and accounts for about twenty to forty percent of the incident energy. The residual heat conduction through the material can then be analyzed within the framework of classic thermodynamics. The depth of material that is thermally affected depends on the deposited thermal energy and on the thermal properties of the material [1, 2].

According to Bauer et al. 2015, the temperatures reached by the material after irradiation with a single ultrashort laser pulse with energies leading to ablation can be estimated if we take into account that the heat is concentrated in the most superficial layer of the ablation surface in a time scale shorter than the time required for heat conduction to the bulk. This residual thermal energy can then be considered as an instantaneous superficial point heat source, and the temperature distribution below this surface after a single laser pulse can be calculated by applying the heat conduction equation. For a Gaussian surface heat source, the temperature distribution within an infinite homogeneous solid after a single laser pulse is given by:

$$T^{\text{single pulse}}_{(x_c,\,y_c)}(x, y, z, t) = \frac{2E_{\text{thermal}}}{\pi\rho c_p\sqrt{\pi\kappa t}\,(8\kappa t+\omega_0^2)} \exp\left[\frac{(x-x_c)^2+(y-y_c)^2}{4\kappa t}\left(\frac{\omega_0^2}{8\kappa t+\omega_0^2}-1\right)\right] \exp\left(\frac{-z^2}{4\kappa t}\right) \quad (1)$$

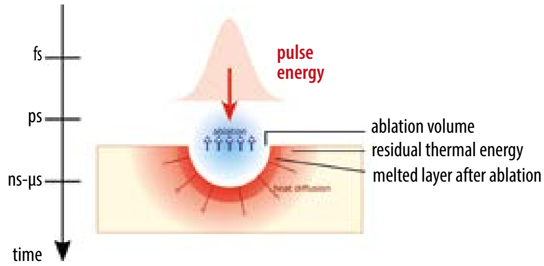


Fig. 2 Illustration of the energy distribution after ultrashort laser irradiation. Adapted from Bauer et al.

where $(x - x_c)$, $(y - y_c)$, and z describe the distances from the center of the point source (x_c, y_c), ω_0 is the spot radius at $1/e^2$ of the maximum intensity, t the time after the energy pulse, c_p the material average heat capacity, ρ the mass density and κ the thermal diffusivity.

For multipulse irradiation, the distance between pulses is $t_{\text{p-p}} = 1/\text{PRR}$, where PRR is the pulse repetition rate. If the beam is scanned on the surface at a speed v, the spot displacement is $dx = v \cdot t_{\text{p-p}}$ and has to be accounted for by adjusting the center coordinates of the gaussian beam. The temperature distribution after N pulses is thus given by:

$$T(x, y, z, t) = \sum_{n=0}^{N} T^{\text{single pulse}}_{(x_{cn},\,y_{cn})}(x, y, z, t + n\,t_{\text{p-p}}) \quad (2)$$

Companies

LASEA

Created in 1999, Lasea is a high-tech Belgian SME which has unique expertise in the design, manufacture and use of laser systems for industrial purposes. More specifically, Lasea offers cutting-edge laser solutions capable of responding to the needs of companies whose production lines include plastic welding, marking, and surface treatment. Its laser products and services are expertise and prototype development, OEM systems, laser workstations and turnkey machines. Lasea is based in the Liège Science Park, allowing it to have strong partnerships with regional Universities and the Space Center. With presently 65 employees, Lasea has manufactured laser production lines all over the world (Europe, US, Australia ...).

www.lasea.com

BOSCH

Robert Bosch GmbH is an international company with more than 400,000 employees at around 280 manufacturing sites, concentrated in four business sectors, and is an industry leader for automotive components and consumer goods. It is also one of the most innovative companies worldwide with currently more than 83,000 active patents and with fifteen new patent applications every working day. Bosch has successfully implemented laser material processing with ultrashort laser pulses in mass production for a number of products produced worldwide, with quantities far exceeding one million parts per year.

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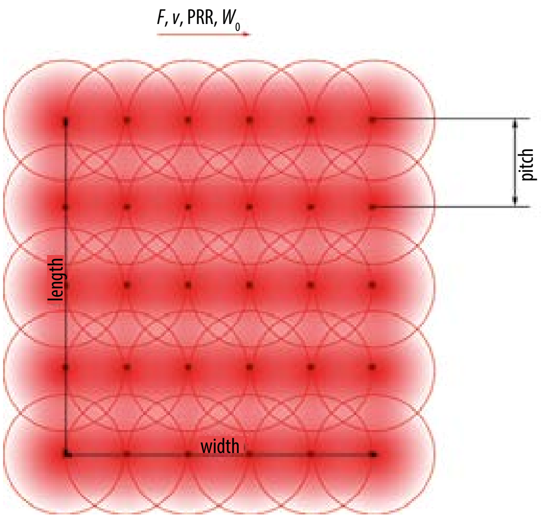

Fig. 3 Disposition of points at which the temperature is determined over an area produced by scanning the beam over parallel lines distanced by a pitch, with a certain fluence, scanning speed and pulse repetition rate.

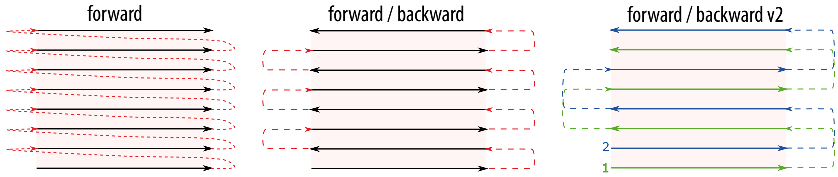

Fig. 4 Scanning strategies simulated. The continuous vectors represent the laser lines, and the dashed vectors represent the lead-in and lead-out lines causing the delays during the irradiation process.

This same approach can be used to determine the maximum temperature reached per point on a treated surface produced by hatching parallel laser lines that are distanced by a certain pitch with a determined speed and repetition rate, as illustrated in Fig. 3. We considered that heat propagates from the surface to the bulk of the semi-infinite solid equally in all directions (x, y, z). We tested three different scanning strategies, by moving the beam in relation to the sample forward, or in two different forward and backward patterns (see black lines in Fig. 4). To these lines we added the time delays corresponding to the acceleration and deceleration ramp times at the beginning and end of each line respectively, as illustrated by the red dashed lines in Fig. 3. This is the typical behavior of a beam moved in relation to the specimen, both when a galvo scanner or mechanical stages are used.

The surface plots depicted in Figs. 5 & 6 illustrate the maximum temperatures per point of the surface when laser milling areas 100 × 100 and 500 × 500 µm² wide respectively on stainless steel, using 1 J/cm² peak fluence, 500 kHz repetition rate, 2 m/s scanning speed, 15 µm spot radius and 15 µm of distance between parallel line scans. Heat accumulation was simulated with and without a 200 µs ramp of acceleration, plus deceleration delays for the three proposed scanning strategies. The area hatching is done from bottom to top, thus in the positive direction of the y axis. The pixel resolution of these surface plots is equivalent to the laser pulse-to-pulse distance. These results show that surface heat accumulation with ultrashort laser milling depends highly on the size of the treated area for the same set of laser processing parameters. Heat tends to accumulate more towards the end of the milling area, as this zone already starts to warm up at the beginning of the area treatment, so the temperature offset is already high when the beam finally hits this region, thus reaching higher temperatures compared with the beginning of the treated part that started out cold. We also observe that not taking the time into account that the beam is off, to carry out the movement from one line to the next one, leads to an overestimation of the maximum temperatures reached because the material has time to cool down in between hatches. It is in any case virtually impossible to scan an area with beam-off times negligible enough for thermal diffusivity in metals, so this is an approach that would allow us to more realistically estimate the temperatures reached.

The results demonstrate that the scanning strategy used does influence the heat distribution on the surface, although this effect is more evident on the 100 × 100 µm² simulated area, which is most likely due to the combined effect of the spatial and temporal distribution of pulses as heat sources. For the larger treated area, the time necessary to scan each line is longer, so the beam takes longer to come back closer to each sur-

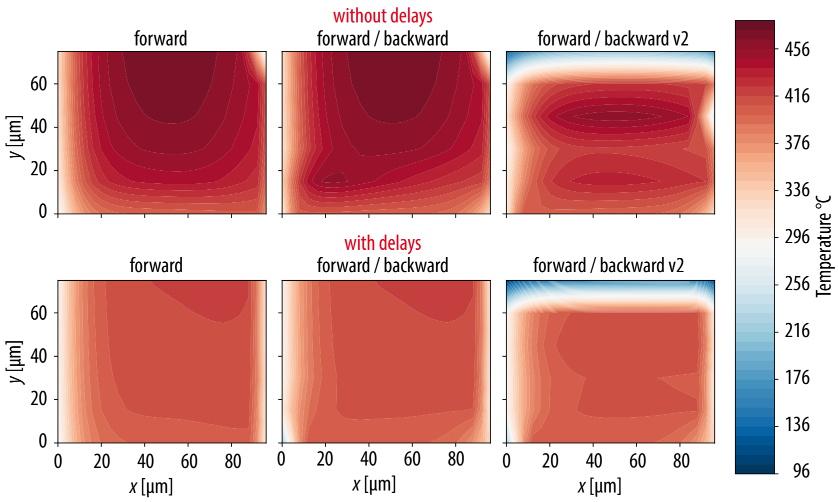

Fig. 5 Surface plots depicting the maximum temperature felt per point of surface upon laser milling an area 100 × 100 µm² wide, using 1 J/cm² peak fluence, 500 kHz repetition rate, 2 m/s scanning speed, 15 µm spot radius and 15 µm of distance between parallel line scans, using the three scanning strategies and with and without acceleration and deceleration times.

INSTITUTE

University of Dresden

The Technische Universität Dresden (TUD) is one of eleven German universities that were identified by the German government as a 'University of Excellence'. TUD has about 35,000 students and over 9,000 employees, 520 professors among them, and is the largest university in Saxony today. Furthermore, TUD has been denominated as a graduate school and a cluster of excellence in Germany's excellence initiative.

https://tu-dresden.de

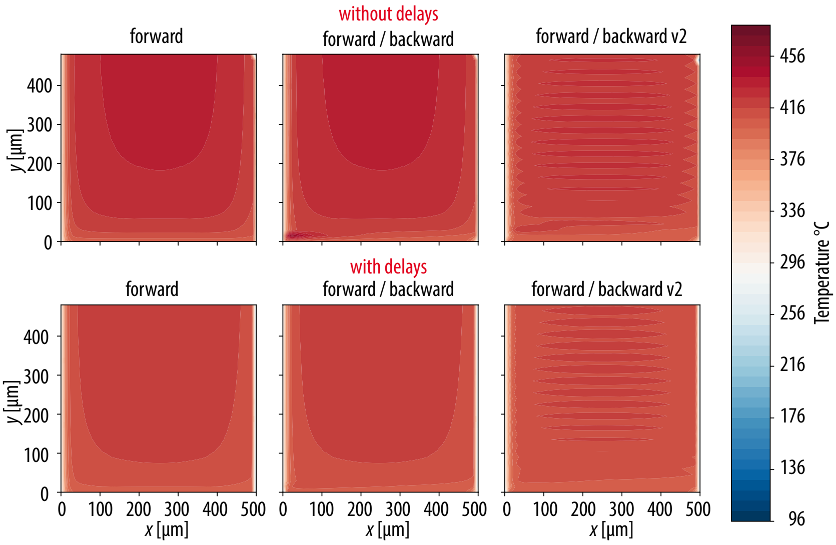

Fig. 6 Surface plots depicting the maximum temperature felt per point of surface upon laser milling an area 500 × 500 µm² wide, using 1 J/cm² peak fluence, 500 kHz repetition rate, 2 m/s scanning speed, 15 µm spot radius and 15 µm of distance between parallel line scans, using the three scanning strategies and with and without acceleration and deceleration times.

face point, giving it time to cool down in the meantime.

*

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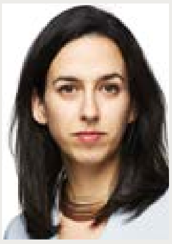
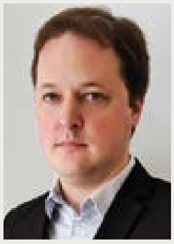
[1] *F. Bauer* et al.: Opt. Exp., **23** (2015) 2, 1035-1043

[2] *R. Weber* et al.: Opt. Exp. **22** (2014) 9, 11312-11324.

Authors

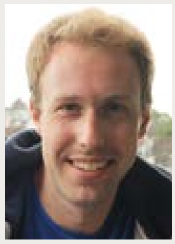


Liliana Cangueiro has been an R&D engineer at Lasea since 2016, working on modelling and process development within the framework of regional or European projects or client demands. She has a background in ultrashort-pulsed laser material processing, surface characterization (microscopy and spectroscopy), laser-material interaction and ablation modeling. She graduated in biomedical engineering at the Nova School of Science and Technology (Lisbon) and obtained her PhD degree on materials engineering at the Instituto Superior Técnico (Lisbon).



David Bruneel works as manager of the process and modelling unit in the R&D department of Lasea. He has long experience of different laser processing techniques and system development with short and ultrashort pulsed lasers: ns, ps, and fs. He obtained his PhD at the Laboratoire Hubert Curien and Fraunhofer IBMT in developing USP process optimization and systems setup, and has now gained more than ten years of experience in previous European and national R&D projects targeted at commercially valuable future applications.

Thomas Kiedrowski studied mechanical engineering at the University of Aachen. From 2003 to 2008 he worked at the Fraunhofer Institute for Laser Technique as project leader in the field of surface technology. In 2009 he received his PhD for his process development of an innovative laser-polishing process. Since 2008, he has been a project leader at Robert Bosch GmbH in micro materials processing. In 2016 he was appointed senior expert for laser applications and system technology. He is also the author of six oral presentations and six patents



Nikolai Schroeder graduated from the Technical University of Dresden with a diploma in mechatronics in 2017, focusing on laser manufacturing technologies. Afterwards he started to work as a research associate at the Fraunhofer IWS Dresden in the field of laser cutting. In 2019, he joined TU Dreden's Institute of Manufacturing Technology. Currently he is doing his PhD under the supervision of Prof Lasagni.

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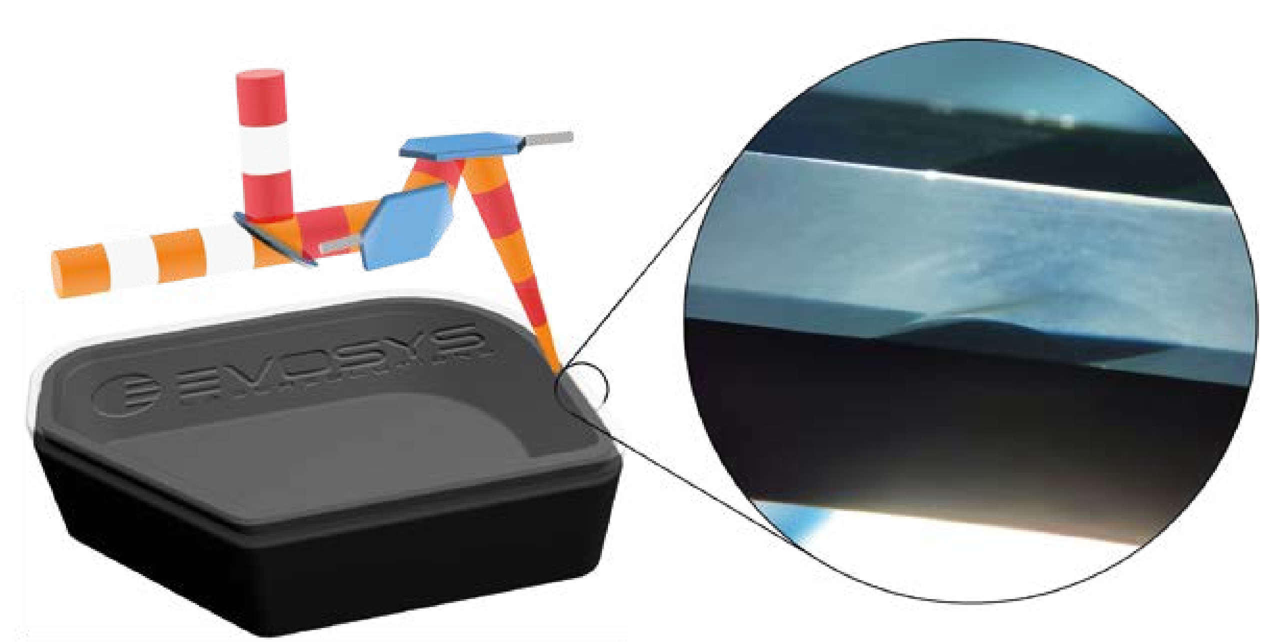
Evosys' advanced quasi-simultaneous welding

A new approach to the joining of polymers

Lea Sauerwein, Christian Ebenhöh, and René Geiger



▲ Principle of the new laser welding process variant developed by Evosys (Source: Evosys)

Evosys Laser GmbH is developing a new method for laser welding of polymers, so-called 'advanced quasi-simultaneous welding' (AQW). The patented technique combines two different processing wavelengths with the method of quasi-simultaneous welding in order to achieve a significant reduction of welding time and enhanced weld seam quality. By the use of differing wavelengths – alternated in a certain time pattern – it is possible to improve and better control the deposition of specific amounts of energy into each item to be joined.

Laser welding is an established and preferred technology for joining engineering polymers due to its numerous advantages. With the most frequently used technique (through-transmission welding), two components are joined in an overlapping arrangement using a single laser beam source. The laser beam is focused through the upper, laser-transparent part to be joined onto the lower, absorbing part, where the laser energy is absorbed and converted into heat. Via heat transfer, the upper joining part is heated up and plasticized as well and a material bond is created. Since most engineering plastics show a relatively high transmission at a wavelength range of approximately 800 to 1000 nm (which is a common wavelength of diode lasers), mostly natural, uncolored materials are used as the transparent joining part. By adding additives, such as carbon black, the laser absorbing properties can be adjusted for the lower part [1, 2].

The high dependency of the process on the heat transfer from one item to the other carries various disadvantages. High geometrical accuracy is needed for the parts in order to maintain proper thermal contact. This is in particular a challenge when using the method of contour welding, where the laser beam moves along the welding path only once. Gaps in the joining interface can hardly be bridged in this case. The absorption of energy mainly in the absorbing part furthermore leads to a high temperature gradient between both components during the welding process, especially when highly transmissive, amorphous polymers like polycarbonate (PC) or polymethylmethacrylat (PMMA) are processed. This can lead to higher residual stresses in the joint area, limiting the process window and reducing the weld seam strength [2].

One approach to reduce these drawbacks is the so-called hybrid welding technique, where the primary laser source is supplemented with a secondary radiation. This secondary radiation aims to warm up the upper joining part directly and not only through heat transfer, thus reducing the temperature gradi-

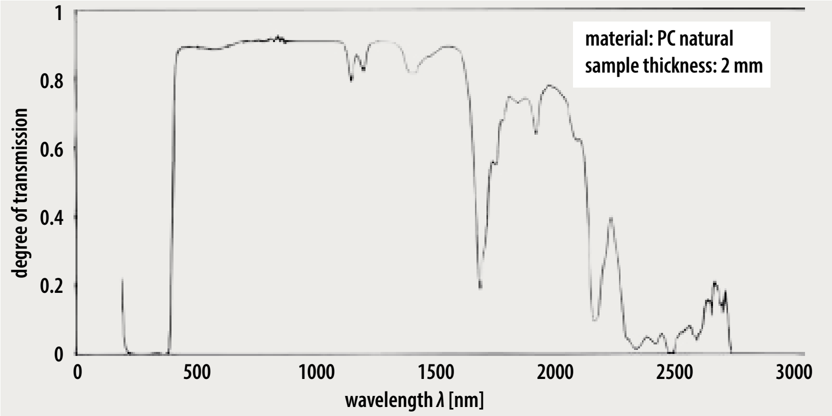


Fig. 1 Transmission spectrum of PC [3]

ent and enhancing the process window. A polychromatic light source is commonly used for secondary radiation [3].

Advanced process control leads to selective energy input

A new concept to employ multiple beam sources is currently being developed by Evosys Laser. This new process, called advanced quasi-simultaneous welding (AQW), differs to the state-of-the-art method by irradiating the working piece with two laser sources alternately. In contrast to simultaneous radiation, this strategy and a purposeful selection of the applied wavelengths allows the application of a selective amount of energy into each joining partner. By switching between both laser sources in a certain time pattern, the process can be better controlled and adjusted to attain the desired process results. Additionally, the use of a monochromatic laser as the secondary radiation source facilitates integration into the commonly used beam guidance systems, such as a galvanometric scanner, which is especially important for quasi-simultaneous welding.

For the described tests, a diode laser with a wavelength of 980 nm is used as the primary laser source, which is commonly employed for conventional through transmission welding as well. It is supplemented by a 1940 nm thulium fiber laser as the secondary laser source. Most polymers show relatively low transmission at a wavelength of around 2 µm, and hence higher absorption compared to 980 nm, as can be seen in Fig. 1 (the diagram shows an example for PC). This fiber laser is therefore a good choice for potentially heating up the upper item directly.

Test setup

The tests are carried out with a newly-developed system technology. Both laser beams are focused separately, which, in combination with a specially designed beam expander, allows individual adjustment of the beam diameters for each application. After focusing, the laser beams are combined and deflected together by a galvanometric scanner. The switching of the lasers is done by a real-time controller system. The length and the variation of pulses are freely adjustable, so the best setting can be chosen for each process. Very precise spatial and temporal adjustment is necessary to control the amount of energy deposited in each item. The beam paths have to be perfectly aligned and the lasers have to alternately switch exactly. Since both lasers have different delays when being switched on and off, this behavior has to be investigated in detail for the real-time controller system to be able to compensate for the shift. If the pulses of the lasers overlap temporally, this leads to an excessively high power density in the material, potentially causing thermal damage. If the pulses are too far apart however, the material cools down considerably, leading to an increased welding time. By carrying out tests like the measurement of pulses with photodiodes, the perfect spatial and temporal adjustment can be determined and confirmed.

Tests are carried out using flat PC plates to investigate the benefits of the new AQW process. Two parts, representing the two items to be joined are put together and held in contact by a clamping tool. The thermal contact, which is highly important for the welding process, is ensured by applying a defined clamping force. Different geometrical arrangements of the two plates are used depending on the benefits to be investigated in the tests.

In the first step, the influence of the new process on the welding time in comparison to the standard process is tested. A T-joint geometry is advantageous for this test, allowing for a collapse-controlled welding process. With this process method, the whole weld seam plasticizes (quasi) simultaneously, which results in a movement of the laser transparent layer towards the absorbing part. This so-called welding collapse can be measured by a tactile distance-measuring sensor. A welding collapse of 0.2 mm is set together with a laser feed rate of 800 mm/s to reflect typical industrial mass production parameters. The welding time until reaching the welding collapse is measured as well as the total collapse after a certain cooling time.

To investigate the possible reduction of welding time, the upper limit of the conventional process window (with one laser source only) is determined separately for both lasers. This limit is defined by the highest laser power that can be applied without negative effects like burn marks on the surface, overheating the expelled melt or thermal decomposition of the base material in the weld seam. For the trials, a laser power just below this process limit is chosen. After welding samples with the standard processes as a comparison, both lasers are alternated in a sequential time pattern,

Company

Evosys Laser

Evosys develops and manufactures tailor-made machines for the laser welding of plastics. With long market and process experience, we offer creative and innovative solutions for demanding processing tasks. We support our customers worldwide from the first component design to quality assurance in series production, and with after-sales service. We are the ideal partner, no matter whether a simple off-the-shelf machine or a complex special system is needed.

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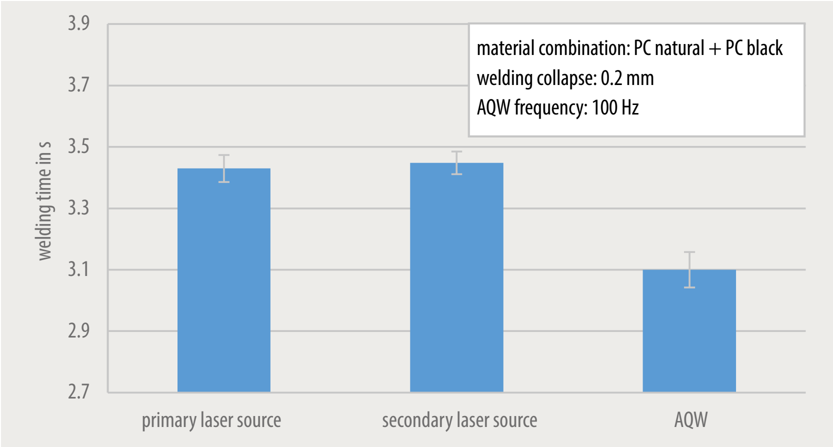

Fig. 2 Significant reduction of welding time with the new AQW process variant (Source: Evosys)

with the laser powers left equal. Different frequencies for switching the lasers are tested and the welding times of the process variants are compared.

The tensile strengths of samples welded with the new AQW method are compared to the standard ones in a second step. To carry out tensile strength tests, the specimens are aligned in a flat-to-flat overlapping arrangement and irradiated with a fixed number of overruns. Feed rate, clamping force and AQW frequency are the same as in the previous tests with the T-joint geometry. In addition to different switching frequencies, the effect of different amounts of energy of the two lasers – i.e. more laser power of the primary laser source in combination with less power of the secondary laser source – are also investigated. The laser powers selected for the standard processes are set as 100 % laser power. Therefore 120 % primary radiation for example means that – compared to the standard process – the primary laser power is increased by 20 %. When increasing the primary laser power by 20 %, the secondary laser power is decreased by 20 %, thus the total amount of energy is the same in all variations. In addition to the tensile strength tests, cross-sections are prepared in order to examine and compare the weld nuggets of the different parameters.

Positive effect of the AQW process on the welding time

For a set welding collapse of 0.2 mm, the upper limit of the process window is reached at a laser power of 50 W for the standard process with the primary laser source and a wavelength of 980 nm, and 51 W for the standard process with the secondary laser source with a wavelength of 1940 nm. A reduction of the welding time by increasing the laser power using only one laser source is not possible as this leads to the previously mentioned negative effects (such as thermal decomposition). When using the AQW process, both lasers are switched with the laser powers of the standard processes and a switching frequency of 100 Hz. The welding time can be significantly reduced by approximately 10 % with this setting in comparison to the standard process with only the primary or secondary laser source, as can be seen in Fig. 2. Furthermore, the reduction of the welding time is not limited to individual feed rates but can be reproduced at different feed rates as well.

Increase of the weld seam strength through AQW

The tensile strengths obtained through tests are plotted in Fig. 3. The standard processes with only the primary or secondary laser source are analyzed as a comparison for the new AQW process. The two columns at the left of the diagram show the tensile strengths of samples welded with the standard processes. As can be seen, the ones welded with only the secondary laser have significantly lower tensile strengths, so the standard process with a primary laser source is the relevant reference for the weld seam strength. Three different parameter configurations of the new AQW process are shown in that figure. All of them are welded with a switching frequency of 100 Hz. The one in the middle of the diagram is welded with the same laser powers as the standard processes. Towards the right side of the diagram, the amount of energy of the primary laser source is continuously increased, whereas the amount of energy of the secondary laser source is decreased. The more energy of the primary laser source is used, the higher the tensile strength of the samples. By welding the parts with the AQW process and a primary laser power of 140 % of the standard process power and only 60 % of the secondary laser power, the weld seam strength can be significantly improved in comparison to the standard process. This means that there is obviously also an optimum ratio between the energy input of the primary and secondary laser source.

The fracture patterns of the specimens used in the tests confirm the higher tensile strength of the samples welded with the AQW method (140 % primary laser power, 60 % secondary laser power). All these parts broke in the base material and not – like the parts welded with other parameter sets or process variants – very close to or in the welding zone, which is an indicator for a very high weld seam strength

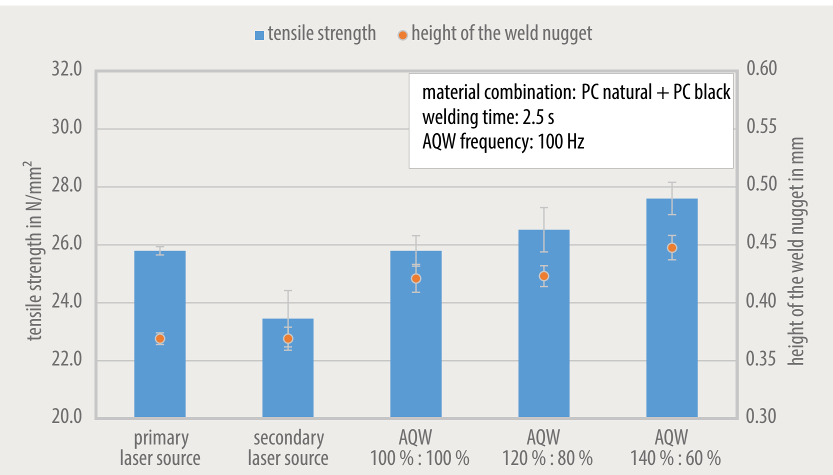

Fig. 3 Increase of the tensile strength and weld nugget height by AQW (Source: Evosys)

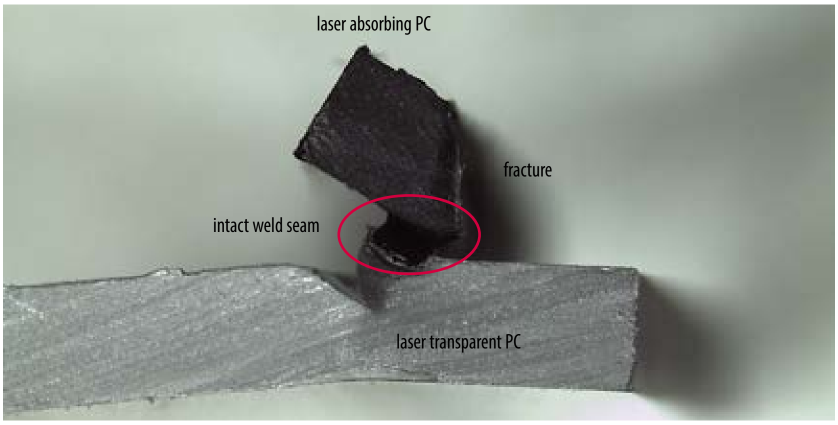

Fig. 4 Fracture pattern after tensile strength tests (Source: Evosys)

Fig. 5 Comparison of a standard (left) and AQW process (right) weld nugget (Source: Evosys)

(and hence quality). An example of this fracture behavior can be seen in Fig. 4.

An explanation for the high tensile strengths can be found when preparing cross-sections and measuring the height of the visible weld nugget in the laser transparent item. The height of the weld nuggets of the different process variants are plotted in Fig. 3, in addition to the tensile strengths. A correlation between the measured tensile strengths and the height of the weld nuggets can be observed, where a big weld nugget with a large surface is related to a high weld seam strength. By welding the parts with this newly-developed process variant, it can be assumed that more energy is deposited directly into the transparent item, so more material is plasticized in this upper component, leading to the enlarged weld nugget. Fig. 5 shows a comparison of the weld nugget of a standard process weld seam and an AQW weld seam.

Evosys AQW leads to a more efficient laser welding process and enhanced weld seam quality

The benefits of the new developed advanced quasi-simultaneous welding process can be confirmed in various trials. The purposeful selection of wavelengths for the primary and the secondary laser source in combination with enhanced system technology allows for a faster and more efficient process with an improved weld seam quality. The welding time can be reduced by about 10 % by better controlling the amount of energy deposited in each item to be joined. The weld seam strength and quality is enhanced by increasing the amount of plasticized and fused material in the laser transmissive item by warming up this component directly instead of mainly through heat transfer. Because of these very promising results, the benefit of the AQW process will be investigated for other materials such as semi-crystalline high-performance polymers.

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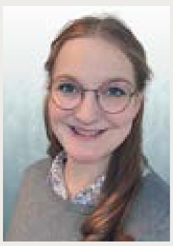

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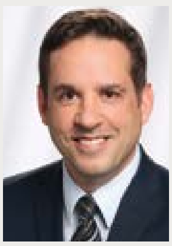

Christian Ebenhöh studied production engineering at the University in Erlangen. Due to his technical education with a focus on laser material processing and plastics technology, and his stations in applications engineering, he has excellent knowledge of process technology. At Evosys Laser, he works as a key account manager.

René Geiger has more than 15 years of experience in laser plastics welding as a development engineer, project manager and team manager. He joined Evosys Laser in 2016 and works as a development manager. He studied electrical engineering at the Georg Simon Ohm University of Applied Sciences in Nuremberg.

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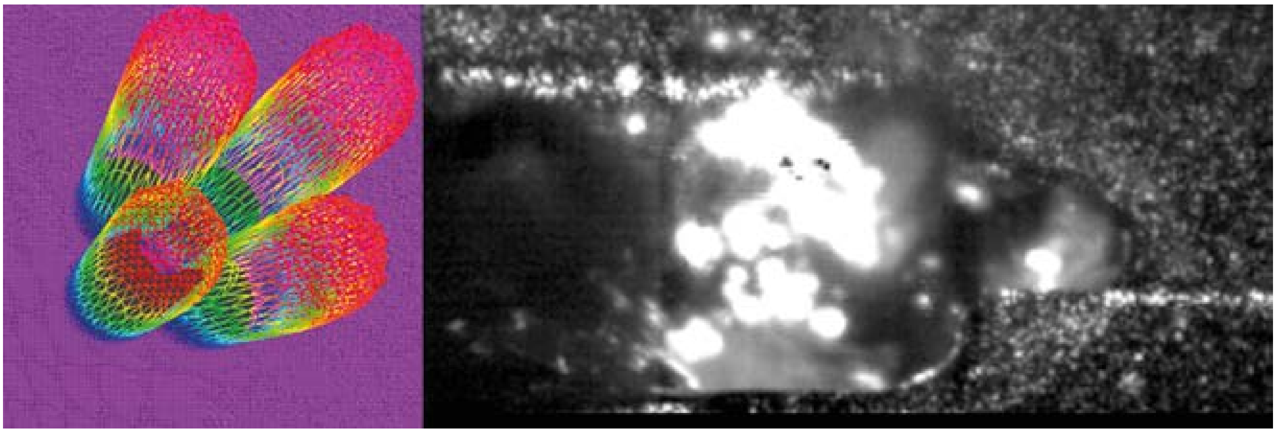
Beam shaping solutions for stable laser welding

Multifocal and multispot beams to bridge gaps and reduce spattering

Joerg Volpp & Alexander Laskin



Source: Adloptica

▲ High-speed image of a multi-keyhole welding process

The laser beam is a highly flexible tool that is used for many material processing applications. New spatial beam shaping technology enables even further functionality to create up to four focal spots in an axial or lateral direction, which enables the distribution of the energy to be tailored. It was shown that certain beam shapes help to suppress spattering and increase the bridgeable gap size during deep penetration laser welding.

Welding is a widely used method to join structures in many industries and is one of the most needed manufacturing methods. Laser beam welding is an advanced method that promises comparably fast processing due to the high local energy input and the ability to create deep weld seams in the deep penetration welding mode, where a vapor channel or keyhole is established. Two main challenges occur:

The laser beam size is comparably small with the typical range of diameters between 50 and 600 µm, which makes welding only possible when the laser beam is not transmitted through a gap between the joining partners [1]. Therefore, welding without the addition of filler material typically requires technical zero-gap configurations.

In the deep penetration welding mode, the typically occurring dynamic effects lead to melt pool movement and ejections, denoted as spattering. In addition to the material loss, those ejections can lead to unwanted spatter attachments on the surface of the welded part, which requires additional processing.

One promising way to avoid laser beam transmission through a gap between joining partners and to stabilize the process is beam shaping. Different methods were examined that enable adapted energy input into the materials. Beam oscillation techniques were shown to improve laser processing by dynamic redistribution of the energy, for example for remote laser welding without filler material [2]. Static beam shaping is another possibility to modify the energy input from a laser beam into the material that allows the optimization of not only the conditions of pre and post-heating but also the spatial intensity distribution in the process zone. Such techniques have already been used for a long time, for example for the hardening of large areas using line beams. In response to the constantly growing power of modern multi-kW lasers, the recent developments of beam shaping optics are aimed at providing optimum distribution of even higher energy delivery to the processing zone without damaging the optical components. Besides shaping the laser beam using the transport fiber with multiple cores or diffractive optical elements offering (almost) unlimited design freedom, refractive

Company

AdlOptica GmbH

The company provides highly efficient, versatile laser beam shaping optics with numerous applications in industry and science. The result of multi-year development has realized families of optical systems called πShaper, foXXus, quattroXX, and aplanoXX, numbering more than ninety models. They have almost 100 % efficiency, a spectrum from UV to IR, power from mW to kW, with cw and pulsed lasers, a wide range of flattop spot sizes, and low sensitivity to misalignment. AdlOptica is located in Adlershof, Berlin, Germany’s leading science and technology park.

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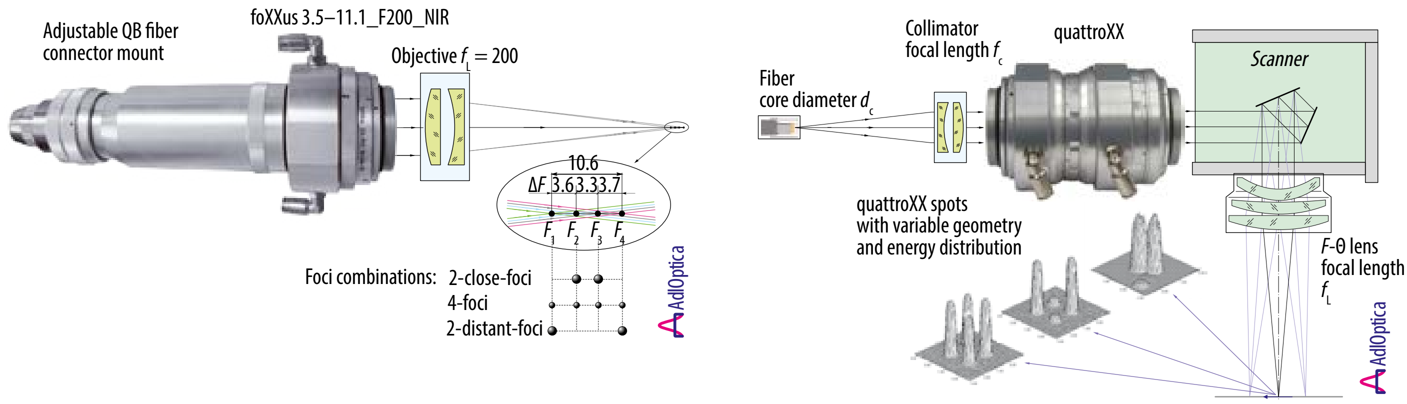

Fig. 1 Optics for beam shaping to create a) up to 4 foci along the optical axis (foXXus) and b) multiple spots in the focal plane (quattroXX). (Source: Leaflets by Adloptica)

beam shaping methods were further developed for lossless energy re-distribution and reduced losses in the optics and are therefore also usable for higher laser powers. One possibility is the spatial re-distribution from a Gaussian to a top hat or donut intensity distribution, while a spatter reduction was observed when changing to top hat beams during welding [3]. The lossless refractive beam shaping solutions for multi-mode lasers are realized in the form of optics splitting the laser energy into multiple foci along the optical axis or in multiple spots in the focal plane (Fig. 1) [4].

Beam splitting along the optical axis is realized using the foXXus optics of a patented optical design, implemented in the form of a water-cooled focusing lens or a collimator providing up to four separate foci, F_1, F_2, F_3, F_4 (Fig. 1a). Clear apertures up to 48 mm and focal lengths, 100 mm and 200 mm, are typical for industrial optics. Depending on the internal settings, the same foXXus device provides various foci combinations: 2-close-foci, 2-distant-foci, 4-foci. In the case of a foXXus collimator, the distances between foci can be varied by changing the focal length of the focusing lens. This is a powerful tool to optimize parameters of laser energy distribution along the optical axis in particular applications, which is illustrated in the experimental data presented below.

A basic approach for building an industrial optical system for lossless beam splitting using the quattroXX refractive beam shaper of a patent pending design is shown in Fig. 1b. The beam emerging from the fiber laser is first collimated, then split up into several smaller beams using the quattroXX, and further focused using a lens. The result is a multi-spot pattern in the focal plane of the focusing lens. The quattroXX spots (patterns) available are square, rhombus, line, and twin-spot, characterized by variable distances between the separate spots and energy portions. All geometrical shapes of the quattroXX spot and energy distribution are controlled by the internal settings of the splitting device, which allows the intensity distribution to be adjusted with minimum or zero in the spot center close to the doughnut or 'inverse-Gauss' spots. As an afocal optical system, quattroXX can be easily integrated with industrial process heads and scanning systems with F-theta lenses.

The impact of different beam shapes on the process dynamics must be investigated due to the complex physical effects occurring during deep penetration welding. Therefore, the impact of multiple-spot beam shaping techniques on gap bridging and spattering were examined using the beam shaping optics shown in Fig. 1.

Gap bridging and beam shaping

Different configurations of materials and setups were used for the experiments, while the energy distribution was varied using the quattroXX. High-speed-imaging was implemented to capture images of the processing zone. A high-speed-image from a recording at a frame rate of 32,000 fps shows a detailed view of the formation of the separate keyholes induced by a four-spot configuration (Fig. 2). The keyhole fronts visibly melt the base material in front of the processing zone, with a narrow melt pool ahead immediately devolving into the keyhole. The fourth keyhole from the trailing spot is established within the melt pool. The melt pool was seen to be stable and showing low melt fluctuations.

In order to evaluate the ability of the different beam configurations to bridge a gap, welding with an opening

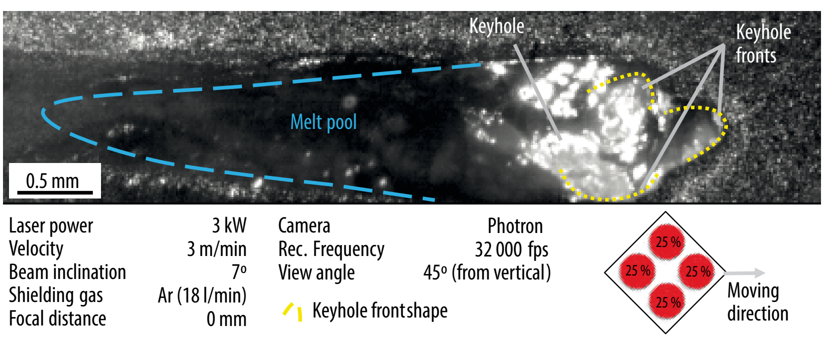

Fig. 2 High-speed imaging frame of a keyhole created by four laser spots

Institute

Luleå University of Technology

The division of product and production development is expert in high-power laser materials processing, with a focus on additive manufacturing and welding. Long experience in process visualization using high-speed imaging and modeling supports the related research activities.

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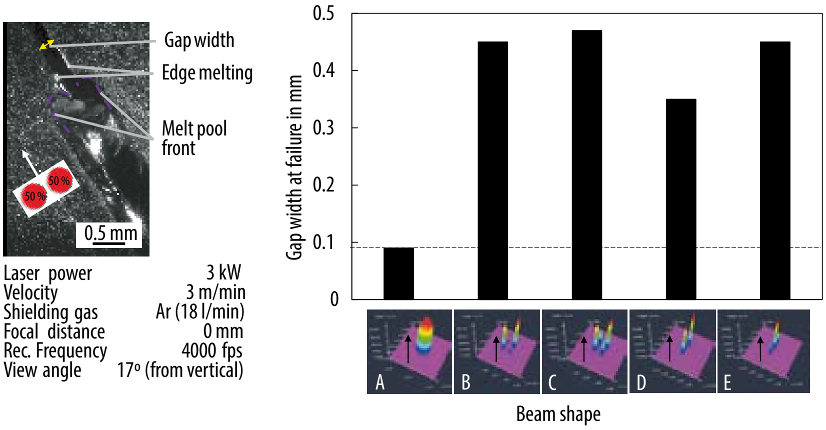

Fig. 3 Gap bridging ability of several beam shapes

gap (from 0 mm to 0.6 mm at a distance of 100 mm) was performed, the break-up point was found and the related gap widths were evaluated (Fig. 3).

All tested quattroXX spots show an increased gap bridging ability compared to the one-spot welding configuration. The distribution of the energy to the edges of the joining partners leads to more efficient energy input. The melt pool movement towards the joining partner sheet supports the melt connection being established over a wider gap.

Spattering and beam shaping

A RedLake Mono N4S2 camera was used at a recording frequency of 4000 fps in combination with a Cavitar illumination system to illuminate the processing zone using a laser at a wavelength of 808 nm, while a notch filter in front of the camera guaranteed the recording of just the light of this wavelength. A spatter recognition and tracking algorithm were used in a sequence of 500 frames per video.

The MatLab code then identified the single spatters and their center points, while the number of spatters was recorded for each frame. To avoid counting the same spatter several times in several frames, subsequent frames were compared to the previous ones to relate spatters, while the criteria were set to be the shortest distance and the size of the spatter to identify the same spatters. Only when new spatters occurred in the frame was the spatter number increased. Based on the recording frequency, the spatter amount per second was calculated for comparison of the welding trials with different beam shapes.

The spatter amounts per second were calculated for different beam configurations (both axial beam shaping using foXXus and quattroXX spots in the focal plane – Fig. 4). Compared to the one-spot-configuration (dotted lines), some configurations show lower, but some significantly higher spatter amounts, which indicates different dynamic process behavior.

For the lateral beam shaping experiments (Fig. 4b), efficient energy distribution to the joining partner sheets seems to be advantageous to reduce spattering. The arrangement of configuration E seems to have a too pronounced central spot that temporarily leads to laser transmission through the gap and thereby to inhomogeneous energy input, which is supported by the inhomogeneous heating of the two supporting spots. Configurations B, C and D lead to an efficient and stable process, due to the energy input into the joining partner sheets.

For the axially shaped beams (Fig. 4a), the tendency is seen that a more homogeneous depth of focus with increased intensities of the laser beam in lower keyhole regions supports a stable process and reduced spattering compared to a one-spot arrangement.

In general, the observations indicate that a stable melt pool can be achieved when the energy input is homogeneous and the vapor exiting from the keyhole has enough space to expand. A widened keyhole opening seems to support the vapor outflow and to reduce spattering.

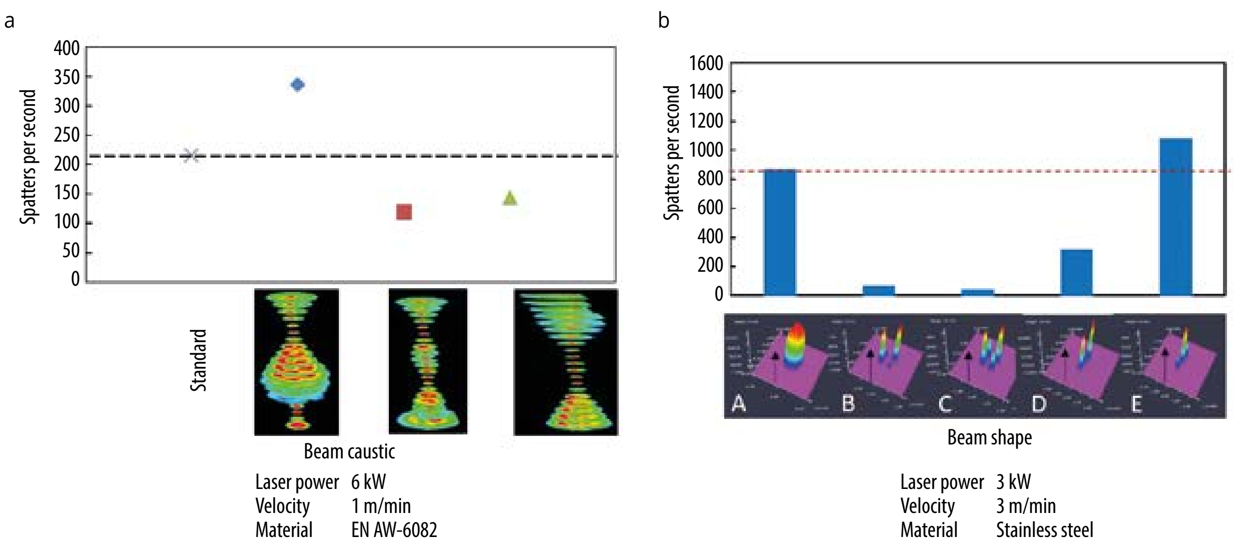

Fig. 4 Spatter occurrence by time for selected beam shapes in axial distribution (a) and spatial distribution (b)

Summary

Based on the high-speed imaging and gap bridging experiments using advanced beam shaping optics, the following conclusions can be drawn:

A high ability to bridge gaps with low spattering was possible when distributing the energy input towards the joining partners in a symmetric way, while additional low-intensity spots in the center lower the dynamic behavior of the melt pools. The conditions of melt mixing are probably enabled by leading the melt from the separate keyholes towards the other sheet, which guarantees the melt connection.

High spatter amounts occur when the melt pool is narrow and the keyhole is unstable, which points to upward or downward high-speed melt movement in the melt pool.

Asymmetric conditions can lead to higher dynamics in the process, reducing the melt movement to the other sheet. However, the melt flow from one sheet to the other is supported by a high-energy spot in the center of the gap.

It could be shown that lateral and axial beam shaping can increase laser welding process stability.

*

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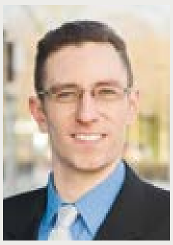

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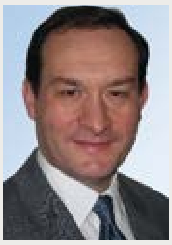

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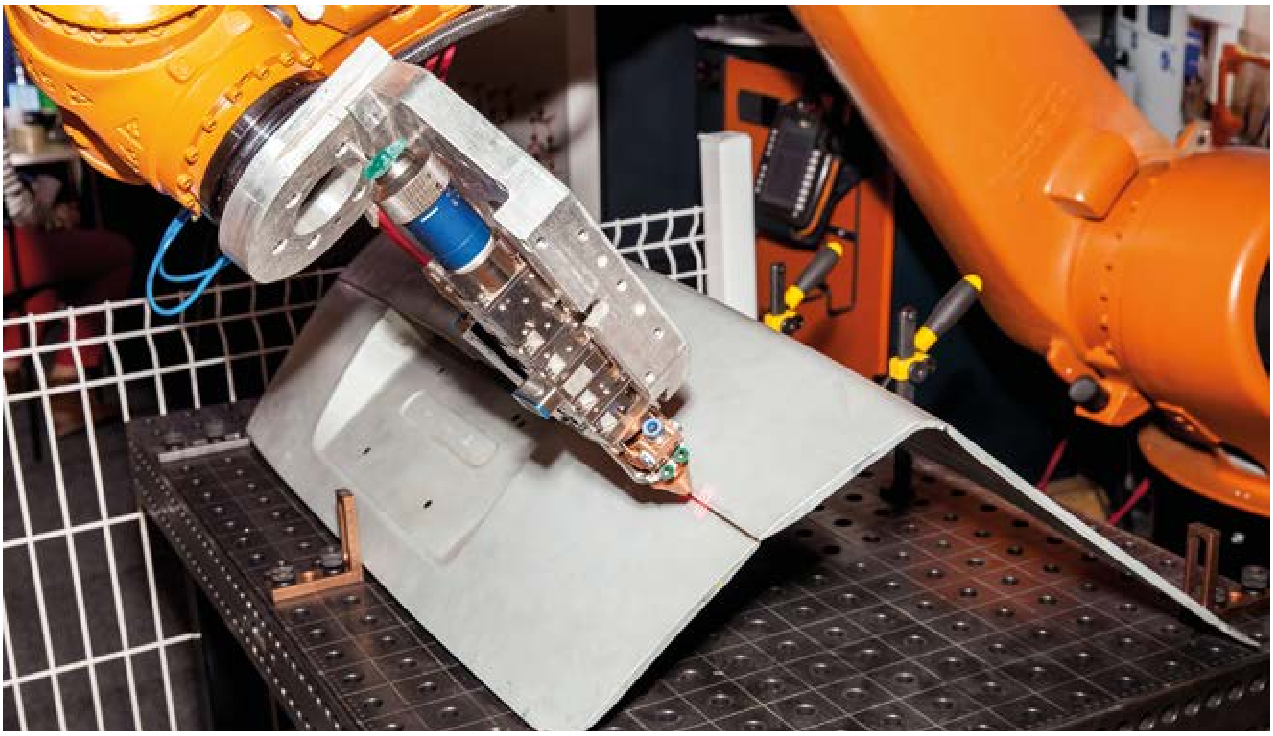
Adjustable ring shaping for laser welding applications

A diffractive method for shaping a laser into a spot surrounded by a ring, with continuously adjustable power ratio

Alexander Brodsky and Natan Kaplan



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High laser welding speed can be achieved by using a ring and central spot laser illumination profile, with an adjustable ratio of the ring energy to the spot enabling optimization of the process. We present a novel and simple diffractive-based concept to achieve such adjustable shaping for standard fiber lasers. The module is rotation-adjustable between 100 % energy in the central spot to no energy in the central spot, can work with both single-mode and multimode lasers, is highly compact (less than 20 mm long) and has the high LDT of passive diffractive components. This concept obviates the need for special ring-type fiber lasers, enabling simpler design of the welding laser head.

The need for ring and spot shaping in laser welding

Laser welding is a widely used technique in many industrial processes in the automotive, ship building, battery pack and other industries [1, 2]. Welding speed is rapidly becoming one of the most critical process limitations in many laser welding applications. One such example is welding in the growing e-mobility market, in which laser are used to weld battery contacts, where fast welding can enable higher throughput and cost saving in battery production. Another example is the growing need for fast and cost-effective laser welding in the automotive industry, as fuel efficiency mandates encourage manufacturers to use more aluminum and advanced materials, requiring laser welding of doors, hang-on parts, ultra-high strength steel components and aluminum body frames.

The need for faster welding speeds is driving an increase in the availability of lower cost, high power NIR fiber lasers. The availability of such lasers translates into power practically no longer being the limit to welding speed. Instead, it has been found that laser welding speed is limited by various physical phenomenon that become dominant at high weld speed, such as spattering, humping and an increase in weld porosity.

These phenomena have been shown to be much reduced when a special illumination distribution is used, consisting of a central spot surrounded by a ring with a certain ratio of the power between

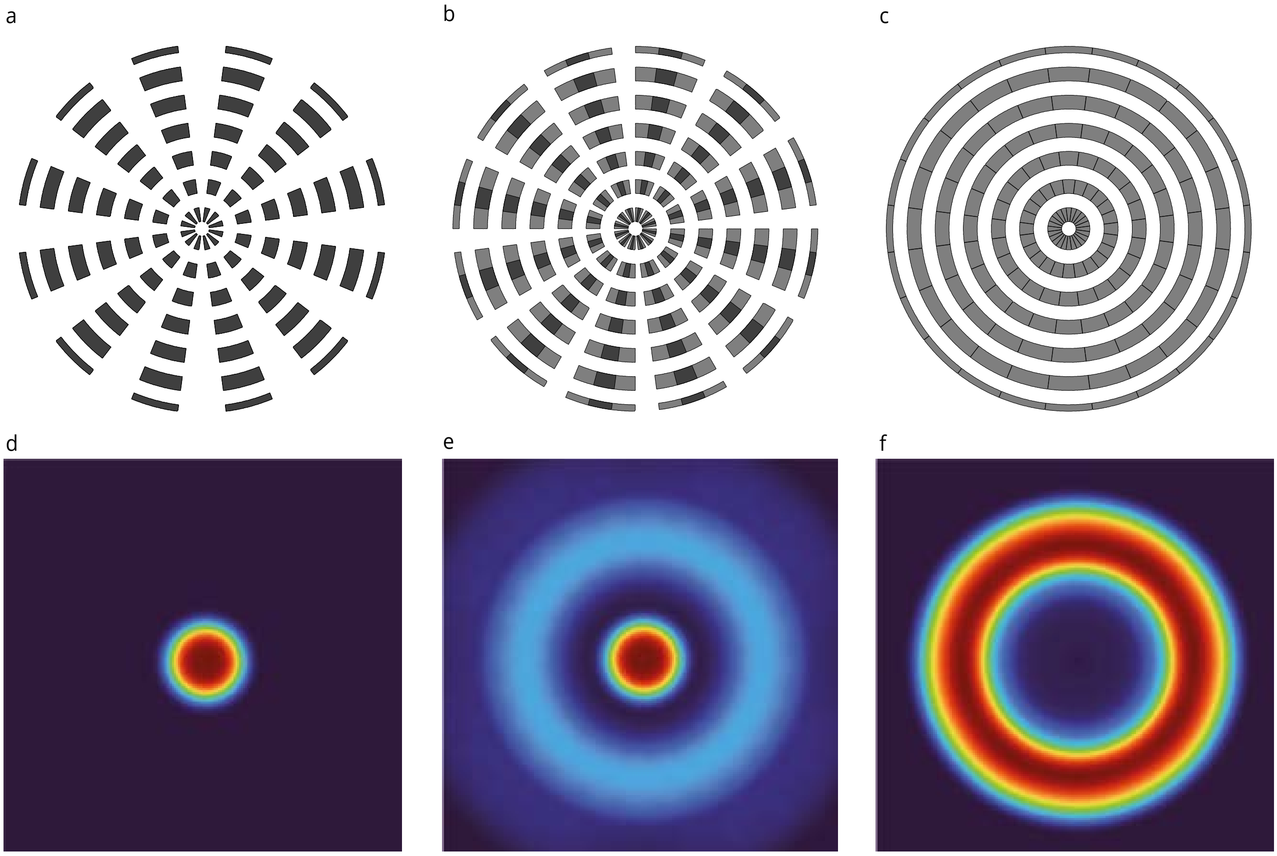

Fig. 1 Upper row shows 3 positions (a, b & c) of relative rotation orientation: 0, 7.5, and 15 degrees respectively between two binary DOEs. Lower row shows the intensity distribution related to each of the rotational orientations on the row above: all of the power is concentrated in the central spot (d), all of the power is concentrated in the ring (f), an intermediate position where some of the power is at the central spot and some is at the surrounding ring (e). (Source: Holo/Or)

the central spot and the surrounding ring. Different welding process parameters (such as metal thickness, metal type and geometry), require different ratios to provide the best process at high welding speed. A solution that can offer a controlled, adjustable shaping ratio of the power is therefore an advantage to many system integrators.

Fiber-based solutions for ring and spot adjustable shaping: advantages and limitations

The method most commonly used to generate a ring and central spot illumination profile is using special multi-mode fiber lasers with either a dual or triple core. The central core is surrounded by one or two concentric ring-shaped cores. Each core can have its laser power set separately, resulting in adjustable power in the central spot vs. the surrounding rings. The fiber output is then imaged directly onto the work plane, giving the desired illumination profile.

Such adjustable spot profile fiber lasers have been released by most leading companies in the high-power (>1 kW) fiber laser market, including Trumpf, Coherent, IPG, NLight, and others.

One of the main advantages of these fiber lasers is that there is no need for external shaping optics – the entire shaping occurs and is controlled at the fiber laser level. One just plugs the fiber collimator into an adapter and can start working with a beam whose intensity profile is computer-controlled and real-time adjustable, enabling fast, defect-free welding.

There are however, some issues with the method that make the fiber-based adjustable ring solutions sub optimal:

First, such laser systems have extra complexity and costs compared to regular multi-mode high power fiber lasers. Second, the high NA of such fibers means that special collimators must be used, often requiring larger optics than would otherwise be needed, compared to the standard welding optics used with fiber lasers today. Finally, there is often a limit to the ratio between the central spot and the ring. In order to get more power in the welding spot, the power within the ring must be increased, as

Company

Holo/Or

Founded in 1989 by Israel Grossinger, Holo/Or was the very first company to develop high efficiency DOEs for commercial use at affordable prices. Thereafter, it developed a process for high laser damage threshold DOEs which, until this day, only few companies worldwide are able to offer.
The company develops, designs and manufactures diffractive optical elements (DOEs) and micro-optical elements for any wavelength, from DUV to far IR, as well as software / automation solutions for the design.
Its main customers are laser system integrators in industries such as medical / aesthetical, material processing, metrology, and others, attended by 13 active distributors on four continents. It works with most of the largest OEM companies in the USA, China, Japan, South-Korea, and Germany.

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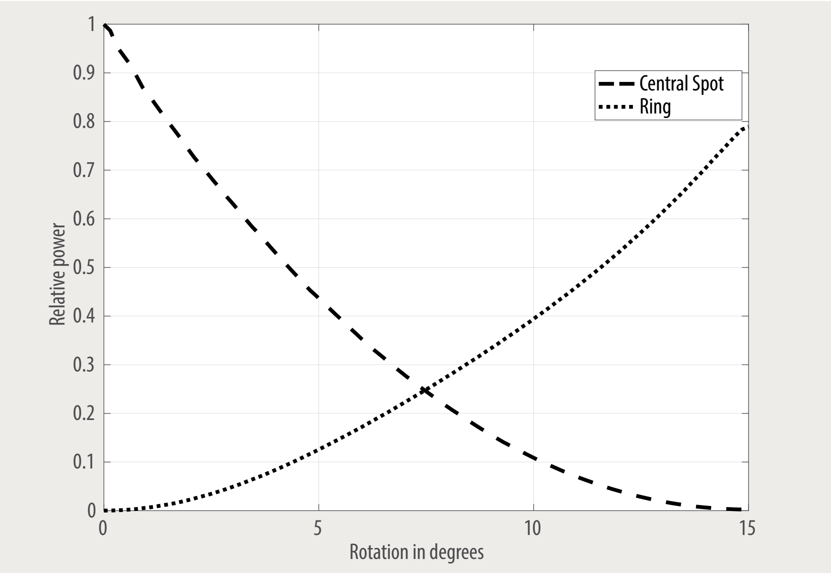

Fig. 2 Plot of the relative power in the central spot and the surrounding ring as a function of the relative rotation angle between the two binary DOEs. (Source: Holo/Or)

the central core can only support power up to a typical limit of <6 – 8 kW. This means that highly useful configurations where most of the power is going into the central spot and only a small fraction is going into the ring cannot be used with the full laser power, unless a customized fiber cores ratio is used.

In this article, we describe an alternative approach to fiber-based ring and spot shaping that allows full adjustment of the power ratio while still being a relatively simple, cost-effective and straightforward optical concept. The method is based on diffractive optics and consists of an external optical module added to the system. Our approach presents a good solution for laser system integrators who already have multi-kW fiber lasers and wish to upgrade their welding system with new capabilities, as well as designers of new welding systems that are looking for performance that cannot be delivered by fiber level shaping solutions. Our belief is that the advantages presented by using the suggested shaping module, which we will elaborate on in this article, outweigh the disadvantage of adding another component.

The suggested diffractive method is based on our previous publication in PhotonicsViews magazine, entitled "Adjustable-Function Beam Shaping Methods" [3], where we reviewed different concepts of adjustable beam shaping, including a sub-aperture-based ring with central spot adjustable shaper. The current concept is a revised version of the one reviewed in that article, which is more application optimized, with better defocus behavior that is compatible with real laser welding tolerances.

A diffractive adjustable ring and spots shaper

The diffractive-shaping solution consists of two identical binary diffractive elements, also called phase plates, placed on the same optical axis. The round clear aperture of each element is divided into an even number of azimuthal segments. Half of the segments are just clear regions, while the other half has the optical function of a diffractive binary Axicon with step height equivalent to π radians.

The adjustment of the power ratio between ring and central spot is obtained by rotating one of the phase plates vs. the other. In a case where the rotation is zero between the plates, as shown in Fig. 1a, the patterned areas overlap, resulting in a phase delay of 2π for the light going through these areas. Effectively, this means that the total phase is zero, and the laser beam is unaffected, resulting in 100 % of the energy going to the central spot.

In the case where the rotation is as a full segment as shown in Fig. 1c, the segments have no overlap, and the resulting phase is that of a binary diffractive axicon, resulting in the generation of a ring with no power in the central spot at all.

Intermediate rotational states between these two conditions result in some of the energy going to the ring, while the rest of it goes to the central spot, in a continuously adjustable ratio determined by the rotation angle. Fig. 1b presents one example of such a state.

The overall transmission efficiency of the energy in the central spot and ring continuously changes from ~100 % at the central spot alone, to ~80 % at the ring alone. The efficiency losses go to higher diffractive transmission orders and appear as secondary rings at higher angles.

The full range of change occurs over a rotation angle equal to a single angular segment, 15 degrees in the presented case, and is periodic (i.e continuing the rotation would again change the ratio in the same way). The power in the central spot changes as shown in Fig. 2, in a non-linear dependance on the rotation angle.

Benefits of the adjustable diffractive ring shaping approach

The diffractive based approach holds many advantages over the fiber-based solutions available in the market today. It enables full range control over the ratio of power between the spot and ring, unlike fiber-based solutions that have more limited tunability, and has further advantages.

Thanks to the simplicity of the concept, this module can be adapted for large beams (15 – 22 mm diameter) that are typically used with multi-kW lasers. The optical elements can be installed into off-the-shelf manual or motorized rotation mounts to create an optical module. Such a module can be placed on the optical axis after the laser collimator or, even better, directly at the entrance to the laser head or scanning system. These configurations allow the welding optics to remain the same as those used with a standard multi-mode fiber laser, with no need to account for larger NA and the required larger and costlier optics, as in the case of ring mode fiber lasers.

The full range of adjustment takes a few milliseconds with a motorized rotation stage, making intensity adjustment possible in-process when needed. However, in a typical case, the adjustability of the power ratio is important only during the welding process optimization phase. Once process parameters have been defined, the adjustable ring and spot shaper module can be replaced by a single passive DOE with the tailored ring-spot power ratio that was found to be optimal for the specific welding process, which presents an even more compact and cost-effective shaping solution.

Another benefit of the diffractive variable shaping approach is the ability to work with single mode lasers. Unlike ring core fiber lasers, where the ring is always multimode and therefore cannot be focused to a small spot at a reasonable NA, the diffractive module enables a small overall spot to be formed that has the ring and central intensity shape, while still providing an adjustable ratio. This ability is especially useful for micro welding with single mode incident beams, as often the process speed limiting factor is not the single mode fiber power, but rather the humping, porosity and other issues that are reduced by diverting some of the laser power to a ring around the spot.

Lastly, the diffractive solution ring angle is insensitive to input beam size and so provides more flexibility for shaping. This is due to the fact that the ring diameter is constant, but its thickness and central spot size can be modified by applying a variable telescope after the collimator, or by using a different collimator. This is in contrast to fiber-based ring shaping, where the ring thickness vs the central spot is fixed, since the geometry of the fiber is basically just imaged onto the work plane.

As we have described in this article, a diffractive-based ring shaping module offers multiple benefits for welding compared to a ring shaped fiber laser, while being simple, low-cost and robust.

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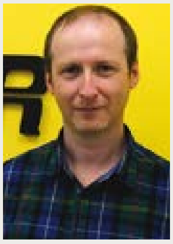
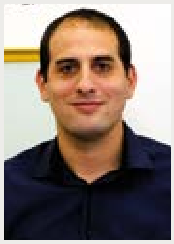
Authors



Alexander Brodsky is Holo/Or's R&D optical systems design engineer. Specializing in laser optics solutions involving diffractive optical elements, Alexander is Holo/Or's lead designer when it comes to combined diffractive-refractive system design. He has eight years of experience in micro-optics development and has authored several peer-reviewed papers about beam shaping methods for M^2 transformation. Alexander has a bachelor of science degree in applied physics.



Natan Kaplan is Holo/Or's R&D manager. A graduate cum laude of the Adi Lautman program for excellent students at Tel Aviv University (physics BSc), Natan went on to specialize in subwavelength structures for antireflective purposes in the mid-IR, where he finished his MSc under the supervision of Avraham Katzir. He has about ten years of experience in micro-optics development and co-authored two articles on laser material processing and several white papers on diffractive optics. He has managed projects within the Horizon 2020 framework (Ultrasurface), as well as other projects (ALTIA, Israeli MAGNET program, Eurostars MultiLas cooperation).

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Smart monitoring of battery welding processes

Sensor systems for laser welding applications along the battery production chain: from cell to package

Nataliya Deyneka Dupriez

Source all images: Lessmüller Lasertechnik

Fig. 1 Active laser welding of a battery cell utilizing a Lessmüller Lasertechnik sensor system for impeccable sealing

One of the key laser application areas in the e-automotive industry is the welding of the battery. Sensor systems from Lessmüller Lasertechnik ensure reliable, high-precision joining, which is vital in the assembly of any battery. Installed to various remote and fixed welding optics, the OCT, WELDCHECK, and WELDEYE sensor systems demonstrate real-time monitoring capability with great accuracy and over a wide dynamic range, enabling faster, cost-effective e-automotive laser processes and streamlined production.

In recent years, laser processing has become dominant in industrial applications such as welding, drilling and cutting due to its short cycle time and non-contact operation. Today, the field of laser application has expanded even more. Controlled laser processing is required in macro/micro fabrication and in additive manufacturing. The demands placed on laser welding by the production of battery systems for electric vehicles in particular are high. Being often the most expensive car component, the battery must be fabricated very efficiently with a minimum number of rejects. It is important that the welds are mechanically stable because the battery has to withstand extreme stresses such as seasonal temperature fluctuations, vibrations and impacts, or even collisions. For this reason, their quality plays a crucial role for safety. Continuous monitoring of the production laser process is needed for the millions of welded joints in order to ensure long-term quality and to produce safe and efficient battery systems. It is important to closely monitor each and every process step in a battery's manufacture using a laser in a fully automated environment.

Nowadays, the monitoring of laser processes is commercially widely applied. The data obtained during process monitoring is used by the quality control algorithms for adaptive, open-loop or closed-loop control of the process that is employed to reduce the number of rejects, to improve the process reproducibility and to save costs. This is because the uncertainty of the quality of a finished product can be recognized at an earlier production stage and be eliminated by optimizing the process parameters in real time.

The Lessmüller Lasertechnik sensor systems can be used for both closed-loop and open-loop monitoring during laser manufacturing. As an open-loop

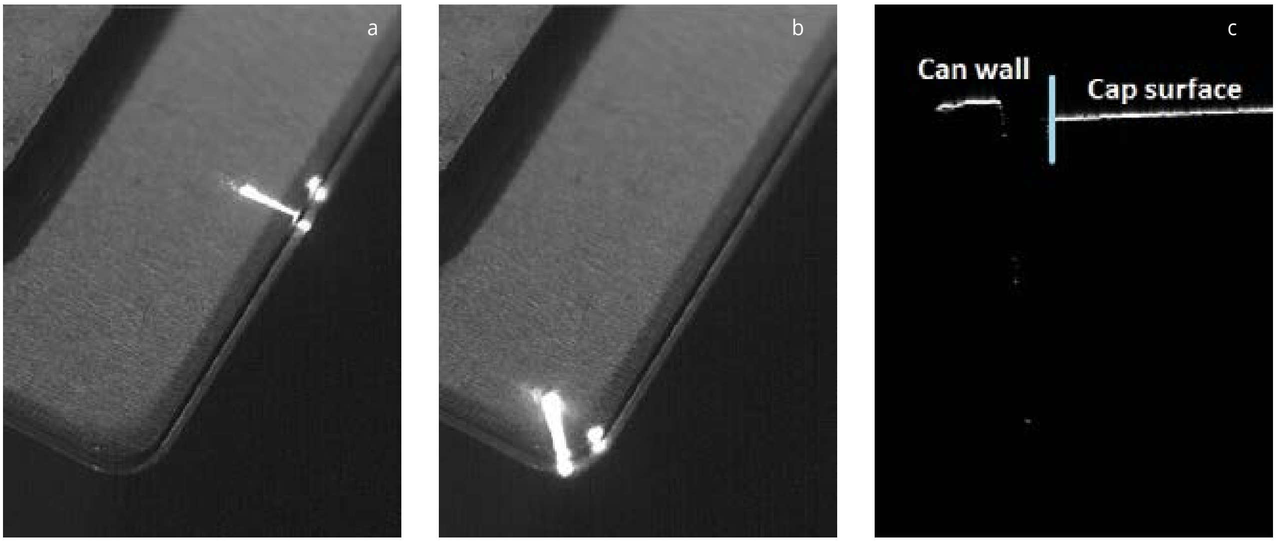

Fig. 2 Can-cap welding with integrated OCT seam tracking and quality control system: (a)-(b) presentation of the OCT beam position by means of pilot lasers, measuring online in pre-process (white line) relative to the laser processing position (white point) where the OCT measures welding depth; (c) pre-process OCT measurement of the can-cap joint showing the joint surface profile (white line) and automatically detected joint location (cyan bar).

system, the sensor sends a signal indicating a faulty weld without real-time fault prevention. However, for quality assurance and process reliability purposes, manufacturing with closed-loop monitoring is essential since the real-time monitoring signals are employed to control and adjust the process parameters online (e.g. welding location, power, speed, wire feed rate etc.) and thus weld quality is continuously supervised.

Among a large number of different non-contact monitoring methods, optical methods are commonly used during laser processing [1]. Obviously, the optical monitoring approach has many advantages, such as non-contact operation, versatility and the ability to process a large amount of information from the optical output. The combining of different optical systems to monitor laser processes is also quite common. The aim of this article is to present several Lessmüller Lasertechnik non-contact optical sensors for the monitoring of automated laser welding of batteries in e-automotive production (Fig. 1). Along the battery production chain, there are a multitude of different laser processing utilization in the electrode, cell, module, and pack sectors: the welding of can-caps, busbars, and housings are some application examples. Lessmüller Lasertechnik provides an appropriate sensor for each application to ensure the required welding precision: the OCT interferometric imaging system, the WELDCHECK photodiode or the WELDEYE camera-based sensor. Either single sensors or several different sensors can be integrated into diverse configurations.

OCT interferometric imaging of battery cell sealing and busbar welding

During the sealing of battery cells, all welds must be executed with extreme precision and reliability because they are subjected to vibration and frequently elevated temperatures in a car. Obviously, accurate control of a predefined welding depth is also extremely important during the welding of both battery cell and busbar as the components are welded together close to potentially explosive chemicals.

Optical coherence tomography (OCT) is widely used to monitor the keyhole depth during laser welding and for the detection of the melt pool shape [2]. Additionally, being equipped with a scanner, OCT can be applied for simultaneous or sequential pre-process, in-process and post-process control [3]. The process parameters are automatically controlled and can be constantly adjusted before the weld fails, so weld irregularities can be solved online.

Fig. 2 shows seam tracking with the OCT during the welding of a can-cap. The prismatic battery housing (can) is laser-sealed to the housing cover (cap). OCT measures the surface topography in real-time along a line (see white line created by the pilot laser in Figs. 2a and 2b) across the can-cap joint in pre-process i.e. ahead of the processing laser (see white point of pilot laser indicating the processing laser position in Figs. 2a and 2b). By applying the evaluation algorithms developed by Lessmüller Lasert-

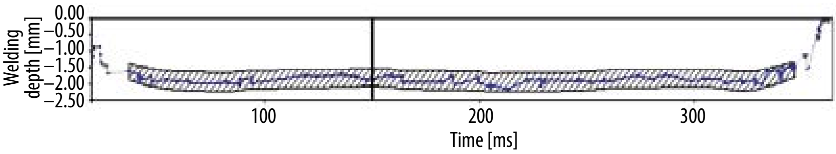

Fig. 3 OCT welding depth measurements over the entire welding time along a single seam during busbar welding. The blue line is a filtered welding depth. The hatched area shows the limits of the acceptable welding depth range. The black vertical bar represents the position where the welding depth of 1.8 mm was measured.

Company

Lessmüller Lasertechnik

As one of the leading experts in process monitoring, Lessmüller Lasertechnik GmbH provides standard and customized solutions for online monitoring and control of industrial laser processing, all developed, designed and manufactured in house: the proven WELDEYE with over 600 systems installed worldwide, the cost-effective WELDCHECK, and the innovative OCT for flexible, precise, and reliable pre, in, and post-process control, allowing a step forward in faster, more accurate and effective manufacturing.

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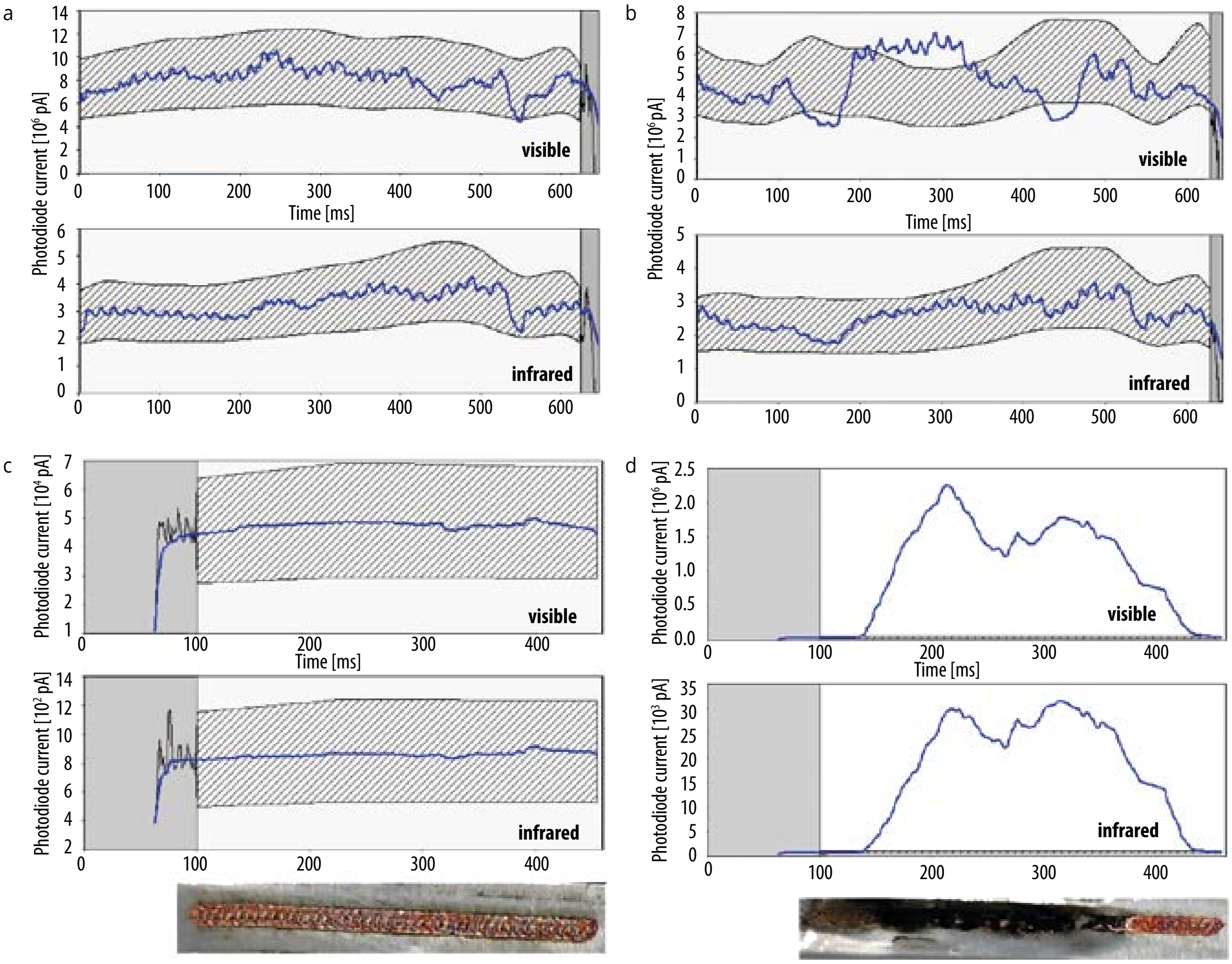

Fig. 4 Several examples of monitoring the busbar welding process with the WELDCHECK photodiode: data obtained on the successful (a) and unsuccessful (b) circular welds; WELDCHECK measurements and corresponding photographs of the resulting linear welds show a good quality weld (c) and burned through weld (d). Each top diagram in a pair shows the intensity of the measured process emission in the visible wavelength range whereas each diagram underneath represents the measured process emission in the infrared wavelength range over welding time. The hatched area shows the limits of the acceptable range of emitted light intensity (in photodiode current units). The gray area is a period during which the quality assessment is not performed.

echnik, the joint location is automatically detected with high accuracy (see vertical cyan bar in Fig. 2c). The data are sent to the subordinate welding unit and used to reorient the OCT measurement figure according to the seam trajectory. This way, the OCT always scans perpendicular to the seam trajectory in pre and post-process, and the processing beam always exactly hits the joint, even on nonlinear weld path geometries (see Figs. 2a and 2b).

Spatter-free welding and welds without pores, cracks or unwanted buckling are requirements for can-cap sealing. OCT tests the finished surface topography online directly behind the welding point, giving an insight into the seam quality. Each scan is repeated every few milliseconds. OCT provides high-speed data acquisition and processing, and ensures not only process stability but also enables the realization of highly dynamic welding. The lateral OCT sensitivity can be adapted to the production line velocity during the active welding process.

Another option is oscillating welding, which ensures hermetic seals. When performing online OCT measurements during oscillating welding, the OCT beam would oscillate in the same manner as the processing beam. By decoupling the OCT measuring beam and processing laser beam, the online pre, post, and in-process measurements can be made in situ during beam oscillation, offering the user two functions in one tool: high resolution real-time seam tracking and precise quality monitoring. A continuous joint trajectory and the geometry of the weld bead are measured with the OCT beam simultaneously with the oscillating movement of the processing beam under any welding conditions. Since the OCT scanning figure does not correspond to the movement pattern of the processing laser, the OCT system must compensate for the movements of the processing laser. This compensation is only possible with systems that work independently of each other and that enable high-speed real-time data communication between each other. Lessmüller Lasertechnik has developed scanner hardware and software solutions for the industrial implementation of this concept.

After welding, the individual battery cells are connected by busbar welding to build modules. The welding joints (electrical contacts) that are connecting the individual cells must be of very high quality in order to comply with the desired operating voltage and capacity. OCT measures how deep the processing laser penetrates into material during the welding of the busbar to the cell, see Fig. 3. The weld penetration depth is estimated by capturing the OCT signal that

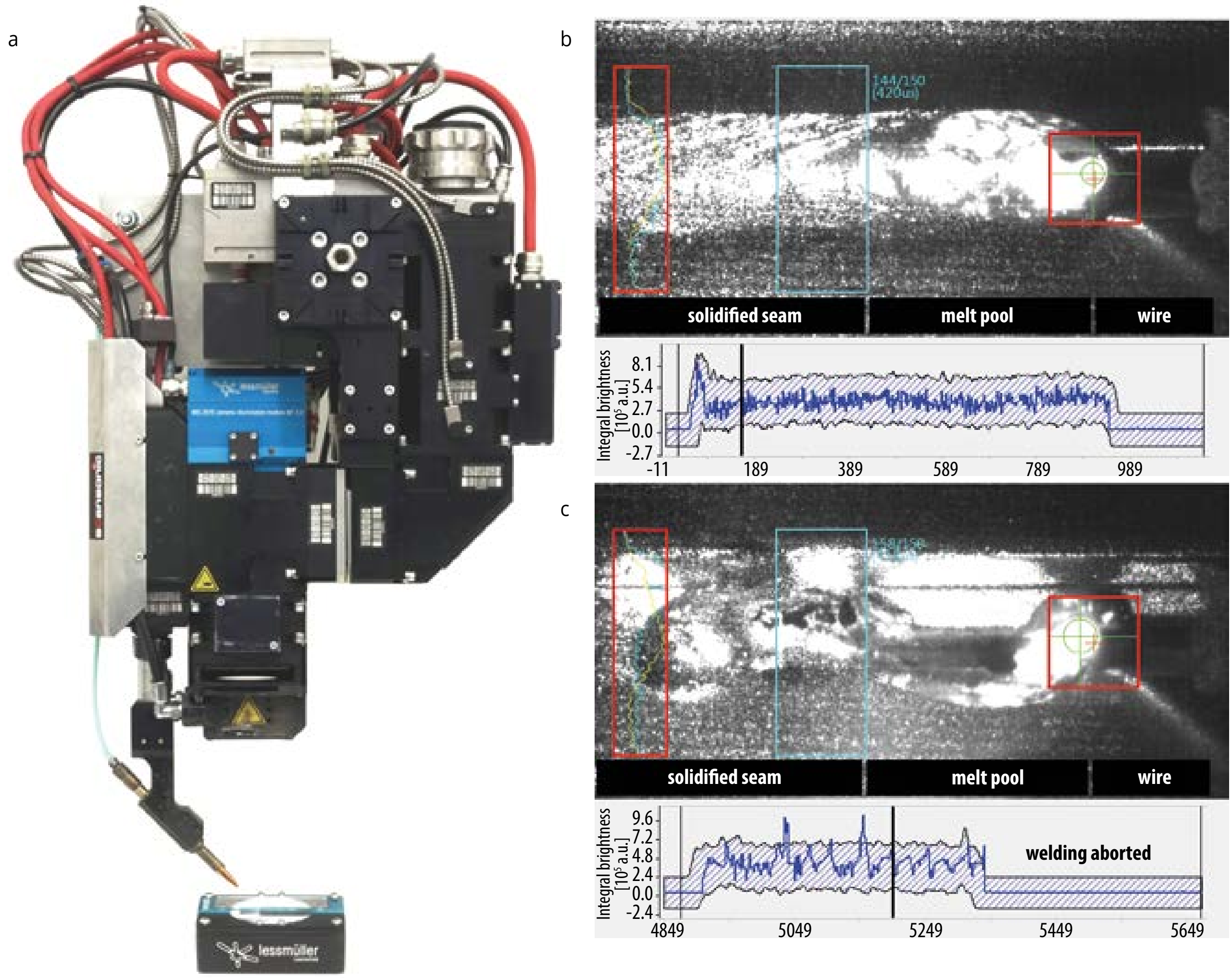

Fig. 5 Scansonic ALO3 welding optics with integrated WELDEYE LM7 system (cyan module in a). Online quality assurance during the welding of the battery housing: camera images and corresponding evaluation diagrams show good quality weld (b) and faulty weld (c). In the red quadrangular frames: if the measured brightness distributions of the current welds (cyan curves) do not match those of the reference welds (yellow curves), the weld is signaled as faulty. In the red squares: the green crosshairs point to the processing location. Diagrams show the variation of the integrated process emmision brightness over welding time. The hatched areas on the diagrams show the ranges of allowed values of the test parameter.

is back-scattered from the keyhole depth and by profiling the melt pool, thereby acquiring the maximum depth. This value can be used to adjust the power of the processing laser online (if applicable). Fig. 3 shows that OCT accurately monitors the shallower and deeper penetrations of the laser. A multitude of welding depth measurements on busbars performed with Lessmüller Lasertechnik OCT were stable and consistent.

WELDCHECK photodiode for busbar welding

In-process welding monitoring is important in order to control the weld quality by adjusting the process parameters. Detection methods for the in-process monitoring of laser processing utilize physical phenomena that occur during laser-material interactions. When the laser beam hits the material surface, the laser radiation is absorbed, reflected, refracted, scattered or transmitted. Back-reflected laser radiation, plasma or metal vapor-induced radiation are most frequently monitored [4]. The amount of this radiation correlates with the weld quality.

The intensity of the emitted process light can be evaluated by using a photodiode. With their inherent quick response time, photodiodes are often used to monitor laser materials processing [5]. The WELDCHECK from Lessmüller Lasertechnik is a commercially available process monitoring system with inbuilt photodiodes. In-process monitoring i.e. monitoring of the plasma plume emission that is formed during manufacturing, can be monitored at visible and IR wavelength ranges. It is a compact, lightweight, and robust instrument that can be easily integrated into the fabrication process: either into conventional laser heads through the standard C-mount camera port or directly into the laser source. This sensor is also simple in operation, maintenance and setup.

As little spatter as possible must be generated during busbar welding, and a sufficient bonding cross section has to be guaranteed to meet the strength and conductivity requirements. However, penetration of the can and overheating of the battery have to be avoided. Fig. 4 shows some examples of the optical monitoring of the process emission using WELDCHECK while welding various busbars. Lessmüller Lasertechnik software enables real-time data evaluation and detection of weld faults, combined with external fieldbus data. Figs. 4b and 4d depict the plasma instabilities correlated with the weld defects. In Fig. 4d the correlation between the measured process emission and the weld penetration can be seen.

WELDEYE camera-based sensor for welding battery housings

Battery modules are combined into one power unit, which is safely enclosed in a sealed housing. The battery housing has to be welded with maximum stability and with no cracks or distortion.

Photodiode sensors like WELDCHECK do not provide any information on the material surface structure, so 3D surface topography measurements with an OCT system or camera-based inspection with the WELDEYE system can be utilized. Camera-based weld quality analysis is a well-known and established monitoring method. However, additional illumination is required to capture the surface features and structure. External illumination is provided by light emitting diodes during laser welding. Intense external WELDEYE illumination enables real-time observation and imaging during the active welding process without influence of the process light. A high-speed WELDEYE camera is used for the alternate recording images with and without external illumination [6]. A non-illuminated image serves for the evaluation of the process emission during a directed energy deposition, whereas an illuminated image reveals the regions of the melt pool and surrounding areas in high-resolution (Figs. 5b and 5c). Monitoring of the laser welding is achieved by the synchronous recording and automated evaluation of the image-based data and of the process parameters [6], by online detection and reporting of the welding faults. This enables a reduction of scrap rate, testing costs and reworking.

A WELDEYE system is used for the online visualization and monitoring of the welding of a battery housing to ensure the required weld quality and tightness. All welds are recorded in real-time, automatically compared with the reference welds and saved. The welding process is controlled online.

Figs. 5b and 5c show selected images with automated real-time image analysis of successful and failed welding of a battery housing. The top images in Figs. 5b and 5c, show the processing zone and adjacent surface of the solidified seam together with the brightness profile acquired within the red framed area. The actual brightness profile is generated from image to image and compared with the reference for real-time quality control. The diagrams at the bottom of Figs. 5b and 5c are the results of online analysis of the non-illuminated images exhibiting process emission stability over the welding time. In Fig. 5c, both the non-linear inhomogeneous melt pool seen on the image and the unstable behavior of the process emission observed on the diagram below give clear evidence of the welding fault, and the welding process is therefore aborted.

The camera-based WELDEYE system is particularly valuable for wire feed welding, where it additionally serves for the alignment of the welding optics, and for the automated surveillance of beam/wire position and wire/nozzle status. The newly developed WELDEYE LM7 camera/illumination module (Fig. 5a) is compact and minimally affects the interfering contour of the welding optics without shortening the distance from the process to the cross jet. This module is compatible with most Scansonic optics, is easy to install and requires no additional protective glasses for illumination.

Conclusion

There are numerous laser-joining steps during the fabrication of a battery for an electric vehicle, starting from the welding of the individual cells that are connected to build modules or packs, and ending up with the welding of the entire battery system. The aim is to fabricate battery systems that comply with the high demands of the automobile industry in terms of safety, performance and service life. To produce optimal welds, the automated laser welding process has to be monitored by means of built-in sensors.

Lessmüller Lasertechnik have developed several optical monitoring systems that are thoroughly commercialized. These are systems that utilize either simple sensors such as photodiodes (WELDCHECK), or systems that use more sophisticated detectors and offer surface feature recognition, such as optical coherence tomography (OCT) and camera-based systems (WELDEYE). Smart process monitoring software is a prerequisite for constant adjustment of the welding parameters. The main objectives of these monitoring technologies are to improve the reproducibility and manufacturing efficiency, to assure the process reliability and the end-product quality along the whole battery production chain.

Seam tracking and seam quality can be controlled online with OCT during the sealing of the battery cells. OCT can be also utilized to measure changes in keyhole depth, which in turn can be used to control laser power while welding the busbars. OCT as a sensor tool offers many benefits in terms of process flexibility, enhanced component reproducibility, precision and productivity.

Radiation emitted by the plasma or metal vapor plume during laser materials processing is considered as an important aim for the monitoring of busbar welding that can be achieved by the WELDCHECK. It is a photodiode-based, cost-effective design system, which can be easily integrated into different types of laser processing setups.

When the cells have been packed into the module, and several battery modules are then combined into a block, WELDEYE can perform process monitoring and seam inspection during the welding of the battery housing. A camera with a high pass filter is used to obtain live images of the solidified seam. Also, the behavior of the emission created by the laser process provides feasible information on the laser welding process.

The application of Lessmüller Lasertechnik optical sensors makes the laser process accurate, repeatable, and reliable, enabling their wide deployment by industries that utilize laser processing for both material modification and fabrication.

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Material processing with fast rise and fall time CO_2 laser pulses

New CO_2 laser system using an integrated acousto-optic modulator

Patrick Kim

A smart phone is an application where thin film technology is used

Source: Getty Images

The recent growth in the organic light-emitting diode (OLED) market has resulted in substantial investments in the display industry, particularly from South Korean companies, but also recently from Chinese players, and this trend is expected to continue for a further three to four years. This expansion of the display industry has resulted in a growth of USP laser markets due to the requirement for higher power and more precise processing quality. This industry is prepared to pay for better laser-based solutions which has fueled the demand for shorter pulsed CO_2 lasers for film cutting applications. One of the key features required in the market is to minimize the heat effect on the material during the cutting process.

In order to address this demand Luxinar has launched the SR AOM, a range of CO_2 lasers with an integrated AOM, that has a rise/fall time of less than 1 µs. These devices minimize unwanted heat accumulation in the material being processed compared with traditional CO_2 laser sources, which typically produce longer pulse rise/fall times of approximately 60 µs. The series is available in two power levels 75 W and 150 W. The SR 25 AOM is a unique proposition with 150 W peak power, a typical power stability of ±2 % and a typical optical rise/fall time of <0.5 µs.

In addition to the display industry, electronic manufacturing services (EMS), automotive and flexible packaging industries demand a reduced heat-affected zone (HAZ) for laser processing, as machining precision and quality become more important. The SR 10 and 25 AOM 9 µm could be a possible solution for many of these applications.

The critical feature of this series system is its exceptionally fast optical rise/fall time capability of <1 µs. Without the fast switching time associated with AOM operation, a typical optical rise and fall time of a CO_2 laser is approximately 60 µs. Whilst this is acceptable for many laser processing applications it can lead to the creation of HAZ on thin polymer-based materials. This is unacceptable for many of the materials used in the electronics industry.

Fig. 1 shows the typical 2 µs demand pulse shape that exhibits a ~350 ns pulse rise time. This short rise/fall time

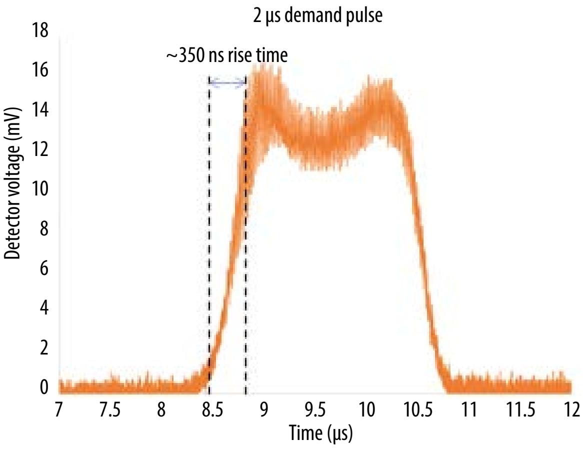

Fig. 1 Luxinar SR 25 AOM pulse shape 2 µs pulse width (Source: Luxinar)

helps to minimize the heat affected zone.

There is a clear benefit of the short rise/fall time, especially for cutting thin film. A wide range of thin films are used in many different industries including display, automotive, EMS, lighting, as well as flexible packaging. An AOM-integrated CO_2 laser can bring a higher quality machined finish with less HAZ compared to a standard pulsed CO_2 laser.

The pictures in Fig. 2 show the results of cutting polarization film (3-layer, 0.23 mm thick) using a standard CO_2 laser (left) and a CO_2 laser with AOM (right). The AOM-integrated CO_2 laser creates approximately 30 % less HAZ and a significantly better edge quality.

Fig. 3 shows another example; the cutting of thin projected capacitive film. This film has a five-layer structure (upper protection film 50 µm – upper silicone 8 µm – touch film 65 µm – adhesive silicone 20 µm – lower protection film 50 µm) and is used to protect display touch screens. The upper and lower protection film layers have to be easily peeled off after cutting. Using a standard CO_2 laser to cut these films results in excess heat accumulation which melts the silicone layers and causes them to stick to the adjacent layers. This then results in the outer layers being difficult to peel off. CO_2 lasers with integrated AOM can help to mitigate this kind of problem.

The picture on the right of Fig. 3 shows the result achieved using the SR 25 AOM 9 µm and clearly demonstrates the improvement possible when compared with the results using a Luxinar SCX 35 operating at 9 µm (left). The cut quality of the upper and lower protection film layers is dramatically improved with a significant reduction in the melted area. A more important benefit relates to the adhesive silicone layer as it no longer sticks to the neighboring layers, thus creating an easy peel protection film layer. In many cases, heat sensitive film applications, such as projected capacitive film, can be cut using picosecond UV lasers, however a CO_2 laser with integrated AOM can achieve similar results with significantly lower investment and maintenance costs.

The title page image shows an example using thin film technology – applications include touch screens, optical clear adhesive (OCA) films, LCD/OLED tablet-related films, vehicle dashboard instrumentation and foldable displays.

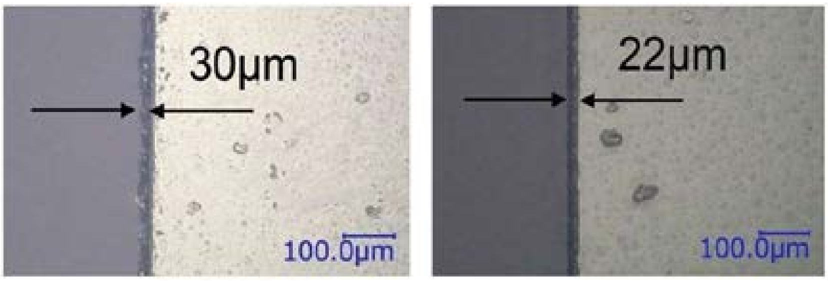

Fig. 2 POL film cutting by CO_2 lasers (left) normal pulsed CO_2 laser, (right) SR 25 AOM (Source: courtesy of MDI)

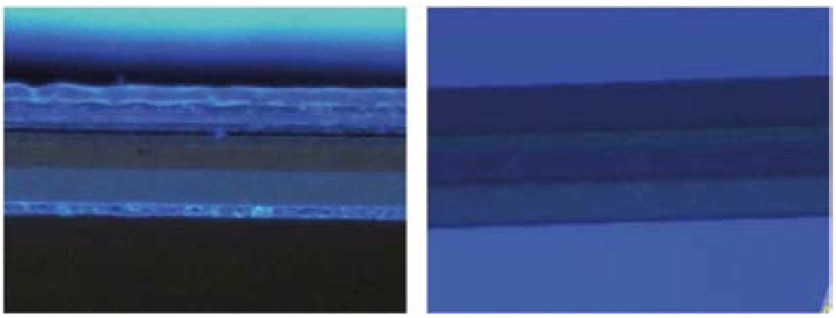

Fig. 3 CP film cutting 193 µm thickness (left) Luxinar SCX 35 9 µm, (right) Luxinar SR 25 AOM 9 µm (Source: Luxinar)

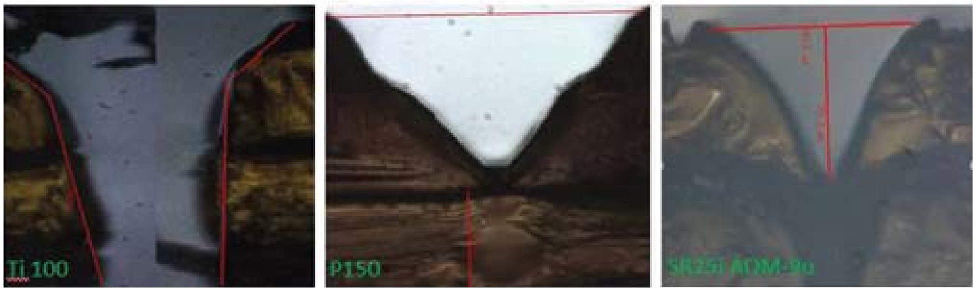

Fig. 4 Cross section of PDLCD film cut by CO_2 lasers (Source: Luxinar)

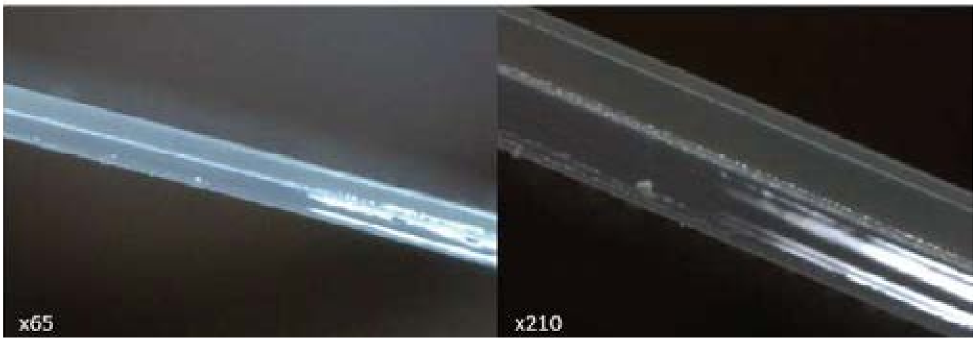

Fig. 5 PDLCD cut edge (Source: Luxinar)

Another interesting application is polymer-dispersed liquid crystal display (PDLCD) film cutting. In PDLCD films, polymers and liquid crystals are mixed in a specific ratio between polyethylene terephthalate (PET) and indium tin oxide (ITO) layers. When inactive, the liquid crystal droplets scatter and as they permeate the screen this results in a turbid (opaque) state. When a voltage is applied, the liquid crystal droplets align, allowing light to pass through. This turns the screen from a non-transparent to a transparent state and is frequently used for office meeting room windows to provide privacy.

PDLCD is also becoming more common in other sectors. As well as its typical use in the construction industry (for window coatings), it can be employed in a large range of other applications such as transportation, advertising screens, art, culture, and in other products and industries which utilize display technology. PDLCD is commonly used in the automotive industry for car sunroofs and in the electronics sector, where display technology is often combined with microprocessor-based devices.

The ITO layers in PDLCD film are very sensitive to heat, and discoloration of the material is a problem when cutting with traditional CO_2 laser technology. Employing an SR AOM 9 µm laser can reduce this discoloration problem since the fast rise and fall times minimize the residual heat accumulation in the material. This reduction in the HAZ also results in an extremely high-quality cut edge. Fig. 4 shows the results of cut edge quality of PDLCD film used in car sunroofs. The tests compared three different system types: 100 W, 9 µm (supplier A), 150 W, 9 µm (supplier B) and Luxinar's SR 25 AOM 9 µm. The trials using supplier A and the SR 25 AOM 9 µm were processed on a "half cut" basis (the normal process is a full cut) in order to demonstrate the comparative edge quality results. As evidenced by the images, the SR 25 AOM 9 µm creates the cleanest cut, fewest HAZ-related defects, reduced taper, and minimized discoloration. The pictures in Fig. 5 show the cut edge of the PDLCD film. All layers have been cut without damage and with almost no discoloration.

Other potential markets

The SR AOM laser from Luxinar may bring benefits to the flexible packaging industry, due to its fast pulse rise/fall time capabilities and its superior pulse-to-pulse control feature which can help to process materials more precisely with less HAZ. Label cutting, selective cutting, and modified atmosphere packaging (MAP), where plastic film is laser perforated to keep food fresh, are other applications which may benefit from this technology, yielding improved quality and consistency.

Summary

As part of the well-established SR series from Luxinar, the SR 25 AOM 9 µm CO_2 laser provides superior pulse-to-pulse control and output power stability. The system has a fully integrated RF PSU, control driver, optical optimization and AOM making it a world leader in terms of AOM-based laser technology. Luxinar's SR AOM 9 µm series is ready for mass production together with easy integration to enable clean and high-quality laser processing, low running costs and maintenance-free operation.

Whether it is for applications that require reduced HAZ, or difficult applications such as engraving, marking or surface patterning, its superior performance makes the SR AOM an ideal option for many laser processing tasks.

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Author

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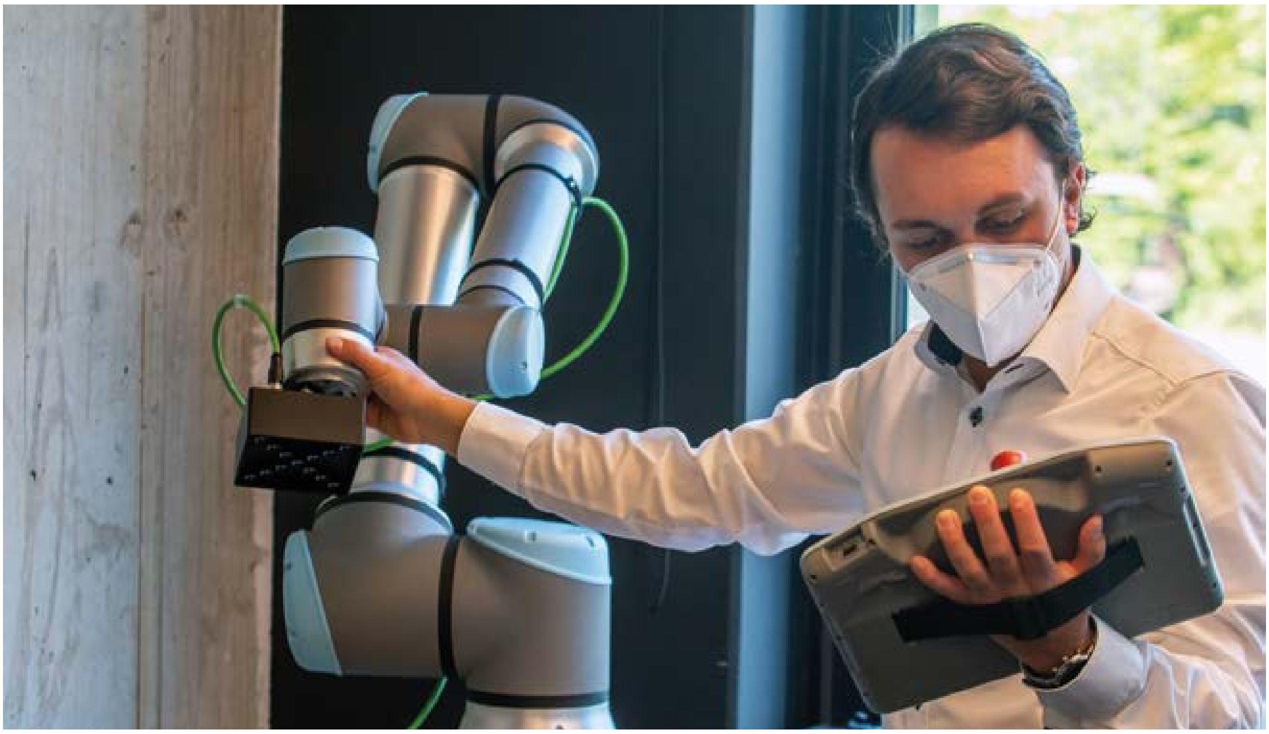
A new dimension for machine vision

Light field technology for lean automation processes

Christoph Garbe and Mareike Schindler-Kotscha



Source all images: HD Vision Systems

Automation is central to producing high quality products in high-wage countries with an omnipresent shortage of skilled workers. Automation is becoming increasingly more complex due to the higher flexibility in produced goods. At the same time, this places high demands on integrated image processing and, for this reason, machine vision solutions have so far often fallen short of expectations. The use of 3D light field technology can help to solve demanding tasks quickly, easily and reliably.

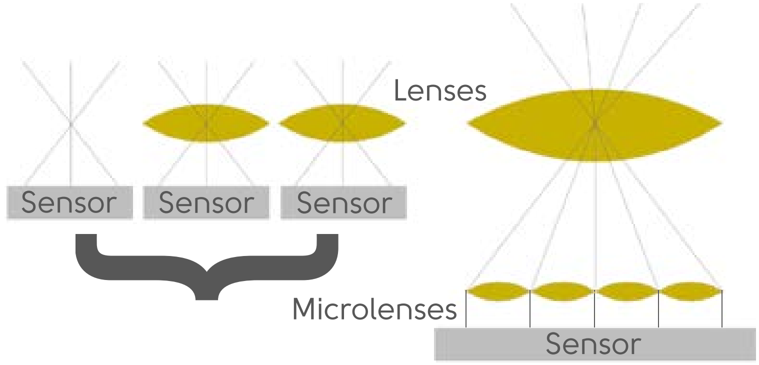
Perhaps you still remember: from 2014 to 2016 it was possible to purchase a so-called 'light field camera' on the retail market. The highlight: taking pictures with this digital camera made it possible to determine the focal point on photos afterwards by using the software that came with the camera. 'Computational photography' was born. The recorded scene was always absolutely sharp – and even a 3D simulation was possible. Unfortunately, the consumer market targeted at the time was not yet ready for this technology. The product was discontinued and the company failed.

Light field and penoptic function

The light field has been known as a physical concept since 1846. In that year, Michael Faraday described in his "Thoughts on Ray Vibration" the possibility of interpreting light, like magnetism, as a field. However, it took until 1908 for practical implementation when Gabriel Lippmann presented his ideas for the first light field camera with an array of camera lenses. There had already been a first precursor five years earlier, but this still worked with pinholes in the image plane instead of several lenses. The view was limited. Lippmann's success was mainly based on the extension of the older camera and improved recording of the light scene.

It was not until 1991 that Adelson and Bergen developed the plenoptic function (Latin plenus = full) theory. It describes the totality of all light-related information of a scene. This includes:

- a beam of light (straight line) from the recorded scene, determined by two angles φ and ζ,
- a place of observation of the light beam (V_x, V_y, V_z),
- the wavelength λ of the light for colored images, and
- the time t for a video recording.



Shot comparison for camera- and microlens-arrays

The actual plenoptic function $P(\varphi, \zeta, \lambda, t, V_x, V_y, V_z)$ results from these individual aspects. With this function, any view at any time from any position and at any wavelength can be reproduced. The plenoptic function then forms the basis for all further calculations for the use of light field technology – for example in industrial machine vision.

How do you capture the light field?

But how can the totality of all the light information in a scene be recorded in an optical way? There are three possible approaches: 1. Sequential capture: several images of the same scene are taken at different locations one after the other. Since only one camera with one lens is needed, this approach is very cost-effective and provides a high image resolution. On the other hand, the procedure is extensive and cannot be used for dynamic or moving scenes. 2. A microlens array: this method captures different images with numerous microlenses on a single sensor. This reduces the price of the capture device; at the same time however, the resolution of the overall image suffers due to the limited sensor. 3. A camera array: here several cameras are placed close together in a fixed arrangement. Together they offer extremely high resolution and fast processing, but this has its price – and brings with it increased calibration effort.

Shot comparison for camera and microlens arrays

All three methods offer good potential for capturing a large proportion of the light field. The life sciences, for example, have recognized this and are equipping microscopes with microlens arrays for improved imaging. However, undreamed of potential also lies dormant in the manufacturing industry – although camera arrays are better suited due to the greater distance to the workpiece. And the movie industry has already discovered the light field for itself: camera arrays help to make post-production much easier here. But in reality, the theory cannot (yet) be reproduced 100 %. Every light field camera is only an approximation of the full theory.

How does the light information get into the image?

With the help of the plenoptic function, it can be determined exactly from which direction the light came in the photographed scene. Corresponding algorithms are used to extract this information from the recorded image data – and to make it accessible to the user in a sensibly recognizable way.

Light field technology usually relies on camera or lens arrays to calculate the camera position and therefore also the corresponding focal point of a shot. This grid – whether with individual sensors or a split one – breaks up the respective light beams once again into individual cones.

Modern algorithms are then able to calculate an exact angle of entry and the position of the originally captured point. The framing and the point of focus of the image become relative. Corresponding software can move both as desired – the image is sharp everywhere and can be adjusted as desired. The angle of view is now also variable. Alternatively, such software can output a holographic image that impresses with its continuous sharpness. The next step up to an applicable point cloud is therefore small.

Of what use is this comprehensive image information in the industry?

This information provides additional potential for difficult tasks in industrial machine vision. For example, light field cameras capture complex materials without any problems, even if they are glossy or gleaming. In a stereoscopic image, the glossy point would often be wrongly interpreted as a surface point. This leads to errors in depth estimation. Overall, the surface for stereo approaches must be assumed to be Lambertian, i.e. absolutely matt reflective. In reality however, this is never achieved. Light field cameras on the other hand calculate this gloss with the help of the arrangement as an array and come much closer to reality.

The light field technology is also advantageous on shop floors where no active lighting is desired. With the camera arrays used, even regular ambient light is sufficient for good object capture because the light field method delivers robust results. At the same time, light field images also provide depth information: distances and spacing can be calculated algorithmically with the help of the slight displacements. This makes light field technology ideal for determining object size, with an accuracy down to 0.1 mm.

Also important is that the geometry of objects can not only be measured from the light field, but surface texture and gloss properties can also be extracted. Detailed point clouds, quantified surface properties or 3D simulation are easily possible. The generated data can then be used for various industrial applications, such as object recognition, bin picking or quality inspection.

Practical applications with minimal effort

Image processing using the light field is a real advantage for automated and robot-based production. Due to its properties, the technology helps to reliably recognize complex workpieces made of shiny or stained metal, dull plastic or (semi) transparent parts for example. In contrast to many previous solutions, it can be implemented without complex lighting, additional cameras and the like. All that hovers above the industrial scene is a compact light field sensor – a blessing, especially for extensive production facilities.

The software used is also important because it determines whether the extensive data produced from the light field recording will also provide reliable results. Although light field sensors can also be operated like ordinary cameras, it is only in combination with suitable software that machine vision of a new dimension is created.

The young Heidelberg-based company HD Vision Systems has dedicated itself to providing precisely this combination of compact light field sensor and high-performance software. With the help of their LumiScanX 3D light field sensor and the corresponding software configurations, they have committed themselves to delivering machine vision for any application. Their solutions for bin picking, object handling and tools for AI quality inspection therefore focus on simple, fast and reliable application – without any expert knowledge. Numerous customers and partners, such as Hirschvogel Automotive or various integrators and machine builders such as the Pütz Group, are already benefiting from this.

Conclusion

Light field technology promises to disrupt existing machine vision technology, if not revolutionize it. Through the combination of a new method of data capture and a downstream algorithm, this physical approach allows additional information to be extracted from object scenes and used for practical applications. This is a significant stroke of luck for companies that previously had to struggle with objects that were difficult to automate.

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Christoph Garbe is founder and CEO of HD Vision Systems and member of the board of directors of the European Machine Vision Association (EMVA). Dr Garbe received the BE degree in physics from the University of Hamburg, Germany, in 1995, and the MS and PhD degrees in physics and the habilitation degree from the University of Heidelberg, in 1998, 2001, and 2007, respectively. Before founding the company, he was working at universities and institutions in San Diego, CA, USA, at the Goethe University of Frankfurt, Germany, and he has been head of the independent research group 'image processing and modeling' at the University of Heidelberg.

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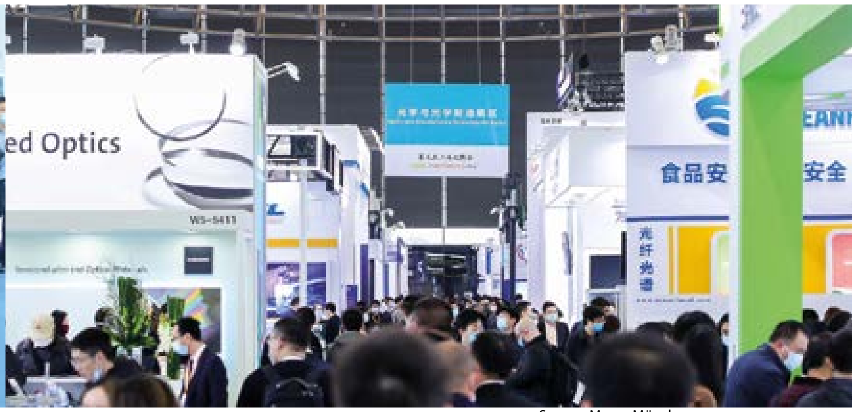
Source: Messe Frankfurt



Source: Messe München

October 05 – 07, 2021
VISION
Stuttgart, Germany
www.messe-stuttgart.de/vision

October 10 – 14, 2021
International Semiconductor Laser Conference (ISLC)
Potsdam, Germany
www.islc2021.org

October 12 – 14, 2021
Advanced Manufacturing Technology Conference (AMTC)
Aachen, Germany / hybrid
www.amtc.community

October 12 – 16, 2021
Fakuma
Friedrichshafen, Germany
www.fakuma-messe.de

October 18 – 20, 2021
40th International Congress on Applications of Lasers & Electro-Optics (ICALEO)
online
https://icaleo.org

October 18 – 21, 2021
SPIE Optifab
Rochester, NY, USA
spie.org/conferences-and-exhibitions/optifab

October 26 – 29, 2021
Blechexpo / Schweisstec
Stuttgart, Germany
www.blechexpo-messe.de ▪ www.schweisstec-messe.de

November 15 – 18, 2021
COMPAMED / MEDICA
Duesseldorf, Germany
www.compamed.de ▪ www.medica.de

November 16 – 19, 2021
formnext
Frankfurt, Germany
https://formnext.mesago.com

November 16 – 19, 2021
productronica / SEMICON Europa
Munich, Germany
www.productronica.com ▪ www.semiconeuropa.org

November 23 – 25, 2021
sps smart production solutions
Nuremberg, Germany
https://sps.mesago.com

December 01 – 03, 2021
Photonics Finland Optics and Photonics Days
Turku, Finland
https://photonics.fi/opd2021

December 07 – 09, 2021
SEMICON West
San Francisco, CA, USA / hybrid
www.semiconwest.org

December 07 – 09, 2021
Laser Symposium & International Symposium Additive Manufacturing (ISAM) 2021
online
www.lasersymposium.de

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

The first major in-person optics event since early 2020

Review: SPIE Optics + Photonics, 1 – 5 August 2021, San Diego, California, USA

During the first week of August, SPIE, the international society for optics and photonics, welcomed optical researchers, engineers, exhibitors, students, and industry leaders to an energetic conference which, for most, was the first in-person conference they had attended in nearly 18 months. While presenters and attendees were also able to participate virtually, there was genuine excitement at the opportunity to connect and re-connect face-to-face in San Diego.

University of Arizona's Jennifer Kehlet Barton elected into the SPIE presidential chain: in 2024, Barton will serve as SPIE President (cf. p. 20). And at the Sunday evening plenary session, Professor Renu Tripathi of Delaware State University was recognized as the first recipient of the 100,000-dollar IBM-SPIE HBCU Faculty Accelerator Award, a five-year program that supports research and education in quantum optics and historically Black colleges and universities.

Source: SPIE

Following CDC, California, and San Diego guidance that Optics + Photonics could be safely held, SPIE sprang into action. After a long foray into solely online events, SPIE successfully hosted over 1,300 attendees and 100-plus exhibitors at our first in-person conference since March 2020, with an additional 1,400 in attendance virtually. While adapting to changing conditions did lead to some last-minute changes in mask-wearing recommendations and requirements, it was great to see many in our community back together, discussing research, networking, and engaging with exhibitors.

More than 2,100 in-person and remote presentations took place throughout the conference. The week featured multiple social and networking events, including the annual SPIE Awards banquet, which was held outdoors to accommodate health and safety guidelines. New social events included the first-ever First-Timers Reception for attendees new to SPIE Optics + Photonics, and the inaugural Black in Photonics meetup, as well as a trivia night, an LGBTQ+ Social; an equity, diversity, and inclusion keynote by Spelman College's Tamara Pearson, and music-infused Happy Hours on the exhibit floor.

During the week, the Society also announced its election results, with the

In addition, four days of panel discussions on emerging applications in artificial intelligence (AI) led to lively interactions between panelists and attendees on hot topics such as using AI as a diagnostic tool in neuroscience, ethical principles of using AI, and opportunities in AI investigations for young researchers.

Attendees and exhibitors said that they were ecstatic to be back in a convention center, seeing each other in person. Nowhere was the excitement of re-connecting more apparent than on the exhibit floor, where more than one hundred exhibitors were celebrating their first in-person show since SPIE Photonics West in early 2020.

"SPIE Optics + Photonics has been a welcome reunion for the optics community," said Laura Roberts, regional sales manager for Schott North America. "We have had steady traffic, and a lot of good discussions have happened. Everybody seems ready to get back to work. Of course, we have to gauge how things change, but Schott is preparing to exhibit at Photonics West. We are very excited to get back to in-person shows and face-to-face meetings with customers, re-forming those connections that we have with our customers and with our colleagues and the industry network in general."

"The conference this year has been really great – we applaud SPIE for putting together such a great show considering the circumstances," said OptoSigma's business development manager Cindy Gong-Harris. "We are excited to show our new technologies and showcase our standard products as well as our custom products, and we're very happy to be here and see people in person, so thank you very much for putting on such a great show. We have been waiting for in-person meetings for a long time; it's been a year and a half since Photonics West, which is the last show that we exhibited at, and we are extremely excited to participate and be here with everybody."

"We are super happy to be back," said PI regional sales manager, USA, Jeff Gabriel. "It's always nice to be able to see people's faces, and we've had a lot of people coming in to talk to us. It is just so much better than email conversations. We're always at Photonics West, so we are looking forward to that as well. Optics + Photonics is proving to be a great starting point for a return to in-person meetings."

"The exhibition has been going great," added Cory Boone, lead technical marketing engineer at Edmund Optics. "And it's just so exciting being back for something in person. The people we are talking to tend to be a little bit more qualified than your typical trade-show lead, so people who are here really want to be here and it has just been great showing off some of our newer products, new technologies, and acquisitions that we have made for new laser-optics manufacturing. We are very excited for future shows, including Photonics West. This has been a great way to kick off in-person shows in the States again."

"In spite of the changing circumstances, we experienced higher than anticipated in-person and remote attendance," noted SPIE CEO Kent Rochford. "More than 2,700 people registered for Optics + Photonics, and we really appreciate all those who came, visited the exhibitors, and participated in the technical program. Ultimately, the community supported the event, and they were happy to be back and networking with each other. For us, that constitutes a terrific success."

https://spie.org

Preview: Blechexpo / Schweisstec

26 – 29 October 2021, Stuttgart, Germany

In its traditional, time-tested double pack format in Stuttgart from the 26 – 29 October, 2021, the 8th Schweisstec international trade fair for joining technology will open its doors together with the 15th Blechexpo international trade fair for sheet metal working – live and in person.

The specialized expert audience will meet at the industry's most important trade fair, namely Blechexpo/Schweisstec 2021, in order to remain at the cutting edge and to draw inspiration from efficient, up-to-date process technologies in sheet metal processing and joining applications. Digitalization, sustainability and process efficiency within the context of a rapidly changing production landscape are driving further development in the sheet metal processing industry. Exhibition topics include standalone and system solutions for process sequences involving the fabrication of parts made from sheet metal, profiles and pipe, as well as associated thermal and mechanical processing, cutting technologies, processing machines, equipment for stamping, bending, braking and forming, system peripherals including controls and software, and solutions for handling and quality assurance.

As a time-tested, traditional platform for standalone and system solutions for entire process chains, Blechexpo / Schweisstec also provides an excellent opportunity for collaboration because the issue of networking is at the top of the agenda for progressive companies – in terms of both process engineering and digital technology. Networking is by no means just a fashionable buzzword and will shape future business. Industry players will respond to the transformation of industrial production at various levels with networking and collaboration. As a result, exhibitors and expert visitors will also benefit from the synergy effects of the trade fair duo, and from the strictly practice-oriented event concept. The clear-cut trade fair demonstrations of fully automated sheet metal processing machines with robotics and gantry solutions, as well as system peripherals with controls and software, provide expert visitors with optimized support in making decisions for their investments.

Hygiene concept ready to go

"High booking levels in recent months for the live event in Stuttgart from 26 to 29 October 2021 underscore just how much the industry sector cherishes the event as a unique, globally recognized marketplace," says Georg Knauer, Blechexpo / Schweisstec project manager. "Exhibitors and expert visitors are looking forward to this fall's trade fair highlight and to a personal exchange at the on-site event." Trade fair promoters P. E. Schall are fulfilling all of the prerequisites for providing exhibitors and expert visitors with ideal conditions for an optimized business exchange at Blechexpo/Schweisstec, and are fully aligning themselves to the hygiene concept adopted by the Stuttgart Exhibition Center.

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

Preview: MEDICA 2021 / COMPAMED 2021

15 – 18 November 2021, Düsseldorf, Germany

Medica 2021, the medical trade fair, and Compamed 2021, the international main event for medical technology suppliers which is held in parallel, will take place as in-person events at the exhibition halls of Messe Düsseldorf. They are closely linked with comprehensive digital products and services.

Expressing their anticipation, authoritative experts and decision-makers of the healthcare industry have clearly committed to participating on site. In a current survey of several thousand international Medica and Compamed visitors from previous years, three quarters stated expressly that they intend to attend this year's trade fairs. With a specific focus on Germany and the neighboring European countries, these visits are a fixed point on the agenda, as three quarters of the survey participants from these countries – with particularly easy travel options – also want to come to Düsseldorf.

The medical technology industry is equally positive about the events. "Our partners and the trade associations stand firmly behind the trade fairs and appreciate the value of in-person events. The exhibitors are very interested in participating and are delighted to see all of the important industry decision makers and to exchange ideas in real life again at Messe Düsseldorf, after so many months of exclusively digital contact with business partners and potential customers," says Erhard Wienkamp, managing director of Messe Düsseldorf, based on his many conversations with participants.

Exhibitors will bring their comprehensive portfolios of medical products, devices and instruments, including all the stages in their development, production and distribution processes, to present at the duo.

Based on the experience with the events that were held entirely online in November 2020 due to safety reasons – but still drew a total of 45,000 unique users from approximately 170 countries and 405,000 page views – programme items that are in high demand will be offered on site, as well as being accessible and viewable for participants online via simply structured ticketing.

This applies for the forums that are integrated into the themed segments of the trade fair, such as: the Medica Connected Healthcare Forum, Medica Health It Forum, Medica Tech Forum, Medica Labmed Forum and the Medica Econ Forum, brought to you by Messe Düsseldorf and the Techniker Krankenkasse. At Compamed, the following forums are on the programme: the Compamed High-Tech Forum by IVAM with a special focus on the microtechnology and nanotechnology sectors and the Compamed Suppliers Forum by DeviceMed, where the content is focused on the entire development and manufacturing field.

www.medica-tradefair.com
www.compamed-tradefair.com

Preview: Formnext 2021

16 – 19 November 2021, Frankfurt, Germany

Formnext will take place as a physical on-site event. With approximately 450 exhibitors, this confirmation has been greeted with delight by the additive manufacturing community around the world, keen to once again meet face-to-face.

"In discussions with members of the community over the last couple of years, we have once again come to realize the significance of Formnext. This fair has an exuberance and spirit of innovation that is unbeatable. Just knowing that we can again offer this type of creative space where people can talk face-to-face, enjoy productive chats over coffee, touch products and discuss their progress embraced by the support of the whole community is wonderful", commented Sascha Wenzler, vice president of Formnext at Mesago Messe Frankfurt GmbH.

Preparations are full steam ahead for Formnext 2021 and the event is shaping up to be an unmissable one. Highlights are to include high-caliber talks by industry experts, the presentations from Italy as the partner country, the innovations from the Purmundus Challenge, and Start-up Challenge Pitch-Next Event as well as the TCT Conference and Stage plus VDMA's and BE-AM's (Built Environment) special areas. Moreover, the American Society for Testing and Materials ASTM is organizing as a premiere an international standards workshop on the day before the event starts. The organizer is going all out to make this first event after a year of not meeting physically.

Formnext will be frequented by the majority of the most significant companies in the industry. Around 450 exhibitors, including 55 % from abroad, have registered already including 3D Systems, Additive Industries, Addup, Arburg, Autodesk, BigRep, DMG Mori, Dyndrite, EOS, ExOne, Farsoon, Formlabs, GE, Hexagon, HP, Keyence, Markforged, Materialise, Meltio, Nexa 3D, Prima Industrie, Renishaw, Sandvik, Siemens, Stratasys, Trumpf, Voxeljet and XJet.

Whilst there is clearly a lot to look forward to, the health and safety of all attendees remains paramount. As the organizer states on its website, the protection and hygiene concept, which was developed last year to comply with, and even exceed, the legal requirements, is therefore continuously being adapted to the pandemic situation. Wider aisles in the halls, as well as additional communication and waiting areas in higher frequented zones at the event, will help people maintain the necessary social distancing. A 3G concept will also be introduced (vaccinated, recovered, tested).

The physical event will be complemented with the Formnext Digital Days two weeks later from 30 November – 1 December 2021. With the rapid growth of the AM community and demand for 3D-printed products in all areas of industry, it is vital to enable those still facing travel restrictions to participate in the exchange of ideas.

www.formnext.com

Preview: productronica 2021 / SEMICON Europa

16 – 19 November 2021, Munich, Germany

The world's leading trade fair for electronics development and production can take place as planned from November 16 to 19 in Munich. The in-person event next fall will also feature a digital supplement in the form of online booths. Industry representatives will have the opportunity to take part in Productronica in person or virtually, regardless of the conditions in place. Falk Senger, CEO of Messe München, is optimistic about the industry meeting in November: "In the past few months we have been working hard on the safety standards and are now excellently prepared for the new start with an optimal safety and hygiene concept. We are looking forward to once again welcoming lots of exhibitors and visitors to Productronica in person."

Messe München has developed a comprehensive safety and hygiene concept in close cooperation with the relevant authorities. This includes important new elements in addition to basic provisions, such as maintaining the minimum distance, the wearing of FFP-2 masks and the traceability of all participants. Access to the exhibition grounds will only be granted to people who have been proven to have been vaccinated, tested or recovered. This data can already be entered at the online registration stage.

In addition, Messe München is making test capacity available on site. Modern ventilation systems that guarantee a regular and reliable supply of fresh air will provide additional protection for exhibitors and visitors in the exhibition halls.

The current surge of electronics development and production gives hope for a successful event in fall, as Rainer Kurtz, CEO of the Kurtz Ersa group and chairman of the advisory board of Productronica explains: "In the first half of 2021 incoming orders in the industry developed very well for the most part. As the pandemic slows down, exhibitors expect a continued positive business trend for this year and the next. In this respect, Productronica 2021 has every chance of being a wonderful reunion for the entire global electronics production industry."

Nearly five months before the start of the event, more than 500 companies have already confirmed their participation: leading key players such as ASM Assembly Systems, F&K Delvotec, Komax, as well as Kurtz Ersa and Rohde & Schwarz will be represented at Productronica 2021.

This year, Semicon Europa will be co-located with productronica in Munich, Germany, creating the strongest single event for electronics manufacturing in Europe, and broadening the range of attendees across the electronics chain.

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