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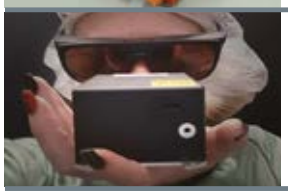
6

PhotonicsViews

OPTICS • PHOTONICS • LASER TECHNOLOGY

Technology Report
Laser processing: solutions for industry



Spectroscopy
Lasers for compact & fast LIBS systems

Focus:

Additive Manufacturing

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Additive manufacturing is a game changer

AM is enabling development and innovation and opening up new applications

Finally, the time has come again: from November 16 – 19, the AM community will meet in Frankfurt at formnext to jointly develop ideas and drive innovation through productive and creative exchange. It has been a long time of exclusively digital encounters and we have all missed the face-to-face meetings that are so important in our young industry. The most important companies in the industry will be represented at formnext again this year. Among the leading exhibitors are many members of the VDMA Additive Manufacturing Working Group, which is also the conceptual sponsor of the trade fair.

The VDMA Additive Manufacturing Working Group was founded in 2014 to increase the acceptance and development of additive manufacturing as an industrial manufacturing process. This also includes the automation and linkage along the additive process chain. This is one key enabler for the economical implementation of the process for series production. The Working Group with its more than 175 members offers a comprehensive platform designed to involve all companies and research institutes participating in the value supply chain. Activities focus on research, standardization, market figures and application-oriented knowledge transfer in the fields of machinery and mechanical engineering.

As mechanical engineers, we are particularly happy that foundries, forges, and users of subtractive technologies are using additive manufacturing to complement or optimize their respective technologies. In this way, additive technologies are turning into a valuable addition for mechanical engineers – AM is a game changer. In some areas, such as the medical industry or in high-performance parts for aerospace, the technology has become a successful key technology due to its beneficial integration of functions, individualization and flexibility. In the mechanical industry, additive manufacturing is a complementary manufacturing process that is enabling development and innovation and opening up new applications. Some examples of successful applications in mechanical engineering are tools, grippers, housings, and the direct integration of functions. If you want to learn more about this fascinating technology, have productive conversations over a cup of coffee, touch AM parts and discuss AM innovations, you are warmly invited to join the experts at the fair.

Yours,

Christoph Hauck

Source: toolcraft

Christoph Hauck
Chair, VDMA Additive Manufacturing Working Group, member of the executive board, toolcraft AG

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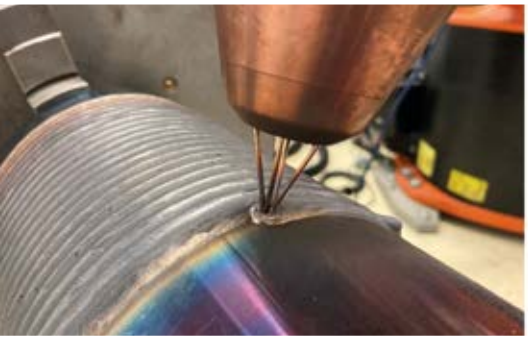
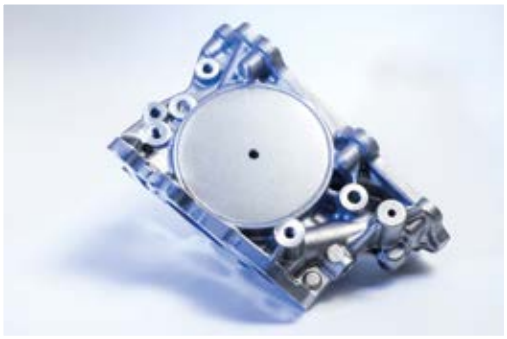




32 Laser processing: solutions for industry

40 Flexible fiber laser for rapid material processing

42 Empowering metal additive manufacturing

Contents

Additive Manufacturing

6/2021

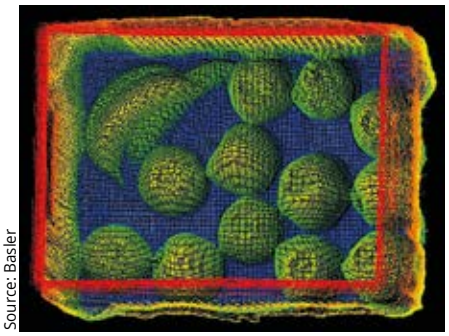
46 Scaling additive manufacturing for mass customization

54 Development of an MPLC-based laser head

59 Lasers for compact & fast LIBS systems

Cover: The new Continuously Tunable Laser CTL 900 from Toptica Photonics is tunable between 880 nm and 950 nm. The long-awaited wavelength range is especially useful for resonantly exciting quantum dots, for spectroscopy or addressing, e.g., rare earth ions or the caesium D1 line.

VDMA: Machine Vision is booming, lack of chips means longer delivery times



Source: Basler

The forecast has been confirmed: the European machine vision industry will grow by 7 % in 2021. The order books are full. Only the lack of chips is slowing the machine vision industry, resulting in longer delivery times.

"The monthly VDMA order intake and sales statistics show: the order books of the machine vision industry are well filled. The demand for image processing components and systems is very high. Unfortunately, due to the lack of chips, the companies are unable to keep up with production and therefore have to make some compromises in their current production plans," says Mark Williamson, chairman of the board of management of the VDMA machine vision department, on the occasion of the opening of the Vision 2021 trade fair.

In 2020, sales in the European machine vision industry had fallen by 4 % compared to the previous year due to the Corona pandemic. The weak demand in Europe as well as in the automotive, pharmaceutical, metal, plastics and rubber industries was responsible for this, but it was a very good result compared to other areas of mechanical engineering. The growth prospects for the coming years remain good. The trend towards 'seeing machines' has been unbroken for years. Image processing has established itself as a key component in the global automation race.

Non-industrial sectors on the rise

Image processing is constantly conquering new sales markets and fields of application. In 2020, the share of sales in the European machine vision industry in sectors such as medical technology, security, agriculture, intelligent transport systems and retail was already 35 %; sales there grew by 9 %. Embedded vision in combination with deep learning will set new growth impulses.

Strong demand from the electronics industry

Sales to the electronics industry (excluding semiconductors) increased by 20 % and sales to the semiconductor industry grew by 10 percent. Sales to the automotive industry – otherwise the largest customer of the image processing industry – fell by 13 %. The share of total sales was therefore only 16 %. Sales to the food and beverage industry stagnated.

Europe remains an important sales market for companies: 52 % of the turnover in the European machine vision industry was achieved, 6 % less than in 2019. Exports to Asia rose by 3 %. Sales in China grew by 10 %. Exports to America rose 5 %.

The sales of image processing components fell by a total of 2 % in 2020. Industrial cameras were excluded from this. The most important component, with a share of 27 % of total sales in the European MV industry, recorded a sales increase of 4 %.

A lack of chips is a burden on the industry

Many companies are struggling with increasing material and delivery bottlenecks. In the VDMA quick poll at the beginning of September, 81 percent of the mechanical engineering companies from all branches named noticeable or serious impairments in their supply chains.

www.vdma.org

Sensor and measurement technology: sales stabilize, order situation picks up

Sensor and measurement technology recorded significant sales growth in the first quarter, while sales remained unchanged in the second quarter. Incoming orders in the industry developed positively overall with an increase of eight percent. The proportion of AMA member companies that have registered short-time work is falling significantly, with only one in five companies now working on short-time.

Revenue sensors and measurement technology compared to Q3, 2008 (Source: AMA)

The AMA Association for Sensor and Measurement Technology (AMA) asked its 450 members about economic development in the second quarter. According to its own information, the industry generated the same level of sales in both the first and second quarters of the year.

Small to medium-sized companies (SMEs) were able to catch up in sales significantly better than the large companies in the sector in the second quarter. The expectations of the small to medium sized AMA members are therefore a little more optimistic than those of the larger members. Overall, the industry expects positive growth of four percent for the third quarter.

Online trading with promising results

Short-time working is only available at SMEs in the industry and mainly affects suppliers in the mechanical engineering, sensor and measurement technology markets, as well as the automotive and electrical industries. Suppliers in the medical technology and energy industries are hardly affected. This underpins the above-average incoming orders for the suppliers of medical technology. The aerospace sales market is also developing well, although the suppliers report below-average results in sensor and measurement technology.

The AMA association is also asking its members about the development of online trading during the Covid crisis. One in six companies is increasing its own online trade, especially suppliers to the energy and automotive sectors. Most of the companies that have set up and expanded online trading report promising results.

The order books are well filled

"Fortunately, our industry is catching up again; incoming orders are developing as our industry expected, following the long-term trend before the corona pandemic," says Thomas Simmons, AMA managing director. "The order books are well filled, short-time working has decreased significantly, sales are stabilizing and the industry is looking to the current quarter with confidence."

www.ama-sensorik.de

Wenglor takes over TPL Vision

At the end of August 2021, the Wenglor Group took over the Scottish-French company TPL Vision. The specialist, founded in 2005, will be integrated into the Wenglor group as a division, but will continue to exist as an independent business unit.

"We are very pleased to be able to strengthen the product portfolio in the machine vision area through the acquisition of TPL Vision," says Wenglor managing director Rafael Baur. "The additional know-how and almost 16 years of experience of TPL in industrial lighting technology are a real gain."

The two central locations of TPL Vision in Perth, Scotland and La Chevrolière, France,where the company moved into a new production facility just this year, will both stay in operation. All employees remain part of the independent Wenglor business unit. TPL Vision offers an extensive range of different lighting technologies. Thanks to its so-called power LEDs, complex tasks can be solved using vision systems, smart cameras or vision sensors. In addition to surface lights, spot, ring, bar or dome lights are part of the range of several thousand products. Special lighting systems for the food industry or UV light are also part of the expertise of the new Wenglor business unit.

Wenglor managing director Rafael Baur, TPL Vision managing director Daniel Huber and the head of the computer vision business unit, Christian Vollrath (Source: Wenglor)

www.wenglor.com

Senswork opens United States subsidiary in Tennessee

Senswork, a manufacturer of optical inspection systems, is looking to better serve the US market and recently opened a subsidiary, Senswork Inc. in Johnson City, Tennessee.

Ryan Lilly, president of Senswork said, "Especially in turbulent times like right now, ensuring product quality is very important. That is why we are pleased to now be able to provide local support to our customers in the US."

"Production processes in Germany are often similar to those in industrial plants in the US," said Senswork vice president Roman Rieger "That is why we are looking forward to applying our expertise in the Tri-Cities region. Our first projects in 2021 with Tier 1 automakers have all been successful."

Senswork focuses specifically on end-of-line solutions, 3D laser triangulation systems, stereo cameras, time-of-flight sensors and depth-from-focus systems. Among its latest products is ZScan, a multisensor system for 3D scanning of large objects. The manufacturer is also a Cognex partner system integrator.

www.senswork.com

Intel Realsense discontinues lidar, facial authentication and tracking product lines

Intel Realsense has decided to refocus their business model and, in doing so, have discontinued their L515 lidar and the facial authentication (FA) product lines to focus on their existing D400 series stereo vision product line.

D400e series industrial cameras and Intel RS D415 (Source: Framos)

Camera products, like the D415, D435, D435i, and D455 will continue to be available for new and existing projects along with their associated modules, the D410, D420, D430, D450, and D4 processing boards.

As a result of this refocusing, their lidar (L515), facial authentication (F450/F455), and tracking (t265) product lines have been discontinued. Orders can be submitted and accepted for the next six months (until February 2022). Software support for these products will continue through the common Intel Realsense SDK.

www.framos.de
www.intel.com

Grand opening of new US headquarters

Synova, inventor of laser microjet cutting, has opened its new 6,100 square foot, state-of-the-art facility in Totowa, New Jersey. The new US technology center will support operations throughout North and South America with the latest Synova CNC machines incorporating its advanced water jet laser cutting technology.

"Coming on the heels of record-setting sales in 2021, our new facility will play a pivotal role in 2022 and beyond, providing greater flexibility in demonstrating micromachining technology to customers involved in the semiconductor industry, high-accuracy medical machining, diamond toolmaking, diamond manufacturing and aeroengine parts manufacturing," says the company's US business manager Jacques Coderre.

"Our new micromachining center (MMC) is not only a place to showcase our equipment, it's also a research and development center where our customers can collaborate with Synova engineers to demonstrate laser cutting technology," says Dr Bernold Richerzhagen, Synova founder and CEO. The new facility will feature both 5-axis and 3-axis systems that will be used for machine demos, application development work, customer training and contract machining.

Source: Synova

New US headquarters in Totowa, New Jersey

The new Synova USA technical center is conveniently located in Northern New Jersey, just twenty miles away from downtown New York City and thirty minutes away from Newark Liberty International airport.

Synova SA, headquartered in Duillier, Switzerland, manufactures advanced laser cutting systems that incorporate its proprietary water jet guided laser technology.

www.synova.ch

Foundation stone laid for research building

The Fraunhofer Institute for Applied Optics and Precision Engineering IOF is getting a new research building. With additional laboratory and clean room space, room will be created on Jena's Beutenberg Campus for new research work, especially in important future fields such as quantum technologies. On July 15, the laying of the foundation stone took place with selected representatives from politics and science.

Source: Fh. IOF

Hand-over from Prime Minister Bodo Ramelow to Andreas Tünnermann

With the new extension building, the IOF will have new laboratories and office space on an area of more than 2,000 sqm in the immediate vicinity of the previous building parts of the institute.

The additional laboratory and clean room space will be used in particular to advance relevant future topics such as quantum technologies. A growing volume of research is expected here in the coming years. The institute is already involved in extensive projects on highly secure quantum communication, hardware development for powerful quantum computers, and quantum-based imaging methods, e.g. for medical diagnostics.

The latest extension is costing € 23 M and is financed in equal parts by the state and the federal government. The completion of the new building is planned for 2023.

www.iof.fraunhofer.de

Aerotech's new subsidiary Peak Metrology

Aerotech, manufacturer of motion control and positioning systems, has established a new subsidiary, Peak Metrology. The aim is to bundle all activities relating to high-precision metrology.

Led by RJ Hardt, a long-time Aerotech engineer, Peak Metrology draws on Aerotech's extensive positioning systems expertise, but focuses exclusively on supporting industrial customers with surface metrology solutions through to complete integration. The first exhibits from the collaboration with metrology specialist Keyence will then be on display at Control 2022, May 5 – 6 in Stuttgart, Germany, including the integration of 3D laser microscopes and Aerotech positioning systems.

Both Aerotech and Peak Metrology customers are expected to benefit from the technological and financial resources, as well as competitive pricing and delivery times. Peak Metrology, based at Aerotech's Pittsburgh headquarters, provides product development, engineering, installation and training services. Already a division of Aerotech in the past, Peak Metrology has a broad customer base around standard and custom precision surface metrology solutions.

For surface metrology applications, the company offers a wide range of products up to turnkey machines. Surface analysis is often integrated directly into the production chain as a quality assurance process, for example in semiconductor production during wafer inspection or the manufacture of flat panels. Here, the quality is assessed after almost every process step.

www.aerotech.com
www.peakmetrology.com

Sick celebrates 75th company anniversary

Dr. Erwin Sick founded his company in South Baden in 1946. At an official ceremony at the company's headquarters in Waldkirch on September 24, 2021, invited guests and companions from politics, business and science, together with the founding family Sick and the board of directors, paid tribute to the past 75 years and took a look into the future.

Erwin Sick, born in Heilbronn in 1909, set up his own engineering office in Vaterstetten on September 26, 1946. The trained optician had the vision to combine precise optics and intelligent electronics for industrial applications. What began as a start-up in a barrack near Munich has developed into one of the leading companies for automation technology thanks to Sick's pioneering work and passion.

Source: Sick

Founder Erwin Sick

Sick's inventive spirit spurred the young company, which moved to its current headquarters in Waldkirch near Freiburg in 1956. The world's first smoke gas density measuring device was developed in the 1950s and was a milestone in environmental measurement technology. Numerous innovations followed and were continued by the sensor experts at Sick even after Erwin Sick's death in 1988.

www.sick.de

Scantinel Photonics receives Best Practices Technology Innovation Leadership Award

Scantinel Photonics, a German startup and Zeiss Ventures spin-off developing a lidar system based on future technology photonics, is the recipient of Frost & Sullivan's 2021 Best Practices Technology Innovation Leadership Award. The global consulting, market research and analysis firm continuously identifies and evaluates companies and growth opportunities in various industries, technologies and regions of the world.

Scantinel's approach to using frequency-modulated continuous wave (FMCW) lidar sensors for obstacle detection and avoidance, object detection and tracking, and simultaneous localization and mapping is considered a game changer and is a key component in the field of autonomous driving. Scantinel is thus considered a pioneer in the field of FMCW lidar systems based on photonic integrated circuits (PICs).

FMCW lidar will help autonomous driving achieve a breakthrough and, according to experts, completely displace the currently used time-of-flight (TOF) lidar systems from the market. Frost & Sullivan distinguishes Scantinel because its solution sets it apart from its competitors in that the German startup is working on a new generation of sensors that is, on the one hand, technically advanced and, on the other hand, will be highly integrable – and that in large-scale production at a competitive price, which in turn is a key criterion for the automotive industry in particular.

www.scantinel.com

Excelitas Technologies acquires PCO, opens new plant in Göttingen

Excelitas Technologies Corp. completed the acquisition of PCO AG, based in Kelheim, Germany, on Friday, September 3, 2021. PCO is a leading manufacturer and innovator in digital imaging for a wide range of scientific and industrial applications.

"Excelitas is proud to add PCO to our expanding portfolio of sensing, illumination, and optical technologies. Globally recognized for its broad variety of superior camera systems that define the leading edge of imaging technology, PCO now provides our OEM customers with a deeper range of end-to-end photonic solutions in the life science and high-performance industrial markets," said Michael Ersoni, Excelitas executive vice president, commercial SBU.

"We see this acquisition as an excellent opportunity to present our products more broadly through the extensive global reach of Excelitas Technologies. We look forward to a common path of growth with our new ownership and will continue to pioneer new benchmarks in camera technology." said Luitpold Kaspar, COO of PCO.

Excelitas acquired 100 % of PCO shares from founder Dr Emil Ott. PCO will continue to operate from its state-of-the-art manufacturing facilities in Kelheim, Germany, expanding both Excelitas' technological scope, as well as geographic footprint in Europe, North America and Asia.

The acquisition of PCO is the latest in a series of strategic acquisitions by Excelitas Technologies since its founding in 2010. It is the fourth such acquisition since Excelitas was acquired by AEA Investors (New York, NY, USA) in December 2017.

On September 21, 2021, Excelitas opened a new plant for its subsidiary Qioptiq in Göttingen. The construction investment amounted to around € 25 M, supplemented by around € 5 M for systems and equipment. This includes a photovoltaic system, a state-of-the-art automatic material store and an ultrasonic cleaning system that meets the highest purity requirements for optical components in the semiconductor industry. The new Excelitas location in the Science Park Göttingen will initially have an area of approximately 18,000 m².

The newly built, tailor-made production hall offers a usable area of about 6,700 m², of which around 1,500 m² are clean rooms of the very high cleanliness class ISO5. Excelitas had already invested substantially in new clean rooms at its headquarters in Königsallee in Göttingen in 2012, 2015 and 2017.

www.excelitas.com
www.pco.de

Source: Beisert / Excelitas

Ceremonial opening (from left to right): Jürgen Trittin and Fritz Güntzler (Members of the Bundestag), Robert Vollmers (Excelitas VP), Ursula Haufe (managing director GWG), Mayor Rolf-Georg Köhler and Konstantin Kuhle (Member of the Bundestag).

Chancellor Angela Merkel visits Laseroptik

On September 17, 2021, Chancellor Angela Merkel visited Laseroptik in Garbsen/Hanover. The company, which has already received several awards, was chosen because of her interest in technology and Laseroptik's special field of activity. First she was guided through the cleanrooms and around the production facilities for laser mirrors and coatings. As a physicist, she showed a keen interest in coating techniques and optical laser applications. Dr Merkel was impressed by the expertise and the worldwide reputation of these specialized products from "the middle of nowhere", which are even used in space missions.

In addition, the Chancellor showed particular interest in the company's social and environmental engagement, such as running a company-owned day care facility, the possibility of employment beyond retirement age as well as the creation of natural habitats for storks, owls, and amphibians.

An outdoor group photo was taken with almost all employees and the day care children before the Chancellor retreated to a private meeting with a select group of employees and CEO Wolfgang Ebert. This face-to-face meeting provided the opportunity to get to know the human and personal side of the German Chancellor.

Source: Bundesregierung / K.-U. Knoth

Laseroptik GmbH
Horster Straße 20
30826 Garbsen, Germany
phone: +49 5131 4597-0
fax: +49 5131 4597-20
e-mail: service@laseroptik.de
Web: www.laseroptik.com

The best innovations in machine vision and optical metrology – inspect award 2022

The presentation of the inspect award 2022 took place at the Vision trade fair – on a smaller scale than usual, but still with overwhelming glamour compared to the lockdown 2020. Awards were presented for the best innovations in industrial machine vision and optical metrology.

Due to the special hygiene regulations that continue to apply, a maximum of 21 people were allowed to be present at the same time in the specially reserved room in the Congress Center West at Messe Stuttgart. However, this did not dampen the joy of the winners. After the actual award ceremony, the company representatives present stayed for a small celebration, including champagne and nibbles.

The jury of the inspect award 2022 nominated ten products in each of the categories 'vision' and 'automation + control'. This was followed by online voting and a final jury vote to select the best innovations.

The winning products in the Vision category

1st place: CBC (Europe) –the ViSWIR lens series of the Hyper-APO series from CBC (Europe) offers high resolution in the wavelength range between 400 and 1,700 nm, with full correction of focus shift. By using very low dispersion and low partial dispersion glass, focus shift is minimized to within a few microns over a very wide wavelength range. This allows spectral imaging with a single sensor camera by simply synchronizing the illumination. Instead of the usual 1-inch format, this ViSWIR Hyper-APO lens has a 2/3-inch format. It also eliminates the need to adjust focus for different wavelengths.

2nd place: Imago Technologies – the Industrial Dashcam is as small as a matchbox, yet it has an integrated computer and records images in full HD resolution – before, during or after a trigger from, for example, a PLC fault status. Via Ethernet, the videos are available to the user on his PC, where he can examine them with a video tool, for example in slow motion. This smart camera is available in black and white or color, with the smallest lens or standard C-mount lenses.


Source: Wiley

The proud winners of the inspect award 2022, vision category, with inspect editor-in-chief David Löh (4th from right)

3rd place: Edmund Optics – the Techspec CW lens series are splash-proof fixed focal length lenses that meet IEC ingress protection ratings IPX7 & IPX9K. They do not require additional protective tubes, allowing for more compact and lightweight imaging systems. The special focus mechanism and fixed apertures also make them much more stable than ordinary lenses against vibration and shock. Multiple O-rings prevent water from entering the lens. The lenses further feature a specially coated hydrophobic protection window, which prevents water droplets from sticking to the lens.

Automation + Control winners

The winning products in the second category were the AOI module for assembly processes KI MultieyeS plus by Göpel Electronic, the H.130 Inline X-ray inspection system by Visiconsult, and QBIC Robotic Vision Control by Cretec Cybernetics.

www.inspect-award.com
www.wileyindustrynews.com

EPIC hires photonic technologies program manager

The European Photonics Industry Consortium has become the world's largest photonics industry association, representing more than 700 member companies. To address the needs of all its members, EPIC is strengthening its team by recruiting a photonic technologies program manager: Dr Panagiotis Vergyris started in October 2021, and it is supporting the technical needs of the growing membership as well as the EU-funded initiatives.

Source: EPIC

Dr Panagiotis Vergyris

Panagiotis has an MSc in applied mathematics and physics and an MSc in microsystems and nanodevices. He completed his studies with a PhD in quantum technologies. He has a strong international profile coming from his experience in several European countries. In the last seven years, he grew professionally in a highly technical environment, where he developed a deep understanding of complex concepts and technologies.

Vergyris dealt with various projects in optics covering a wide spectrum that includes integrated photonics in various platforms, free-space optics, light detection and steering systems, lasers, single photon generation and detection systems, microscopy, interferometry, spectrometry and others.

www.epic-assoc.com

iPronics appoints Ana Gonzalez as Director of Strategic Partnerships

On September 10, 2021, Dr Ana Gonzalez joined iPronics Programmable Photonics as director of strategic partnerships, responsible for all sales and service activities building strong relationships with clients and strategic partners, closely working together to achieve long term goals and objectives.

Ana joins iPronics after more than fifteen years of expertise in photonic integration, strategy, operations, and sales. She spent five years at the European Photonics Industry Consortium (EPIC) as R&D manager identifying business opportunities among the European ecosystem and facilitating the exploitation of R&D results in the photonics community.

Gonzalez graduated from the Autonomous University of Barcelona with a bachelor of chemistry. She also holds a PhD in diagnosis, developing photonic devices for medical applications from the Catalan Institute of Nanoscience and Nanotechnology, Spain.


Source: iPRONICS

Dr Ana Belén González

"Ana's knowledge of the photonics industry and technology is the perfect fit to realize our long-term vision for the company," says Prof Jose Capmany, chief operations officer at iPronics.

The company developed the first general-purpose photonic processor that is reconfigurable by software.

https://ipronics.com

Neil Anderson new Vice President, Gratings and OCT

Wasatch Photonics welcomed Neil Anderson, PhD, as the new vice president of gratings and OCT. In this role, he will be responsible for commercial leadership and growth of the company's transmission gratings and optical coherence tomography business.


Source: Wasatch Photonics

Neil Anderson

Neil will be working with the teams in Logan, UT, and Morrisville, NC, to develop innovative product solutions matched to current and emerging market needs in laser pulse compression, OCT, astronomy, and photonics. He is a well-known and respected figure in the optics and photonics industry and brings fifteen years of experience supporting customers with optical component and subsystem product technologies across the analytical instrumentation, industrial (laser and process), semiconductor, life science, medical, and scientific research markets.

In addition, Neil has a proven record of building collaborative partnerships through long-term relationships with customers, partners, and industry key opinion leaders. His deep photonics technology background and expertise in spectroscopy, application knowledge, and ability to understand and focus on what customers need will complement and enhance Wasatch Photonics' reputation as a leader in VPH gratings and OCT spectrometers.

"Neil's technical knowledge, business acumen, and strong industry network allow us to offer more value as a partner," says CEO Dr David Creasey.

https://wasatchphotonics.com

Phabulous announces its new Head of Business & Sales

The Phabulous Pilot Line Association has hired Jessica van Heck as new head of business and sales. With this high-level strategic hiring, the pilot line front office is now fully operational and ready to offer accelerated innovation and production cycles from prototyping to piloting up to large volume production.


Source: PHABLOpS

Jessica van Heck

As new head of business and sales, van Heck will be the cornerstone in the development of the business opportunities, thus enabling the association to support its customers, while creating a sustainable business model. Jessica has a bachelor degree in engineering and over twenty years of experience in the corporate world ranging from sales and marketing to business and product development. "As an engineer I love understanding technology and as a business developer I love converting that knowledge into the benefits that these technologies have to offer to its end-users," says van Heck.

www.phabulous.eu

Optisense sales team continues to grow

Optisense, expert in contactless coating thickness measurement, is further expanding its proximity to customers and enlarging its sales team: Sascha Schmidt, who has been responsible for hand-held measuring devices since recently, and Patrick Voos, who now strengthens the team for industrial measuring solutions, are on board.

Source: Optisense

Sascha Schmidt (left), Patrick Voos

Sascha Schmidt (46) is a field salesman with a passion. He is expanding the sales of mobile coating thickness gauges. Previously, the Leverkusen native was sales manager at Erichsen and TQC Sheen. TQC has been a partner of Optisense for many years and therefore Schmidt was already very familiar with the solutions of his new employer: "The application potential for the mobile Optisense measuring solutions is enormous, as companies can quickly get into photothermal coating thickness testing. The handheld devices offer many advantages. They measure wet, powdery and solid layers precisely and without contact and are also light and compact," explains Schmidt.

The 42-year-old business administrator Patrick Voos gained extensive experience as an internationally operating laboratory manager in dealing with materials testing systems. The strategic sales orientation is important to him: "The growth-oriented sales structure of Optisense also includes sharpened customer segmentation."

https://optisense.com

Dr Kaierle appointed University Professor

Prof Volker Epping, president of Leibniz University Hannover, welcomes Dr-Ing Stefan Kaierle as professor for laser additive processing. (Source: LZH)

Dr-Ing Stefan Kaierle, scientific-technical director of the Laser Zentrum Hannover LZH, has accepted the appointment as professor for laser additive processing in a joint appointment procedure of the Leibniz University and the LZH, effective as of August.

"Additive manufacturing with lasers is a highly topical and forward-looking field," says Kaierle. "The newly-established professorship excellently addresses this topic and thus expands the teaching and research in mechanical engineering and optical technologies in Hannover." Prof Volker Epping, president of Leibniz University, adds: "The joint professorship sustainably consolidates the co-operation between the Laser Zentrum Hannover and the university." The LZH emerged from three LUH institutes 35 years ago.

Kaierle studied electrical engineering at the RWTH Aachen University. In 1999, he received his doctorate in mechanical engineering from the RWTH on the topic of "Autonomous Production Cell for Welding with Laser Radiation".

www.lzh.de

TQ strengthens robotics division

TQ-Systems, known for its embedded vision modules, is expanding its robotics division by hiring cobot expert Dirk Thamm. He comes from a subsidiary of robot manufacturer Kuka.

Dirk Thamm, who holds a degree in mechanical and production engineering, has made a name for himself as a robotics expert for many years. At Faude, a subsidiary of Kuka, he was most recently the managing director responsible for automation technology, as well as a cobot system integrator responsible for implementing application solutions with universal robots. Dirk Thamm started his professional career at Festo, where he headed the handling, robotics, and automation division, among others.

Source: TQ-Systems

Dirk Thamm

"Collaborative robotics will be a gamechanger for production in Germany. After all, only automation can preserve local jobs," Thamm is certain. This is where cobots come in useful, he says, because they can be put into operation in a day, even without robot specialists. That is why he is convinced: "In the next ten years, every company producing in Germany will have at least one robot."

www.tq-group.com

Changes to executive board of Zeiss

The president and CEO of Carl Zeiss Meditec AG, Dr Ludwin Monz, has announced to the supervisory board that he will not be accepting another term in office. The supervisory board notes his decision with regret. Dr Monz and the supervisory board have agreed to end his term on 31 December 2021. Dr Monz is currently responsible for the Zeiss medical technology segment. He is also president and CEO of the listed company Carl Zeiss Meditec AG. He will be bowing out of this role as well.

Effective 1 January 2022, the supervisory board will be transferring his duties to Dr Markus Weber who is currently responsible for the Zeiss semiconductor manufacturing technology (SMT) segment and will relinquish his current duties on 31 December 2021.

The supervisory board has appointed Mr Andreas Pecher to take over from Dr Weber as head of Zeiss SMT segment and executive board member of Carl Zeiss AG. Mr Pecher is currently head of the semiconductor manufacturing optics (SMO) strategic business unit. His successor at SMO will be announced in the coming weeks.

Source: Zeiss

Dr Markus Weber

"The supervisory board would like to thank Dr Monz for his outstanding commitment and the incredible success he has had in advancing the Zeiss Medical Technology segment," said Dr Dieter Kurz, chairman of the supervisory board of Carl Zeiss AG.

www.zeiss.de/meditec-ag

THE LARGEST PHOTONICS INDUSTRY ASSOCIATION IN THE WORLD

By dedicating ourselves to serving the photonics industry, we have become the largest photonics industry association in the world.

Thank you to all our members for making this happen.

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www.epic-assoc.com

Laser for particle measurement

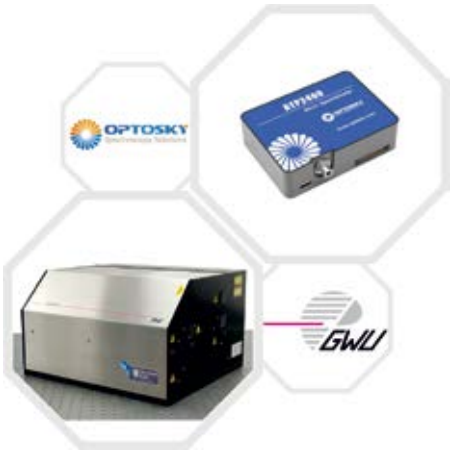
Manufacturer: Laser Quantum.
Supply: "gem 532 nm" and "opus 532 nm" lasers that maintain constant low noise over long periods of time—one of the key characteristics in maintaining very low false positives within the particle measurement process.

Background: In a semiconductor wafer fabrication process, particle measurement is used to ensure that chemical, cooling and cleaning fluids are free from such contaminants. As industries such as these begin to leverage the power of particle measuring against contamination, size and space of the equipment required to perform this analysis start to become an issue. OEMs and system integrators need ease of integration without incurring costly platform redesigns.
Features: The new laser series are designed with the system builder in mind specifically to address the requirements of this specialist application. Using patented high performance cavity technology, the lasers maintain constant low noise over long periods of time. They are easy to integrate and feature a small form factor and high wall plug electrical efficiency, delivering distinct benefits in thermal management, enhanced by an advanced air cooling system enabling the lasers to be used in environments where water cooling is not permitted or feasible. Thanks to an advanced integrated power feedback, these lasers are able to intelligently maintain and optimize their own power levels in order to maintain beam specification with no power fluctuations, making them the laser of choice for high reliability, 24/7 system integrated applications.

Laser Quantum,
A Novanta Company
Emery Court, Vale Road
Stockport, SK4 3GL, England
phone: +44 (0)161 975 5300
e-mail: sales@laserquantum.com
Web: www.laserquantum.com

Modular, fiber-coupled spectrometers and widely tunable solid-state laser sources

Manufacturer: Optosky. Distribution: GWU-Lasertechnik.
Supply: Modular "ATP series" CCD spectrometers with fiber coupling offering a simple and reliable way for wavelength measurement as in spectroscopic applications. The compact and robust design, without movable parts, makes them flexible instruments for various application fields in, e. g., the laser laboratory, in production monitoring or in-field use.

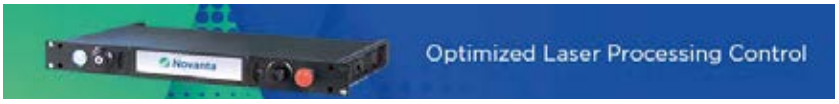


Features: The different model categories range from ultra-compact mini spectrometers, with a size of only 45 × 40 × 24 mm^3, to high-resolution devices with thermo-electric cooling for high sensitivity and low noise with an excellent price-performance ratio. The UV-VIS series can be flexibly configured from 180 nm to the NIR. IR spectrometers can even extend the detection range to 2600 nm. The spectrometers can thus be combined with any YAG-OPO system from GWU-Lasertechnik. Typical applications of ATP spectrometers range from quality monitoring to LIBS or Raman spectroscopy. Due to the widely configurable detection range, the series is also ideal for wavelength monitoring. Paired with the solid-state laser systems from GWU-Lasertechnik, which can be continuously tuned from 190 nm to 2700 nm, a perfect package for excellent performance and optimum comfort of use can be provided.

GWU-Lasertechnik
Vertriebsges. mbH
Bonner Ring 9
50374 Erftstadt, Germany
phone: +49 (0)2235 95522-0
fax: +49 (0)2235 95522-99
e-mail: info@gwu-group.de
Web: www.gwu-group.de

Laser Controller System

Manufacturer: Novanta.
Supply: Next generation laser controller system "ASC" for the control of scan heads, lasers, sensors, actuators and other peripherals.
Features: The solution incorporates real time feedback from the Optical Coherence Tomography technology. It offers powerful performance thanks to updated electronics, changeable multi-functional interface boards for added flexibility, and open platform with embedded Linux OS. This solution provides an optimized synchronization of all devices and signals, which is important in laser systems.



Novanta Europe GmbH
Werk 4
92442 Wackersdorf, Germany
phone: +49 9431 7984-0
e-mail: TeamArges@novanta.com
Web: www.arges.de

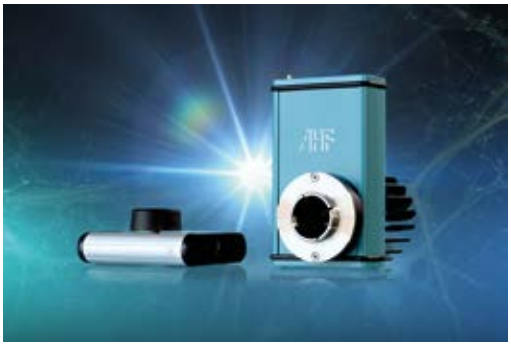
Company profile B&M Optik

30 years of know-how and Made in Germany – that is B&M Optik, the optics partner for solutions. The company offers masterful solutions for various optical needs, using excellent optical components that also include several special characteristics.
The company supports and their challenges and will work hand-in-hand with the customers, from the idea to the prototype, from the A sample to mass production. The skilled staff will project-manage and ship nearly all optical components and is continuously investing to bring the optical component engineering and manufacturing to the next level. They will also reliably manufacture various subassemblies, which include combinations of optical and mechanical components. They assemble and cement systems made from plano optics, prisms, and lenses with value-added features, they manufacture the individual components to the customer's exacting requirements, they will realize the desired optical function by integrating your components to specifications and will be helpful when it comes to improving the optical performance of the customer's products.

B&M Optik GmbH
Am Fleckenberg 20
65549 Limburg, Germany
phone: +49 (0)6431 9860-0
fax: +49 (0)6431 9860-20
e-mail: office.limburg@bm-optik.de
Web: www.bm-optik.de

LED light source for fluorescence microscopy

Manufacturer: AHF analysentechnik.
Supply: New "AF-2000" LED light source series for fluorescence microscopy with high variability and optical performance at a low price.
Features: The spectral range of the white-light version "AF-2000white" covers from 410 to 660 nm with an output power similar to the market leaders of high-end LED light sources. It matches perfectly routine microscopy with imaging of all kind of fluorophores (besides DAPI). In addition, an "U", "V" and "NIR" version will be available, containing 365 nm, 385 nm or 730 nm LEDs for imaging of, e. g., DAPI and Cy7. All models of the series are controlled by an easy-to-use handswitch with an intuitive "turn & click" concept. Due to its effective design (incl. TTL-trigger and USB connection) no active cooling is necessary, thus there is no noise and no vibration. Maximum power consumption will be 36 Watt with an expected lifetime of 30,000 hours. The light source can be connected directly to the microscope by corresponding adaptors, optionally a light guide version is available.
Typical applications will be fluorescence, bright-field and dark-field microscopy, as well as semiconductor inspection.



AHF analysentechnik AG
Kohlplattenweg 18
72074 Tübingen, Germany
phone: +49 (0)7071 970901-0
fax: +49 (0)7071 970901-99
e-mail: info@ahf.de
Web: www.ahf.de

Company profile APE

The APE Angewandte Physik & Elektronik GmbH is a worldwide operating developer and manufacturer of devices in the field of ultrashort laser pulses. The portfolio includes autocorrelators, spectrometers and other Instruments for pulse diagnostic. As one of the international market leaders in the field of wavelength conversion, APE also offers accessories such as pulse pickers and devices for dispersion compensation. APE Instruments are used in scientific institutions and research centers worldwide. The scientific fields of application include physics, biology, chemistry, medicine and interdisciplinary research. Today, the devices are utilized for laser manufacturers, microscopy companies and in the industrial production, especially in the field of quality assurance.
All of the products are entirely designed, developed and produced in the mechanical and optical manufacturing facility in Berlin, Germany by a dedicated team of specialists. APE is represented by a motivated sales team at headquarters in Berlin, in the North American market by APE Inc. located in Vancouver, WA, USA and through a global network of distributors. In order to support the growing market of ultrashort pulse laser technology and its constantly changing requirements, APE places a strong focus on R&D and a close exchange with the respective users. This allows for a deep understanding of new challenges and enables to respond promptly by offering services ranging from contract development, custom-specific device variants to OEM manufacturing. This enables the company to meet and exceed the high demands of an ever-changing market.

APE Angewandte Physik & Elektronik GmbH
Plauener Str. 163–165, Haus N
13053 Berlin, Germany
phone: +49 (0)30 986011-30
fax: +49 (0)30 986011-333
e-mail: sales@ape-berlin.de
Web: www.ape-berlin.de

Spectrophotometer-on-a-chip digital health monitoring solution

'Clinic on the wrist' integration combining hardware, application firmware, and cloud analytics.

Rockley Photonics, a globally active silicon photonics technology company, revealed a complete full-stack, 'clinic-on-the-wrist' digital health sensor system in July. Its sensor module and

'Clinic-on-the-wrist' (Source: Rockley Photonics)

associated reference designs for consumer products integrate hardware and application firmware to enable wearable devices to monitor multiple biomarkers, including core body temperature, blood pressure, body hydration, alcohol, lactate, and glucose trends, among others.

The sensor module communicates with custom, cloud-based analytical engines via a smartphone app. "Our full-stack sensor solution, which brings together optical and electronic hardware, firmware, algorithms, and cloud-based analytics, is an exciting milestone on our roadmap. Our reference designs will significantly aid our customers and partners with the deployment of our technology and accelerate their own scalable, high-volume product delivery," said Dr Andrew Rickman, chief executive officer and founder of Rockley Photonics. "We believe that combining machine learning algorithms with continuous monitoring of an extended set of biomarkers from accessible wearable devices will provide new actionable insights to enhance and transform digital healthcare."

Through its 'clinic-on-the-wrist' technology utilizing a miniaturized chip solution that provides continuous, non-invasive monitoring of core biomarkers, Rockley expects to be able to overcome the key challenges associated with mobile wellness monitoring. While many of today's wearable consumer electronic devices use green LEDs to monitor heart rate, Rockley's infrared spectrophotometers can detect and monitor a much wider range of biomarkers, which could dramatically increase the functionality of wearable devices.

The central and differentiating element of the sensing system is a non-invasive sensor module based on the Rockley platform's spectroscopy technology. Unlike more common spectroscopy solutions that use broad-spectrum light sources, its sensor module generates a large number of discrete laser outputs from a single silicon chip covering a broad optical band. The sensor non-invasively probes beneath the skin to analyze blood, interstitial fluids, and various layers of the dermis for constituents and physical phenomena of interest. Such biomarkers have historically been measurable only by using bench-top equipment.

https://rockleyphotonics.com

A label-free live-cell microscopy solution with high image quality

Small brightfield microscope, equipped with a high-quality 6.4 MP CMOS camera

The Lux3 BR live-cell imager is ideal for capturing crisp brightfield images and videos suitable for scientific publications. (Source: CytoSmart)

CytoSmart Technologies has launched a new brightfield live-cell imaging system, the Lux3 BR. It is a small brightfield microscope, equipped with a high-quality 6.4 MP CMOS camera. The new live-cell imager is designed to work inside a standard cell culture incubator as all other CytoSmart microscopes, without disturbing temperature, airflow, and optimum culture conditions for the cells. This allows researchers to perform long-term live-cell imaging experiments, ensuring optimal cell growth and health. Very detailed brightfield images can be captured using the new device. In both x and y directions, 2072 pixels combined with 1.45 mm field of view provide a resolution of 0.7 µm/pixel. Even at the commonly required image resolution of 300 dpi for printed (scientific) publications, these images can fill the entire page width if desired, without compromising the image quality.

Jan-Willem van Bree, CTO at CytoSmart Technologies said, "We are very excited to expand our label-free microscopy solutions for live-cell studies. For cell biologists who want to incorporate live-cell imaging into their workflow, the resolution of live-cell imaging microscopes may be too low to accurately quantify complex read-outs, such as cell tracking or differentiation processes. This causes inaccurate and variable results that compromise the research output. Unlike the high-end microscopes with an incubation box, the Lux3 BR ensures that cultures are not exposed to temperature, humidity, or CO_2 fluctuations that can stress the cells, as the device easily fits in every CO_2-incubator."

A setup with the Lux3 BR can be easily expanded to two or even four devices that can be operated and controlled individually via a single laptop. Since both the Lux3 BR Duo Kit and Multi Lux3 BR devices can be placed directly next to each other in the same incubator, it allows systematic comparison of control and treated samples, as all monitored cell cultures are maintained in an identical culture environment.

https://cytosmart.com

A depaneling process for insulated metal substrates with metal cores

Laser can now successfully separate IMS, metal core PCBs

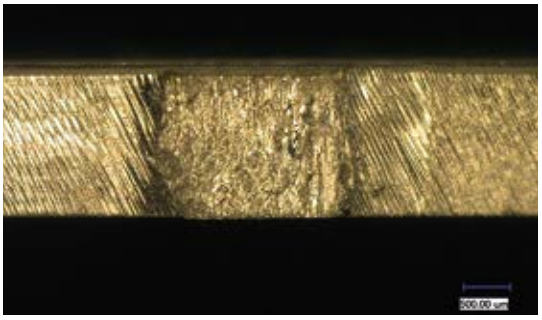
LPKF has developed a special solution for depaneling and IMS processing that involves cutting of the printed circuit boards by a powerful laser. The laser brings with it several advantages and is more than just an economically attractive alternative to mechanical depaneling processes.

With this solution, printed circuit boards with aluminum, copper, or stainless steel metal cores are cut and depaneled in a specially developed LPKF laser process. The laser source works with process parameters that have been optimized for the specific application. No mechanical stress is induced in the material due to the non-contact nature of the process. The board and the components retain their stability and quality because the material in the vicinity of the cut is minimally affected by the process.

The standard of cutting quality must be high because of the sensitive applications in which the technically-challenging IMS circuit boards are used. Use of the laser has benefits here too by avoiding the deposition of metal swarf during the process. This can happen, however, with milling and other mechanical machining methods and can trigger short circuits. Thanks to the LPKF laser technology, this danger is avoided. The reliability of the laser-cut printed circuit boards is just as high as before the cutting process.

Process speed is an important aspect in the high-volume production of the various different types of circuit board. To take this into account, the laser systems from LPKF allow very high effective cutting speeds, which vary depending on the desired cut quality as well as the printed circuit board material thickness and material composition.

Insulated metal substrates, also known as metal core printed circuit boards, can be found in a multitude of applications with strict heat dissipation requirements. Foremost among them are power electronics applications. Measuring transducers, transistor arrays, and motor drivers can all be equipped with IMS. Other important applications can be found in the automotive/transport sector, where those substrates are used in headlights/lights, GPS, and power modules. IMS are also indispensable in today's communications and consumer electronics.



With the new solution, high-quality cut edges such as these can also be realized cost-efficiently with aluminum substrate materials. (Source: LPKF)

www.lpkf.de

High-volume sheet metal cutting

Trumpf presents laser blanking system at its Neukirch site

High-tech company Trumpf recently presented a new blank cutting system during a customer event at its Neukirch site. The new system uses laser blanking to process up to 25 metric tons of sheet-metal coil stock without any human intervention. This is of particular interest to high-volume manufacturers such as automotive suppliers and automakers, electrical cabinet manufacturers, elevator producers and HVAC manufacturers. "Volume manufacturers often use presses for blanking operations. But that means they need to adjust or even replace the tool whenever they make the slightest modification to their components, which ultimately costs time and money. Many industrial sectors are seeing significant reductions in the scale of individual production runs, which makes these modifications even more costly and time-intensive. The laser allows users to carry out these modifications without requiring a new tool, so it is much, easier, faster, cheaper and more flexible," says project manager Oliver Müllerschön, who is responsible for the new system at Trumpf. The company developed the new system in cooperation with the Siemens technology group and mechanical engineering company ARKU. Together with Trumpf, Siemens is responsible for the control system and ARKU for the coil system.

Compared to conventional blanking presses, the new system heralds a significant reduction in construction and logistics costs. It makes production more profitable by eliminating tooling costs, optimizing the use of material, reducing assembly costs and boosting flexibility in the production environment.

The material flow is different to that of conventional 2D laser machines, leading to much lower cycle times and new automation opportunities for high-volume production series. The system can be flexibly adapted to any contours, and the ability to arrange all the contours at different angles greatly improves the nesting of parts as compared to conventional press lines. This can reduce the amount of material used by up to 30 percent. The new system is designed for thin sheet processing and can generally handle sheet thicknesses of up to four millimeters. This figure can rise to six millimeters in some cases, though this depends on coil width.

Trumpf collaborated with Siemens on the control unit for the unloading system, which consists of a support conveyor belt and a robot. This makes use of the new Sinumerik One CNC control software, which is fully integrated in the TIA Portal. The TIA Portal forms the hub of an end-to-end digital engineering process.

Source: Trumpf

Two workers prepare the laser system for processing sheet metal blanks under fully automatic operation.

www.trumpf.com
www.automation.siemens.com

Shaping the future

EPIC continues its virtual journey and slowly restarts physical events

It is a busy closing quarter of 2021 for EPIC – the European Photonics Industry Consortium. Currently, in the middle of Season 5 of the very successful EPIC Online Technology Meetings, we have a calendar filled with both online and physical events until the end of the year. The new season of online technology meetings started strongly in September with the largest meeting to date: the first event after the summer break – the Online Technology Meeting on New Developments in FMCW LiDAR – attracted more than 200 registrations.

The world's largest photonics industry association introduced a series in this period focussing on mid-infrared technologies at all levels of the supply chain. Shortly after the official launch of the Mid-IR Alliance in May, three EPIC online technology meetings on mid-IR technology were announced. EPIC members and end-users also joined a meeting on industrial manufacturing in July and a meeting on environmental monitoring in September.

The EPIC Online Technology Meeting on Mid-IR Technologies for Security and Surveillance will take place on 24 November. The key aim of this and previous events is to provide a platform to exchange ideas among laser and detector manufacturers, developers of mid-IR cameras and sensors, and manufacturers of photonic integrated circuits and software for modelling and packaging services.

Source all images: EPIC

The EPIC team as the dissemination partner of PIXAPP and JePPIX pilot lines at ECOC 2021 in Bordeaux, France

As the travel restrictions eased internationally in the second half of 2021, EPIC finally took part in several European photonics exhibitions. The first show of 2021, attended in-person by the EPIC team, was ECOC 2021 in Bordeaux, France. EPIC was able to reconnect with its member companies after busy 18 months of online activities, and organized the association's annual TechWatch and VIP Party in conjunction with the ECOC event. There was a lot of positive energy in the exhibition hall in the south of France and all visitors and exhibitors were looking forward to face-to-face exhibitions and conferences finally becoming more frequent.

www.epic-assoc.com

Upcoming EPIC events:

- 15 November 2021
  EPIC Online Technology Meeting on 3D Printed Optics: State of the Art and Applications
- 16 November 2021
  EPIC TechWatch on Laser and Photonics Applications at Compamed High-Tech Forum by IVAM, MEDICA
- 22 November 2021
  EPIC Online Technology Meeting on Advanced Laser Manufacturing for Automotive
- 23 November 2021
  EPIC Virtual Company Tour – Canada Special 1 (in cooperation with Optonique)
- 24 November 2021
  EPIC Online Technology Meeting on Mid-IR Technologies for Security & Surveillance (in cooperation with the MidIR Alliance)
- 30 November 2021
  Product Release December
- 1 December 2021
  EPIC Online Quantum Technology Meeting on Large Scale Qubit Generation
- 6 December 2021
  EPIC Online Technology Meeting on Medical Devices
- 7 December 2021
  EPIC Virtual Company Tour – Canada Special 2 (in cooperation with Optonique)
- 13 December 2021
  EPIC Online Technology Meeting on Challenges for LED/MiniLED/MicroLED
- 20 December 2021
  EPIC Online Technology Meeting on Photonics for the Food and Beverage Industry

www.epic-assoc.com/epic-events

EPIC hires Anna Trachtová as Marketing Manager

The European Photonics Industry Consortium has become the largest industry association globally, with more than 700 members, within the last few years. To address all the needs of its members, EPIC is strengthening its team by recruiting Anna Trachtová as a marketing manager. Anna will start in November, focus on marketing EU projects and support all EPIC marketing activities and events.

Anna studied at the University of Economics in Prague and has been working in marketing for more than ten years. She started her career in companies such as PricewaterhouseCoopers and Manpower Group. For the last five years, she has worked as a marketing manager in the most important law firms in the Czech market.

Anna is passionate about marketing and likes to find new ways to do things or communicate the message. She is looking forward to working with EPIC members and to be part of the photonic community.

www.epic-assoc.com

DGaO Deutsche Gesellschaft für angewandte Optik
The German Branch of the European Optical Society

HS PF

INVITATION AND PROGRAM CALL

The German Society for Applied Optics (DGaO) invites you to the

123nd ANNUAL MEETING OF THE DGaO

7 – 11 June 2022 in Pforzheim, Germany
at the Hochschule Pforzheim

The following main topics from applied optics will be in focus:

- Optical metrology and measurement systems (especially for industrial processes and automation)
- Optics in medical technology
- Computational optics (computational optical metrology, image processing, artificial intelligence)
- Display and lighting technology
- Laser material processing
- Optics in automobiles, and
- Optics design

Source: Hochschule Pforzheim

Call for abstracts

We invite you to submit oral presentations (12 minutes plus 3 minutes discussion) and posters from the list of topics above or from the general field of applied optics. Please use the online system at www.dgao.de. The abstracts should not exceed 1,200 characters (including blank characters). Conference language is German, English contributions are welcome.

Program Committee

C. Faber (HAW Landshut), S. Reichel (HS Pforzheim), A. Bielke (Berliner Glas), K. Blankenbach (HS Pforzheim), J. Burke (Fraunhofer IOSB, Karlsruhe), C. Falldorf (BIAS, Bremen), M. Hanft (Zeiss, Jena), M. Hofmann (TU Ilmenau), C. Husemann (Zeiss, Jena), C. Pruss (ITO, Stuttgart), H. Rehn (Fisba, St. Gallen), C. Sinn (Köln Optik), A. Toulouse (ITO, Stuttgart)

DGaO Young Scientists Award

In 2021, the DGaO will again award the DGaO Young Scientists Award for the best dissertation and for the best master's thesis of 2020 in the field of applied optics. Detailed information is available on the DGaO website. Proposals for the DGaO Young Scientists Award can be submitted until April 30, 2021 to our DGaO office (katja.richter@dgao.de).

Deadlines

Submission of abstracts: by January 14, 2022, (receipt).
Notification of acceptance: from the middle of February 2022
Program mailing and publication: April 2022
Binding registration: from the middle of February 2022
End early-bird registration: by April 29, 2022

Contact

Conference management
Prof. Dr. Steffen Reichel
Hochschule Pforzheim
Fakultät für Technik
Tiefenbronner Str. 65
75175 Pforzheim
Tel: +49 (0)7231 28-6569
E-Mail: steffen.reichel@hs-pforzheim.de

Conference organization on site
Sophia Zundel
Hochschule Pforzheim
Fakultät für Technik
Tiefenbronner Str. 65
75175 Pforzheim
Tel: +49 (0)7231 28-6158
E-Mail: sophia.zundel@hs-pforzheim.de

DGaO - Office
Katja Richter
c/o Technische Universität Ilmenau
Department of Technical Optics
P.O. Box 10 05 65
98684 Ilmenau, Germany
Tel: +49 (0) 3677 692491
E-mail: katja.richter@dgao.de

Bringing the optics community together again

Annual conference and general assembly of the DGaO – new board elected

The 122nd Annual Meeting of the German Society for Applied Optics (DGaO) was held in Bremen from 21 – 23 September. The management and organization of the conference were in the hands of the Bremen Institute for Applied Beam Technology (BIAS) of the University of Bremen. Thanks to a sophisticated hybrid concept, a broad professional exchange both in attendance and online could be made possible again after the pandemic-related break of the previous year.

Source all images: DGaO

The new board (l. to r.): Young DGaO representative Christian Eder, EOS representative Prof Ralf Bergmann, past president Prof Stefan Sinzinger, treasurer Alfred Jacobsen, secretary Prof Christian Faber, president Ricarda Kafka, next year's conference director Prof Steffen Reichel, and assesors Dr Silke Wolff, Prof Andreas Heinrich, Dr Christof Pruss, and Marco Hanft

The organizers' plans worked out: 170 experts participated in this year's DGaO's annual meeting, with 100 participants being able to attend directly on-site at the conference location in Bremen. The conference had been moved from the traditional Pentecost week to September in the hope of a more relaxed pandemic situation due to higher vaccination rates. The experts were able to discuss together online and on-site thanks to the very good technical and organizational preparation.

The technical subjects covered were optical metrology, micro structured optics, display and illumination technology, optical design and simulation, additive manufacturing, hyperspectral imaging, and computational imaging and machine learning. Many submissions were received despite the difficult circumstances, and the program committee compiled them into a diverse program of six keynote lectures, sixteen sessions with 73 short talks, and an online poster session with eighteen posters.

The conference managing director Prof Bergmann opened the scientific conference with his keynote lecture. In his talk on 7D metrology, he introduced the coherence function and how it can be applied in various interferometric measurement methods. A separate session on speckle metrology was held due to the large number of submissions. The parallel session about sensor calibration showed the central role that the camera chip plays as a sensor in today's metrology.

Presentation of the DGaO Young Scientists Award to André F. Müller (center) by Prof Heinrich (left) and Prof Sinzinger (right).

The first day was rounded off by the poster session. An entirely virtual format was chosen for this to allow full participation while respecting hygiene rules. A compilation of the posters was available in advance for the participants. During the session, authors were available in separate virtual breakout rooms to present their topics. This allowed interested participants to 'move' virtually from poster to poster. Specific discussion groups then emerged in the small breakout sessions. Tim Käseberg (PTB) was awarded for the best poster for his contribution "Single structure characterization using imaging Mueller matrix ellipsometry".

Keynote presentations on Étendue determination (Henning Rehn), a printed miniaturized spectrometer (Andrea Toulouse), and deep learning in optical design (Christoph Menke) set the stage for sessions on optical design and additive manufacturing on the second day of the conference. Contributions on theoretical and experimental aspects highlighted how new technologies affect the design of system architecture and optics.

On Wednesday afternoon, the DGaO Young Scientists Awards for 2019 and 2020 were awarded to five young scientists. A. F. Müller (U Bremen), A. Vanselow (HU Berlin), A. Zannotti (U Münster), C. Bilsing (TU Dresden) and C. Heide (U Erlangen) presented their work in plenary lectures. The DGaO Young Scientists Awards are given for the best master's theses and dissertations, and are endowed with 500 and 1000 euros respectively.

A special highlight was the Fraunhofer lecture on exoplanets by astrophysicist Prof Dr Katja Poppenhäger. In an inspiring way she gave insights into how the spectrally resolved light curve method can be used to discover and study exoplanets in our neighboring solar systems. Sizes can be estimated, orbital periods determined or atmospheric evaporation explored. Prof Poppenhäger's infectious enthusiasm for this topic quickly captivated and fascinated the audience.

These impulses were further discussed at the gala dinner that followed. After a break of more than two years, everyone took the opportunity to have direct conversations while enjoying excellent food.

The keynote lectures on whispering gallery resonators (Martina Hentschel) and computational imaging (Christoph Husemann) set the stage for the sessions on Thursday, where topics in micro and nanostructured optics, hyperspectral imaging, and machine learning were presented and discussed.

New president: Ricarda Kafka

The DGaO general meeting was held at the end of the conference. Participation was possible either in presence or online. The organizers had prepared a suitable question protocol to conduct the numer-

Some of the participants were directly on site in Bremen. (Source: University of Bremen, Prof Ralf B. Bergmann)

ous votes and had organized a certified online voting. Based on these votes, the proposed new bylaws of the society were adopted and a new board was elected. Ricarda Kafka is the new president of the DGaO and is supported by Prof Stefan Sinzinger (past president), Prof Christian Faber (secretary), Alfred Jacobsen (treasurer), Dr Silke Wolff (assessor), Prof Andreas Heinrich (assessor), Dr Christof Pruss (assessor), Marco Hanft (assessor) and Prof Ralf Bergmann (EOS representative). The 2022 meeting will be held at Pforzheim University. As managing director of next year's conference, Prof. Steffen Reichel is also a member of the board. The representative of the meanwhile well-established Young-DGaO youth organization, Christian Eder, reported on this year's Summer School of the Young-DGaO. The promotion of young academics via the Young DGaO is now also part of the adopted amendment to the statutes.

The 122nd annual conference in Bremen in its hybrid form was a complete success. The conference once again enabled direct scientific exchange and networking, which had been missing for a long time. The online participants were also involved in the best possible way. This success was down to the work of the conference office under the direction of Prof Ralf Bergmann and the efforts of Heike Weers, as well as the team of BIAS and the DGaO office (Elizabeth Erhard and Katja Richter). The DGaO would like to take this opportunity to express its sincere thanks for this outstanding work. A very special thank you goes to the long-time DGaO secretary Ms Elizabeth Erhard, who was starting her well-deserved retirement at the end of the conference, amidst long-lasting applause from the conference participants and DGaO members. *Marco Hanft*

www.dgao.de

The Young DGaO concludes two successful Summer Schools in Ilmenau and Stuttgart

The Young DGaO is the young scientists organization of the German Society for Applied Optics. Its aim is to promote and network young scientists from the field of optics in Germany. For this purpose, the Young DGaO organizes an annual summer school with lectures, workshops, company visits and leisure activities. Changing venues ensure a wide range of topics and participants. The Young DGaO, founded in 2019, has now already hosted three Summer Schools. After Aalen (2019), the venues were Ilmenau (2020) and Stuttgart (2021).

Source: DGaO

Group photo taken at the Summer School 2020 in Ilmenau with the necessary distance.

The one at the TU Ilmenau in the department of technical optics focused on micro and nanostructuring. The participants got an in-depth view into various institutions of the TU Ilmenau during laboratory tours. Presentations by local companies and an excursion to Carl Zeiss in Jena provided a good mixture of science and industry. With an extensive hike up the 'Kickelhahn', the organizers from Ilmenau already established our first tradition, following the example of Aalen in 2019. Despite the pandemic, six external and eight local participants could be invited under strict hygiene regulations. The representative of the Young DGaO thanks all organizers under the leadership of Julian Wüster and Leonhard Lenk for this.

This year's Summer School took place at the 4th Physics Institute of the University of Stuttgart, with the help of the SCoPE research center. Technical presentations by all participants and extensive discussions provided deep insights into the activities of other (PhD) students and young professionals. The organizers from the University of Stuttgart ensured an international character of this Summer School. With English as the language of communication, international participants researching and working in Germany were able to fully enjoy all the activities and discussions, a tradition that will certainly find its way into following Summer Schools. As a contrast to the Summer School in Ilmenau, the departments of the University of Stuttgart offered deep insights into the field of quantum optics. Again, the Young DGaO representative thanks the organizing team led by Claudia Imiolczyk.

Another Young DGaO Summer School is planned for 2022. If you are interested, please keep an eye on the website for dates and announcements. *Christian Eder*

www.dgao.de

OSA has a new name and look

'Optica, advancing optics and photonics worldwide'

Source: Optica

The OSA's mission has stayed substantially on the same course its charter members envisioned over a century ago. The significance of the field, the expertise of its founders, and the dedication of those who followed enabled the society to become a global forum for light science and technology. In concert with the rapid development of the field, the scope and reach of the organization continues to expand. This growth inspired the OSA's leadership to carefully consider whether its name reflected the society's work, constituents, and future.

In 2017, the board of directors launched a multifaceted examination of its name and its alignment with the organization as a whole. This work included wide-reaching consultation with the diverse customers it serves. Communications, branding, and design experts advised along the way during a methodical search for an identity that signifies a vibrant, global association. The new name must be expansive enough to remain relevant to the future generations who will change the field and the world for the better. At the conclusion of much study, 'Optica, advancing optics and photonics worldwide', emerged as the best representation of the society.

This change emerges from the continuity of the society's mission, core values, and dedication to excellence. It continues to serve as a leading global forum for light science and technology. And its commitment to remain the professional home for optics and photonics innovators and all those with an interest in the field is unwavering.

www.optica.org

Mark Williamson chairs VDMA Machine Vision

General meeting elects new board

Source: VDMA

(from left): Donato Montanari (Deevio), Martin Klenke (Teledyne Imaging), Mark Williamson (Stemmer Imaging), Uwe Wiedermann (Isra Vision), Olaf Munkelt (MVTec), Horst-Heinol Heikkinen (Asentics), and Heiko Frohn (Vitronic). Not in the picture: Hardy Mehl (Basler)

During the general meeting of the VDMA Robotics + Automation association, the members of the VDMA machine dision division elected a new board. Mark Williamson, managing director of Stemmer Imaging Ltd, was subsequently elected chairman.

"The European machine vision industry is in an excellent position. Between 2013 and 2019, turnover in Germany alone grew by an average of 9 % per year. In 2020, while turnover declined by 4 % due to Covid-19, the decline was nowhere near as drastic as in many other industries with good prospects for future growth. The VDMA Machine Vision division, with over 115 members across Europe, has an important role to play in enabling this potential growth," said Williamson after his election.

He added: "Our thanks go to the former chairman, Klaus-Henning Noffz, who during his nine years on the board – including the last three years as chairman – has achieved many things for the industry with a great deal of commitment." Noffz, has decided not to run again for personal reasons.

www.vdma.org

Nine elections ensure continuity for Spectaris

Hybrid general meeting of the German industry association

Source: Spectaris / T. Rücker

(from left, front) Roland Dimbath, Mathis Kuchjeda, Dr Sebastian Braun-Lüdicke, Inga Kuhls, (back) André Schulte, Josef May, Dr Thomas Renner

The agenda of this year's general meeting of the German industry association Spectaris included extensive board elections on September 16. The event was held for the first time and with great success as a hybrid in the French Friedrichstadt Church in Berlin.

In the process, Lukas Eckermann, (Otto Bock HealthCare), was elected as the new chairman of the Bremen / Lower Saxony regional group. Justus Wehmer (Carl Zeiss Meditec), was re-elected as chairman of the Mecklenburg-Western Pomerania, Thuringia, Saxony, Saxony-Anhalt regional group.

Dr Thomas Renner (Toptica / Eagleyard Photonics, is the new chairman of the Berlin / Brandenburg regional group, Roland Dimbath (Rodenstock) leads the Bavarian regional group.

Dr Sebastian Braun-Lüdicke (Aesculap) heads the Baden-Württemberg group, Markus Lusser (Leica Microsystems) remains chairman of the Hesse, Rhineland-Palatinate, Saarland regional group, while Friedrich Schmitz (Schmitz u. Söhne) chairs the NRW regional group.

Inga Kuhls (Drägerwerk) was re-elected to chair the Hamburg / Schleswig-Holstein regional group, Josef May will remain chairman of ophthalmic optics in Spectaris, and is also chairman of the board of the overall association.

www.spectaris.de

New developments in LiDAR optics

Three questions for Dirk Hauschild, Head of Research & Development, Laser Optics business unit, Focuslight Technologies

PHVS: Does lidar complement current camera-based technology?

Dirk Hauschild: Yes, as technology is evolving rapidly. Optical resolutions are continuously increasing and computerized analyses of the lidar scanned environment can be performed at rates of more than one hundred scans or analyses per second. This enables lidar to replace most camera-based safety technologies due to the 3D feedback generated by lidar sensors as they encounter objects. In addition, easy-to-use diode laser-based technologies will bring the lidar sensors to commodity pricing levels within a few years, addressing any cost concerns.

The measurement of distances, improved depth perception, and changes in distance can only be done precisely with lidar technology. Over the last thirty years, lidar has evolved from a single point of measurement, used to measure the speed of cars, to the current high-definition 3D lidar, driven by state-of-the-art laser sources, optics, and electronics. This allows analysis of the environment, feedback, and even decision-making within a few milliseconds.

Combining lidar sensors within an AI based network of online and offline traffic participants improves the level of safety that can be achieved. Camera-based technology can suffer from optical illusions as it lacks the accurate third dimension information that lidar technology can provide.

Camera-based technology does have an advantage in the analysis and processing of logical information in pictures, such as names, signs, and speed limits. But due to data security regulations, the processing and temporary storage of pictures must follow government laws, limiting the potential features of this technology. As a result, cameras and lidar systems will co-exist as systems combine their specific advantages into an enhanced solution.

Source all images: Focuslight Technologies

PHVS: How is growing demand for autonomous transportation technology influencing optics development?

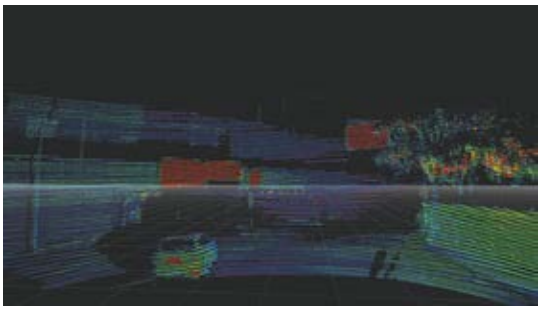
DH: Scaling productivity and keeping quality at the highest level for the safe and reliable operation of lidar sensors is a key challenge for all optics manufacturers. Massively parallel processing of optics with a single workstation will become the only path for lidar optics suppliers. The wafer-based production used at Focuslight already addresses this challenge, and functionality vs. price will be the new benchmark for precision shaped glass optics.

Most lidar applications want to cover the full angular spectrum around the vehicle to ensure the safety of the driver, passengers, and pedestrians. Reducing the cost means reducing the number of systems needed, which requires increasing the angular field of view per system, so wide angle diffusers are increasingly needed. Focuslight has scaled existing mass production technology to produce micro-optics at wafer level that is customizable for individual wide angles with high order acylindrical shapes, and attains a quality standard suitable for automotive applications.

PHVS: Why are glass optics still needed in lidar sensors?

DH: Long-term stability in harsh environmental conditions can currently only be addressed with glass optics. Since multifunction optics with a higher added value will be needed to decrease their size and cost, hybrid technology and materials will play an important role. But the focus is still on 'safety first'!

The use of polymer-based optics is the preferred low-cost solution in industry and in consumer applications for low power and the redundant use of light where a degradation of transmission and collimation accuracy is not critical. Polymer-based designs can cover only a limited angular spectrum and resolution because of the limits in the optical index of refraction. Until polymer materials are available with more than ten years performance warranty, the use of parallel processing of lenses in glass, e.g. wafer-level technologies, will be the preferred path to optimize performance, price, and availability.



Lidar point cloud map from Focuslight partner Tanway Technology

www.focuslight.com

"Don't put all your eggs in one basket!"

Visiting Mike Richardson at Photonic Insights

Jose Pozo

The technical director of EPIC, Jose Pozo, talks to Mike Richardson, managing director at Photonics Insights, an R&D company focused on developing low-cost spectrographic solutions particularly for agricultural markets.

Source all images: Photonic Insights

After studying physical anthropology and media at Washington State University, which involved a field study of Netsilik Inuit in Alaska, Mike spent most of the 90s travelling the world. After spending some time in Asia, he ended up in Russia, where he taught crews how to operate a QA system on factory trawlers in the Bering Sea. In 1998, he returned to Seattle to get married and, in pursuit of a steady job, he applied for a trainee position with Microsoft.

At that time, the company was expanding rapidly and looking to expand their talent pool. As Mike recalls, it was an unconventional interview as they were more interested in problem solving capabilities than technical knowledge. Accordingly, he was asked to come up with a plan to move Mount Fuji and to say how he would determine which light switch from multiple switches outside a locked room would activate a light bulb inside the room. The answers he gave were, respectively, 'stone by stone' and 'measure the temperature'.

Mike passed the interview and was taken on by Microsoft as a trainee test engineer, which involved writing code to test software. In 2001, he moved to NetIQ, where he managed the testing of an App Analyzer, an enterprise application used to optimize utilization of Exchange servers. This was followed by three years as quality assurance lead/project manager at the Port of Seattle's Hazmat (hazardous materials) Mobile Command Center. It was here that he first learnt about spectroscopy because one of his jobs was to develop a spectroscopic device to detect anthrax.

In 2008, he became quality assurance manager at Hewlett-Packard, where he worked on a first of its kind BVT for high-definition video conferencing and built a test lab including all the hardware, networking, and AD infrastructure.

Things were looking up as in 2013 he became a software developer / project manager for the Walt Disney Company. His job was to help build an artificial intelligence-based media archiving system using a triple store database based on semantic technology.

Then disaster struck in the form of a rare immune system condition called hereditary angioedema type 3 seronegative. This condition causes the immune system to attack the body and, throughout 2014, Mike was taken on numerous occasions to intensive care. With the cost of medication at around ten thousand dollars a prescription, it was not long before his health insurance company withdrew cover. By the middle of 2014, because of spiraling medical costs and time off work, Mike had lost his house and his job with Disney and was living with his wife and two children at his mother's house.

Move to Germany

As no company in the US would offer him a job, Mike began to apply for jobs in Europe. His first possibility was with a company in Berlin but, having spent the previous night in hospital on an IV drip, he collapsed three hours into the interview. His next interviews were more successful and in February 2015, he began working as a software quality assurance consultant for Berlin-based Outfittery, a major clothes distributor.

Reflecting on this traumatic period, Mike says, "I was pretty much close to dying and I came to understand the importance of not just surviving but of living, and I realized that the most important things we have are not material but the relationships we make with other people."

Eight months later, Mike joined Smartfrog Ltd, a Berlin-based start-up producing high-tech home security cameras. He started as their software test manager but quickly became involved with production of the hardware in Shenzhen, China, handled by their Chinese partner, Zmodo. Over the next three years, he put together hardware

and QA teams and developed a complete manufacturing infrastructure.

Photonic Insights

During his time with Smartfrog, Mike became increasingly involved in the Berlin photonics community and developed a particular interest in spectroscopy, especially how the technology could be used to improve health. He came up with an idea for a smart toilet that used optical sensors to analyze human feces in real time and, in 2018 having set up Photonic Insights to commercialize the technology, he successfully applied to Fraunhofer IZM's Start-a-Factory scheme to develop a prototype.

The next task was to build a team and, as he had limited financial resources, Mike offered to sell most of his shares to André Sprenger and Daniel Heltzel, whom he had met through the Berlin start-up ecosystem. The result was Photonic Insights GmbH with Daniel as CEO, André as chief data scientist, and Mike as managing director.

Since 2018, Photonic Insights has developed into an R&D company focused on developing low- cost spectrographic solutions – particularly for agricultural markets – that can be used at the point of need in the field. Their three areas of competence are 1) optical sensors that provide analyte information quickly, remotely, and non-invasively; 2) machine learning (ML) based on generalized algorithms that construct their own data-based logic to evaluate information obtained from the optical sensors; and 3) actionable coupling, i.e. integration of the optical sensors and ML to provide immediate classification of the sensor output, e.g. via Bluetooth, low energy Wi-Fi and 5G, to enable practical use in the field.

The company's business model also has three components. The first is applied research with industrial partners and research institutions to explore

cutting-edge optical and ML technologies; the second is due diligence, i.e. helping public and private partners to evaluate whether a tech-intense solution is as good as marketed and suggesting viable alternatives.

But the most important arm of their business strategy is to encourage joint ventures with their partners as soon as a promising application becomes apparent. In this way, instead of remaining at the consulting or research level, the technology can be used for real world applications.

Their latest joint venture is Spectrify AI which, in partnership with Fraunhofer and Veracity AI, is providing AI spectral analytic devices to ensure consistency in the quality control of tea, herbs and spices in Asia. Using the unique reflective patterns returned from the material, the devices are able to identify and determine the material's salient characteristics and AI algorithms learn and understand the unique light patterns of the material to provide real-time analysis.

The future

Photonic Insights aims to move beyond standard spectrometry into quantum-enabled spectrometers that will enable faster and more accurate processing in real time. Central to this development will be a focus on building modelling applications to show users how to use the instruments.

With regard to markets, Mike sees a pressing need for spectrometry technology to ensure food quality. As he points out, the worldwide growth in the demand for food is leading, for example, to the development of genetically modified organisms to enhance protein output for certain legumes and the growth of lab-grown meat. The introduction of these misfolded proteins into the food chain is potentially dangerous. It is not just a case of amplifying the green revolution; what is needed are some radical changes through the introduction of spectrometers to enable real-time safety assessments of food.

If you started again, what would you do differently?
"I would secure more funding at the beginning. In my case, I did it all by the seat of my pants and if you are hustling for money and trying to build the company at the same time, it is easy to lose focus. Admittedly, bringing investors on board will result in having less of the pie, but 10 percent of something that works is better than 100 percent of something that fails."

"I would also come to Europe earlier. There is nothing wrong with the US, but I identify far more with the European mindset and Europe's ecosystem makes it an excellent place to build a deep technology."

What are your words of wisdom for the next generation of entrepreneurs?
"First, don't put all your eggs in one basket. You never know how things will pan out and having alternatives is critical for all parts of building a company, and it will keep you sharp."

"Second, it is better to share equity with your partners to give them the incentive to grow the company. Keeping 100 % may allow you to buy a Lamborghini, but in my view it is better to grow the company and employ twenty people because that is what is needed to make the breakthroughs to save this planet."

"Third, don't be afraid of failure. Failure is educational and makes you better prepared the next time round."

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

Healthcare decentralization promoted by PICs

Integrated photonics is one of the key supporting technologies in the development of point-of-care devices

Elena Beletkaia

The traditional healthcare system has a significant need for change due to increasing costs, growing populations, and rapid demographic changes. A more holistic approach that enables preventative and personalized healthcare is envisioned as a future solution.

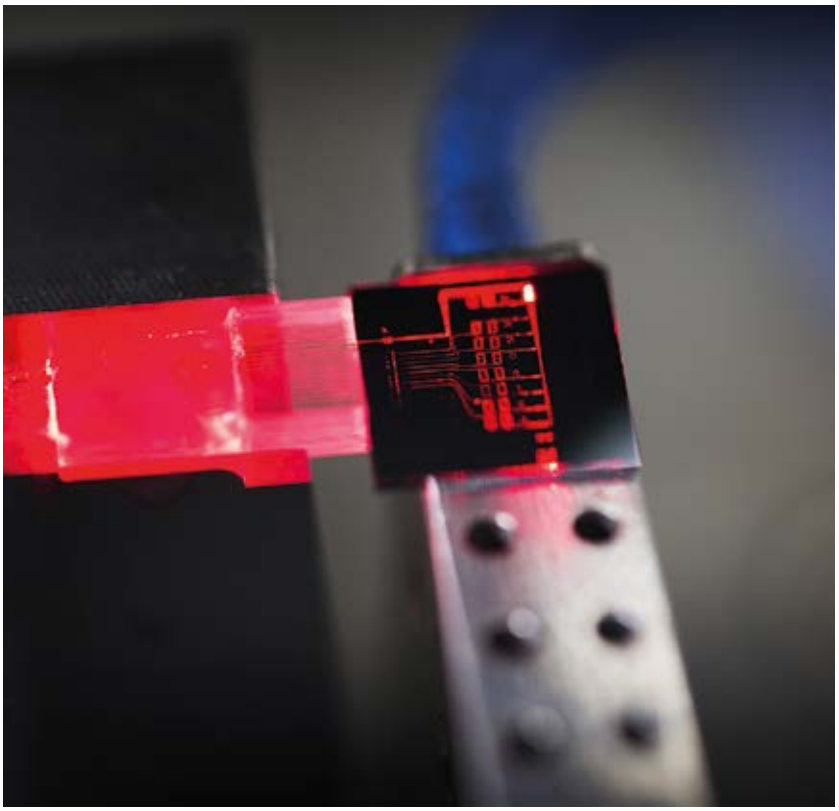


Fig. 1 Lionix International's biosensing platform. (Source: Lionix)

Such an approach requires the decentralization of care, and shifting diagnosis and treatment closer to the patients. At the same time, decentralized healthcare allows the delivery of many primary, preventative and urgent care services at retail locations, and therefore an expansion of access to healthcare services. With additional focus on rehabilitation and continuous monitoring, there is a significantly beneficial impact on the comparative cost of care when measured against the same procedure or visit to a general hospital or a medical clinic. Despite the considerable benefits of a holistic approach, its integration is not yet gaining wide adoption. One of possible setbacks is that the implementation of such healthcare methods also requires alternative medical devices, and this is where 'integrated photonics' can provide the answer.

Point-of-care (POC) diagnostic devices have a huge potential to improve operations at nearly every point of healthcare: emergency care, laboratory, critical care, operating room, intensive care, radiology, etc. POC devices allow instant testing near the place of patient care and provide physicians and medical staff with lab-quality diagnostic results in a short time. Furthermore, when integrated with the patient's electronic medical records, the results from POC devices can be used to monitor the overall condition of the patient in preventative, diagnostic or post-treatment care. An ultimate POC device would be an unobtrusive biosensor, such as a wearable device. They are gaining ever more interest due to their ability to provide continuous measurement of physiological parameters in a non-invasive manner.

Silicon photonic biosensors

The volume of point-of-care testing has been increasing steadily since its introduction about forty years ago, and in 2020 the worldwide point-of-care diagnostics market reached approximately 29.5 billion dollars. The Covid-19 pandemic has accelerated the global demand for rapid and accurate diagnostics. Further improvement of POC devices and the expansion of their market is being aided by the rapid development of supporting technologies.

There have been significant advancements in integrated photonics over the last few decades. Photonic integrated circuits (PICs) are compact, multifunctional, cost effective, multiplexed and fast, bringing great potential and a lot of benefit to medical and healthcare applications. One PIC can contain multiple optical devices, such as lasers, amplifiers, couplers or detectors, making integrated optics the perfect technology for POC and wearable biosensors.

A common platform for biomedical applications are silicon nitride (SiN) PICs. SiN has a wide transparency range from the visible to the mid-infrared (MIR), allowing the detection of biological molecules. One can combine a reach set of sensing modalities and tests for multiple items together on a silicon photonic chip while the sensing can be done without physical contact. Because it is an on-chip implementa-

tion, the system can already be economic at moderate volume production and even allow single-use disposable biosensors. On-chip integration also enables a high degree of miniaturization down to implantable devices or electronic pills. Furthermore, silicon photonics already has a mature technological supply chain. Some companies enabling PIC or PIC-based technologies for healthcare include, for example, Bay Photonics, Bialoom, Bright Photonics, Ligentech, Lionix, Phix, Rockley, Soitec, and Teem Photonics.

PIC-based biosensors are expected to be applied in many areas of medical, healthcare and life science where sensitive, efficient, effective and time-dependent diagnostics is crucial. The Netherlands-based Lionix International in partnership with Surfix and Qurin Diagnostics have developed a photonic biosensor chip that offers 100-times improvement in sensitivity over other chip-based biosensors (Fig. 1). With novel interferometric sensing components, Lionix International's biosensing platform provides fast results with sensitivity comparable to lab-based analyses. The point-of-need sensor requires minimal intervention by the user; the integrated microfluidics handle liquid samples directly and a biofunctional sensor coating enables direct detection of biomolecules with no need for additional biorecognition dyes. Furthermore, sensor chips are volume manufacturable and can be coated differently to detect any disease marker or pathogen (including DNA, proteins and viruses) or even a combination of markers. Lionix' development pipeline already includes a PIC-based biosensing platform for the detection of Covid-19, cancer biomarkers, waterborne pathogens and traces of life on Mars. The technology also offers cost-effective screening of drug precursors for the pharmaceutical industry.

Fig. 2 A multibeam LDV demonstrator implemented in the H2020 CARDIS project (continued by the H2020 InSiDe project, inside-h2020.eu). The laser source is hybrid integrated on the PIC, based on micro-optical bench (MOB) technology. (Source: Imec).

Plasmonic augmentation

The plasmonic augmentation of silicon photonic biosensors can lead to improved diagnosis and therapy of acute infections. In sepsis diagnosis, achieving an early and informative result is a prerequisite for rapid and successful antibiotic therapy as well as for effective therapy monitoring. That requires frequently recurring measurement of multiple analytes next to the patient without discomfort.

Cyprus-based start-up Bialoom develops miniaturized, powerful and fully flexible photonic biosensors that can uniquely address the need for faster and more informative diagnosis of complications related to infections. Their plasmonic waveguides, when used as the sensing transducer element, offer the required sensitivities in microscopic dimensions. In practice this means that detection of nearly any targeted biomolecules can be performed using only a thousandth of a single blood droplet or less. In diseases like sepsis, the small size of plasmonic transducers allows dense detection multiplexing on a single biochip. Microliters of a sample could, in principle, load tens or even hundreds of such elements, addressing the need for immediate multiparametric analysis of diseases and assisting clinicians with evidence-based diagnosis, but also effectively supporting emerging AI-based diagnostic tools.

Also in the case of sepsis, speed is crucial as the risk of morbidity and mortality increases incrementally over time. With the right microfluidic structures, plasmonic transducers can provide fast measurements. The time to complete a detection assay can be from a few minutes down to split seconds for biomolecules with elevated concentration. Ultrahigh sensitivities are possible due to the near-perfect overlap between the optical mode and the sample under test. Bialoom offers micrometer sensors instead of millimeter or even centimeter long solutions, such as photonic evanescent wave sensors and electro-chemical sensors with their compromise on sensitivity.

Photonics packaging

Even though PICs can house a lot of functionality on a small surface, a PIC by itself is not a functional product as

MedPhab

The purpose of Europe's first pilot line dedicated to manufacturing, testing, validation, and up-scaling of new photonics technologies for medical applications ranging from diagnostics to surgical tools and therapeutics, is to accelerate the commercialization of diagnostic devices and instruments for treatment based on photonics, and to reduce the R&D costs. The chosen areas are devices intended for hospital use (to assist doctors), home care devices (to monitor patients) and equipment for chemical diagnostics (based on the use of serum, saliva, or urine samples). MedPhab will also provide a seamless transition from pilot line production to up-scaled production without the need 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.

https://medphab.eu

such. To make it become a part of a photonics-enabled module, it needs to be connected to components like optical fibers, other PICs, cooling solutions, and electronics. The design and manufacturing of the package in which these connections are made is the core business of Phix.

The field for photonics packaging and assembly for medical usage is evolving in several directions, and all with their own challenges. Going in-vivo with photonics devices requires the use of biocompatible materials and long trial periods before a new procedure is developed. On the other hand, there are components that are used ex vivo (e.g. for smartwatches) and even consumables for one-time usage sample diagnostics. The latter being used in high volumes and one time only requires a different integration scheme to allow for a similar cost-per-treatment/measurement. Phix offers photonics packaging solutions, ranging from single manufacturing steps to complete joint development with manufacturing scale-up.

Interested in developing POC or learning more ...

To help companies with their development of photonics-based solutions, including PIC-based medical devices, the EU-funded MedPhab project is launching its second open call with a cut-off date of January 31, 2022. MedPhab is the first European pilot line for photonics-based medical diagnostics. The aim is to accelerate the uptake of the latest photonics technologies in medical applications. MedPhab provides R&D services covering the full product development chain from early phase proof-of-concepts to certified manufacture. With the ambition to create an ecosystem, MedPhab offers high quality infrastructure and extensive knowledge to provide design, fabrication and testing services, and acts as a one-stop shop where experts in the medical field communicate with the customers to find the best solution.

To learn more about how photonics technologies are enabling a new generation of medical devices and how integrated photonics contribute to more precise and less invasive diagnostics and clinical procedures, join and watch the EPIC Online Technology Meeting on Medical Devices on 6 December 2021 at 15:00 CET. At this meeting, the whole supply chain will come together for an open discussion on how to endorse photonics-based medical devices.

www.epic-assoc.com/epic-online-technology-meeting-on-medical-devices/

Author

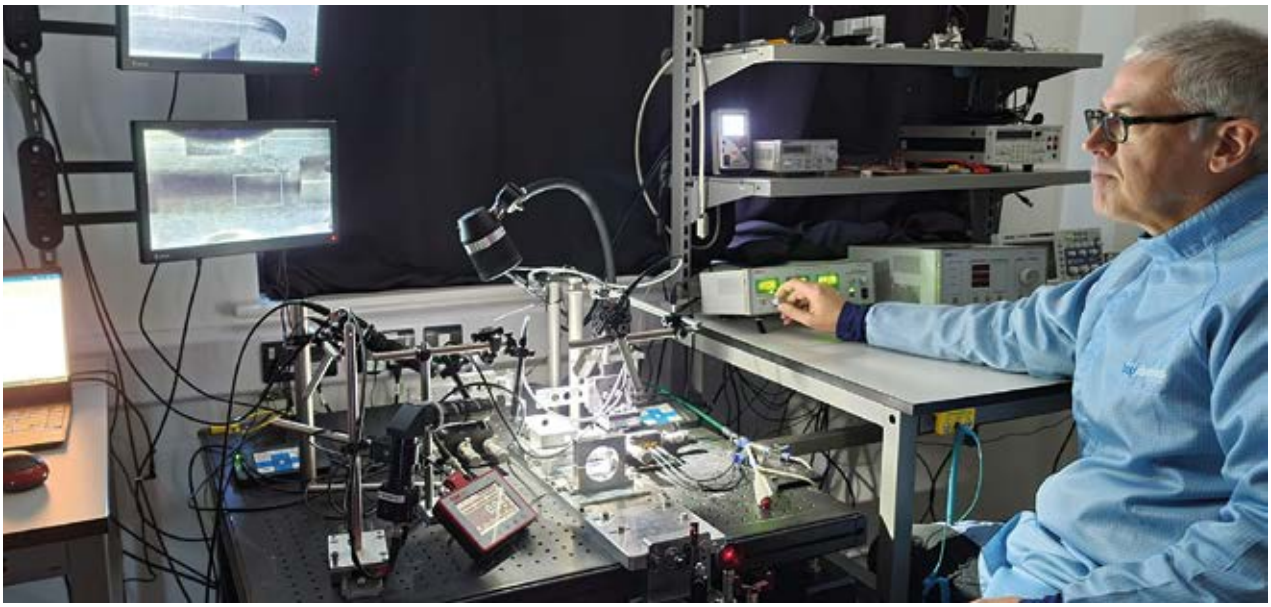
Elena Beletkaia is a project leader at the European Photonics Industry Consortium (EPIC). She graduated from Lomonosov Moscow State University, where she specialized in biophysics. In 2015, Beletkaia received a doctorate from Leiden University, where her research focused on biochemical and biophysical mechanisms underlying metastasis of Ewing sarcoma. Later, in the collaborative setting of NKI (Netherlands Cancer Institute) and the University of Twente, she investigated the application of noninvasive spectroscopic/multiphoton methods for intraoperative resection margins assessment. All of Beletkaia's research projects have involved the understanding and use of multiple microscopic and spectroscopic techniques.

Dr. Elena Beletkaia, EPIC – European Photonics Industry Consortium, Rue Hamelin 17, Paris, France; e-mail: elena.beletkaia@epic-assoc.com, Web: www.epic-assoc.com ebeletkaia

Industrialization of quantum communication technologies

The landscape of the photonics industry for the future of secure communication and quantum key distribution solutions

Sana Amairi-Pyka



Source: Bay Photonics

The growing number of cyber-attacks together with the complexities of cyber risk management are driving the development of quantum-based data security solutions. In this article, we look at the applications, challenges, and future business opportunities in the field of quantum key distribution, which is emerging as a promising solution to ensure highly secure data transfer, particularly in the telecom and finance sectors.

Recent cybersecurity statistics are alarming. According to Forbes, 2020 saw a record number of cyber-attacks on companies, governments, and individuals: 44 % of small businesses experienced more than one cyber-attack and, more alarmingly, an IMF study suggests that global bank losses due to cyber-attacks were 9 % of net income at a total of around 100 billion dollars [1].

The average cost of a data breach has been calculated at around 3.86 million dollars, but it is not just numbers and costs: the sophistication of threats has also increased due to the application of emerging technologies such as machine learning and artificial intelligence, and especially from greater tactical cooperation between hacker groups and national governments. These threats are forcing governments, militaries, and businesses to explore the more secure ways of transmitting information based on quantum physics.

Quantum communication is based on the superposition law of quantum physics: a particle, i.e. a photon, can represent multiple combinations of 1 and 0 simultaneously. These particles, known as quantum bits or qubits, can be encoded and then transmitted through the same optical cables used for digital signal transmission. However, from a cybersecurity perspective, the key advantage is that if a hacker tries to observe them in transit, their super-fragile quantum state 'collapses' to either 1 or 0. This means that a hacker cannot tamper with the qubits without leaving behind a tell-tale sign of the activity.

▲**Fig. 1** Bay Photonics' single photon quantum alignment packaging capability.

Quantum key distribution (QKD) involves sending encrypted data as classical bits over networks, but the keys to decrypt the information are encoded and transmitted in a quantum state using qubits. Under BB84, a widely used protocol for implementing QKD, the sender creates an encryption key in the form of qubits whose polarization states represent the individual bit values of the key. The qubits are then sent to the recipient over fiber-optic cable and, by comparing measurements of the state of a fraction of these qubits – a process known as 'key sifting' – the sender and recipient can establish that they hold the same key.

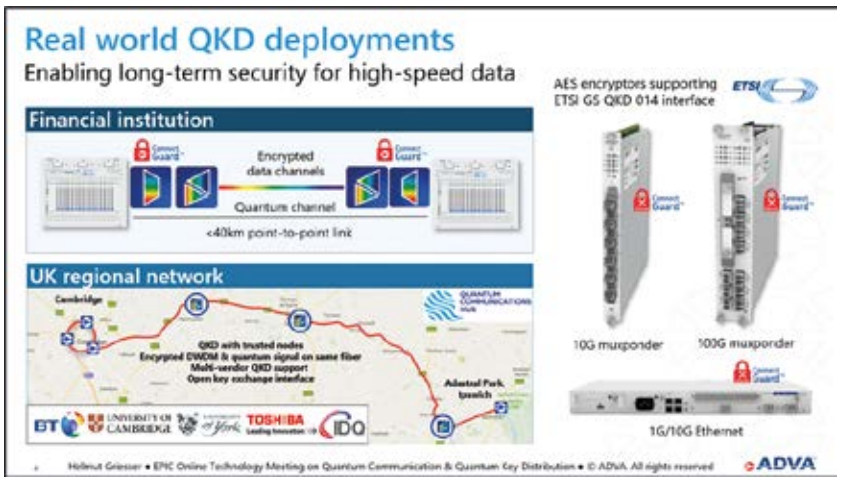


Fig. 2 ADVA Enabling long-term security for high-speed data (Source: ADVA)

The next stage is to establish whether a hacker has tried to intercept the key, which is done using a process known as 'key distillation'. This involves calculating the percentage of error rates due to 'collapses'. A small number of collapses are inevitable due to decoherence in transit, but if the error rate is high, it suggests that an attempt has been made to hack the key. In this case, both parties ditch the suspect key and keep generating new ones until they are confident that they share a secure key. Once this has been established, the sender can use the key to encrypt the data and send it in classical bits to the recipient, who uses his or her key to decode the information.

Development of QKD networks

Attracted by the advantages of QKD for ultrasecure data transmission, network providers and financial institutions in Europe, the US and China are currently conducting trials with QKD systems. In Europe, two potential end-users of the technology are British Telecom (BT) and Deutsche Telekom. In the UK, BT has installed a 7-km secure quantum link between the National Composites Centre R&D facility, and the Centre for Modelling and Simulation in Bristol, as part of the UK AQuaSec project. BT leads AIRQKD, a project that establishes a UK ecosystem, from single-photon components to networked quantum systems for short to mid-range communications in free space. In AirQKD, developed modules will be used to enable quantum-secure communications in two key infrastructures: connected vehicles and 5G. BT also contributes to the European OpenQKD project, which aims at setting up and testing quantum communication infrastructures in several European countries. Although still in its early stages, two QKD milestones to readiness have been achieved. The first is the development of ISO standards (to be published in 2021). The second is assurance and a common criteria framework to enable validation of QKD systems and make them production-ready. As Catherine White, senior researcher at BT explains: "The attraction of quantum encryption and QKD for BT is the fact that it is the only way of providing true non-deterministic randomness and detecting hacking attempts. Additionally, QKD is theoretically immune to all foreseen and unforeseen advances in computational methods, including quantum computing."

Meanwhile, Deutsche Telekom is aiming to provide a secure communication platform throughout Germany for three use cases: the protection of governmental and public agency traffic; the protection of Telekom's network assets; and the protection of critical infrastructure used by their public sector and business customers. The architecture is highly modular in four levels. At the lowest level are the QKD systems for the generation and distribution of secure keys along with the quantum link. The next layer is for the management of the secure keys provided by those QKD systems and being in charge of the routing of secrets over longer distances. Above that is a centralized software instance to compute the key routing path and handle key requests without having access to the quantum keys themselves. The top layer accommodates the key consuming encryption and decryption devices and comprises various applications for

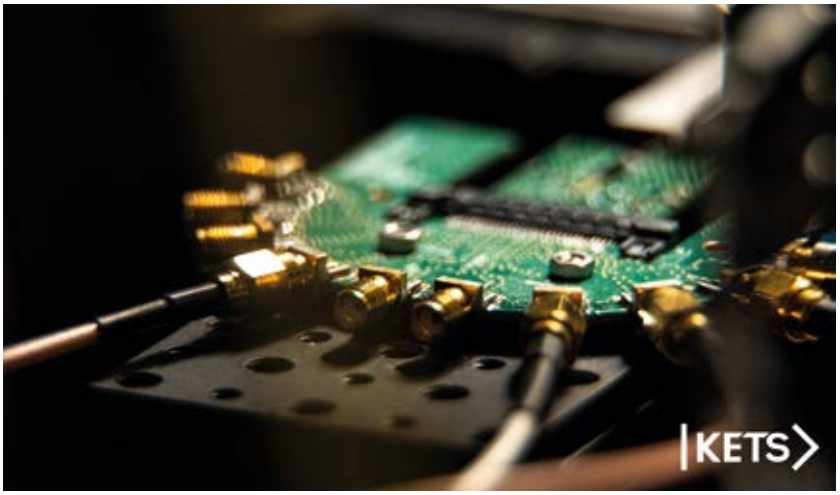


Fig. 3 Kets' QKD and QRNG are designed with the low SWaP-C that will allow companies to easily and cost-effectively integrate [noun missing]. (Source: Kets)

the protection of their routers, switches, firewalls, and network equipment.

The aim is to have a modular 'Lego' approach combining QKD with maths-based post-quantum cryptography (PQC) to form a QKD platform based on the following principles: 1) clear separation between the QKD platform and key consuming devices/applications, 2) a platform deployment which is minimally invasive to existing equipment such that there is no risk of spoiling existing assets, 3) smooth integration so that everything can work with today's networking mechanisms, 4) a strict dual vendor approach i.e. competing suppliers for all entities to avoid 'vendor lock-in', 5) standardized interfaces and certification, and 6) speed, so that almost everything can be in place within the next couple of years*).

*) This work has received funding from the European Union's Horizon 2020 research and innovation program under grant agreement No 820466. www.civiquantum.eu

Business opportunities

The global quantum cryptography market is estimated to grow from $ 89 M in 2020 to $ 214 M in 2025, at a CAGR of 19.1 % [2], reaching $ 1.1 B by 2030 [3]. This includes technologies such as QKD, post-quantum cryptography, QRNG, quantum-safe key management and security consulting. A considerable part of this growth will be driven by the development of new enabling components and technology required by the QKD networks. Some of these technologies can be developed by enhancing existing ones while others will need to move from the lab to fabrication.

Examples of companies currently providing components and technology for QKD networks together with some of the challenges identified are:

ADVA Optical Networking is working on QKD encryption projects with many of Europe's leading telecom providers, including BT, Telecom Italia, Telefónica, Colt and Deutsche Telekom. ADVA provides 10 Gbit/s and 100 Gbit/s muxponders (a sender and receiver that also offers several time-multiplex client signals on a single wavelength) for AES encryptors supporting ETSI GS QKD 014 interfaces for the quantum key. The company also supports certificate-based authentication and is currently developing similar solutions for a 1 Gbit/s and 10 Gbit/s Ethernet device. As part of the BT project, ADVA is sending and receiving optical signals over multiple spans with the quantum channel multiplexed onto one of the transmission fibers and extended by trusted nodes (circles in Fig. 2).

Helmut Griesser, director of advanced technology at ADVA, explains the challenges of moving a complex and new technology from research into mission-critical networks: "There are physical limitations that must be overcome, but implementations also need to withstand the most sophisticated attacks. Our team began investigating the use of QKD for secure key exchange in high-bandwidth optical transport in 2014. This work combined ADVA's expertise in highest-bitrate photonic transport and line-rate encryption of optical channels. Through our engagement in many trials and demos as well as open research, we are helping to create the basis for a robust and reliable QKD application, ready for even the most demanding use cases."

VPIphotonics specializes in simulation software for integrated photonics and optical transmission system and network applications. With regard to QKD, VPIphotonics has developed a system-level model library for QKD as part of the EU's Quantum Flagship €10M Uniqorn project, which was set up to advance quantum communication technology for DV and CV systems by carefully laying out each element along the development chain from fabrication to application. The VPItoolkit QKD library, which plugs into their existing optical transmission system simulation solution, can be used to help design and implement QKD systems by studying component imperfections, coexistence scenarios and making estimations of secret key rates.

Bay Photonics has been supplying proof-of-concept and prototype devices for quantum projects since 2015. They specialize in packaging design and the assembly of prototypes of PICs used in a range of quantum devices for secure communication in lidar and high-speed receive/transmit modules for data communications. For Bay Photonics, a major challenge for QKD is the cost of encryption. As Glenn George (see Fig. 1), Bay Photonics' CEO explains, while their customers, especially in the market of datacenter interconnects, are increasingly aware of the value of encrypting the data and are prepared

Organization

EPIC – European Photonics Industry Consortium

EPIC is the world-leading photonics industry association representing more than 700 members across 35 countries. EPIC promotes the sustainable development of organizations working in the field of photonics, EPIC fosters a vibrant photonics ecosystem by maintaining a strong network and acting as a catalyst and facilitator for technological and commercial advancement. EPIC publishes market and technology reports, organizes technical workshops and B2B roundtables, supports EU funding proposals, advocacy and lobbying, education and training activities, standards and roadmaps, pavilions at exhibitions.

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to pay an increase of 20 – 30 % for classical encryption, they are reluctant to pay almost double for QKD encryption. The main difficulty is how to define the additional value of quantum key distribution over classical encryption and, in this respect, it would help if some certification procedures defined a dedicated security level for what can be achieved with QKD.

Kets Quantum Security is developing two new quantum technologies: an integrated quantum random number generator and an integrated QKD system that allows the transmission of secure pairs of digital keys. Both are based on PIC technology manufactured in standard fabrication processes and have the same high performance as conventional technology (see Fig. 3). Kets has worked out how to miniaturize quantum-safe hardware to a size, form-factor, and at a price-point that makes it of interest to industry, including telecoms, data centers, and defense and space. Kets's quantum random number demo kit was ready in January 2020 and a QKD demo kit will be available by the end of 2021. They have delivered two QKD proof-of-concept projects: a QKD transmitter for Airbus, and the other with BT as part of the TIP Ecosystem Acceleration Centers project designed to accelerate success for start-ups in the telecoms market. Kets has recently opened their first overseas office, in Paris, that will enable them to work within the Paris-QCI project that will roll out one of the first national testbeds within the larger QCI project across the Paris region over the next two years.

QuantLR is positioned at the forefront of the worldwide mass deployment of quantum cryptography (QKD) by providing the world's lowest-cost secure quantum cryptography solution and implementing this unique and advanced technology on fiber-optic communication infrastructure on a global scale. It achieves this by using off-the-shelf components and is the ultimate level of security against any attack – whether such attacks use current solutions or future quantum-based computer technology. QuantLR is taking off, quite literally: the company is an official research partner of a mission to the International Space Station aboard a SpaceX Crew Dragon spacecraft later this year, where experimentation of quantum encryption capabilities from optical communications between Earth and the International Space Station will take place.

Quandela has been working on the commercialization of efficient generators of optical qubits based on III-V semiconductors, which enclose nano emitters in photonic cavities. These emitters form a new generation of enabling technologies for the distribution of keys and the entanglement distribution via fiber links or free-space links. A major challenge they had to overcome is to integrate these devices into a compact, energy-efficient cryostat such that they can be installed in any facility.

Quside specializes in quantum random number generation and has produced a commercialized and customer-proven randomness module, the FMC 400. This randomness module generates quantum-derived random numbers at entropy bounds above 90 % at 400 Mb/s. Randomness is based on their proprietary phase-diffusion quantum technology, and this device can be installed in any hardware technology that requires secure communication. It has been designed with an interface that allows smooth integration with existing devices and, for those customers who cannot integrate in a plug-and-play way, there are prototyping kits available with other interfaces. The FMC 400 is the fastest way to secure data and accelerate randomized workloads. The module is also non-deterministic and allows for cryptographic agility.

Excelitas Technologies provides extensive photonic manufacturing, design and integration expertise to leading OEMs worldwide. Within their expanding portfolio of light sources, optics, optronics, sensors and detectors, Excelitas provides a variety of high-performance APDs and pulsed laser diodes that are ideally suited for quantum applications. They were the pioneers of SPCM (single-photon counting module) technology with their introduction of the first SPCMs to the market in 1987. Their latest SPCM models feature high PDE at 800 nm and have been used in space for QKD as well as for metrology applications.

Conclusion

This brief review of some of the companies working in QKD illustrates the wide range of technologies that will be required to make QKD a reality. While this is good news for the European photonics industry, it is important to bear in mind that things are still very much at a testing stage and several challenges such as cost, integration with existing devices and the need for standardization and certification remain to be overcome. This article is based on a highly interesting technology and business development meeting organized by EPIC on 11 November 2020, and that is available on YouTube: EPIC Online Technology Meeting on Quantum Communication & Quantum Key Distribution*).

[1] Alarming Cybersecurity Stats: What You Need To Know For 2021 (forbes.com)

[2] Global Quantum Key Distribution Qkd Market – Industry Reports (industryresearch.biz)

[3] Quantum Key Distribution (QKD) Market to reach US$ 1.1 Bn by 2030 (transparencymarketresearch.com)

***) epic-assoc.com/epic-online-technology-meeting-on-quantum-communication-quantum-key-distribution**

Author

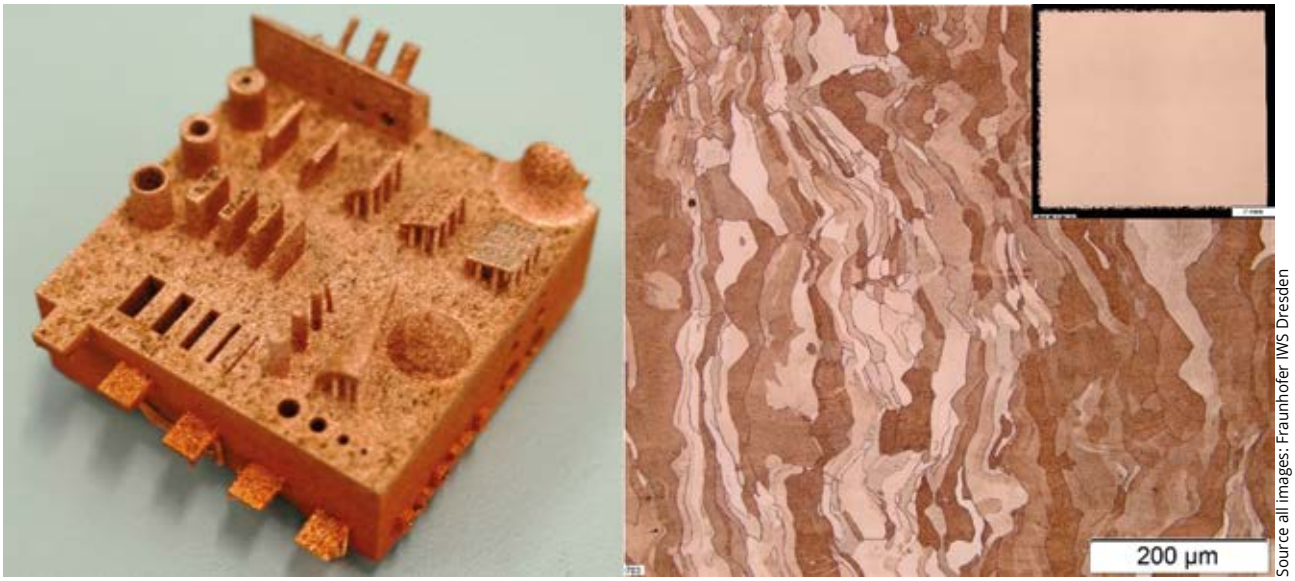
Sana Amairi Pyka is an experimental physicist, specialized in quantum- optical metrology and a project leader at the European Photonics Industry Consortium (EPIC). She works mainly on innovations in optical manufacturing technologies and the quantum photonics industry. Among her responsibilities are the dissemination and communication of the Horizon 2020-funded European PHABULOuS project, the new pilot-line providing highly advanced and robust manufacturing technology for optical free-form and microstructures.

Dr. Sana Amairi Pyka, EPIC – European Photonics Industry Consortium, Rue Hamelin 17, Paris, France; e-mail: sana.pyka@epic-assoc.com, Web: www.epic-assoc.com Sana Pyka EPIC sanapyka

Laser processing: solutions for industry

Comprehensive preview to Laser Symposium and the 4th International Symposium for Additive Manufacturing (ISAM), 2021

C. Leyens, J. Standfuß, A. Wetzig, F. Brückner, M. Barbosa, J. Hauptmann, E. Lopez, M. Seifert, D. Dittrich, P. Herwig, H. Hillig, L. Stepien, S. Gruber



Source all images: Fraunhofer IWS Dresden

Over at least the last four decades, laser-based processes have matured from niche applications to widely accepted tools in industrial processing chains. Starting with CO_2 lasers, the development of new laser sources such as fiber and disk lasers, either continuous-wave or pulsed, have boosted the use of lasers for cutting, joining, surface modification and heat treatment, coating and – more recently – additive manufacturing, to name just a few applications.

Today, laser sources ranging from a few watts to multi-kW in power provide manufacturing solutions for a wide spectrum of applications in many sectors: automotive, transportation, aviation and space, energy, tools and dies, oil and gas, medical, etc. Based on high technical maturity levels and proven economic benefits in modern production, scientists and engineers are nevertheless constantly pushing the envelope to open up new horizons in laser processing. This article highlights examples of the latest achievements, trends, and new fields of application.

Dynamic beam shaping for high-performance laser welding

Dynamic beam shaping eases the welding of crack prone materials and opens up new fields of application, e.g. in e-mobility. Newly developed, piezo-driven actuators are replacing the established galvanometric-driven 2D scanner optics. Allowing beam manipulation in all three spatial directions, these new actuators provide extensive, multiparameter processing matrices. While in-depth process understanding is already required for 2D scanning, it becomes even more essential if new laser systems such as coherent beam combining (cf. p. 40) with high intensity beam modulation are used for welding.

A newly-developed X-ray tomoscopy (time-resolved tomography, [1]) setup was used (Fig. 3) to investigate the interaction between laser beam and melt pool during welding. High-speed X-ray imaging shows the effect of stepwise degassing by the oscillating keyhole at high scanning frequencies, Fig. 2. The results indicate a stabilizing effect of beam shaping during the welding of aluminum die cast material [2]. Furthermore 2D-beam shaping has an influence on the melt pool movement and the formation of seam defects. Current research is focused on the fundamental understanding of the interaction between seam quality and processing-related melt pool characteristics [3]. Correlating defect formation with melt flow has great relevance for industrial applications.

▲**Fig. 1** Pure copper benchmark geometry (left), microsection of 99.98 % dense sample (right), microstructure of LPBF pure copper (inset top right)

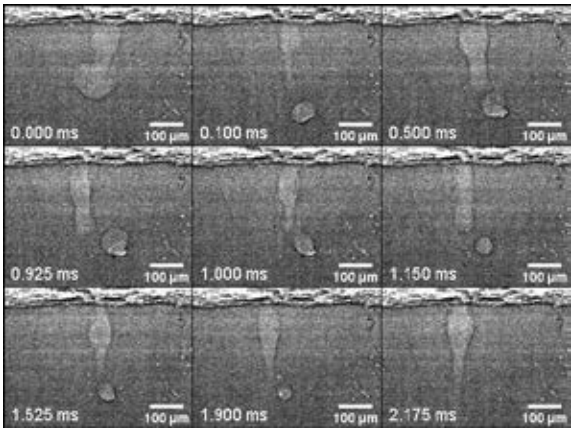


Fig. 2 X-ray imaging of formation and degassing of a gas volume inside the melt pool by dynamic beam shaping in AlMg3 during laser welding.

High-speed laser cutting

The availability of single mode fiber lasers with power levels of 5 kW and beyond enables high cutting speeds of thin metals in general. Since, in the case of contour cutting of 2D and 3D parts, the machine kinematics and dynamics are typically the limiting factors, high cutting speeds can only be achieved for linear cutting. Here, the objective is to replace the mechanical shear cutting of band material by fast laser slitting. The advantages of laser slitting are obvious: no tool wear, no tooling time, and technological advantages both for high strength steel and for 'soft' metals like aluminum and copper. A cutting speed of at least 200 m/min must be achieved for economic processing of electrical steel. After evaluation of the process window (i.e. laser power, focal position, nozzle stand-off, and gas pressure) the results were transformed to a pilot slitting line machine equipped with a 2 kW single-mode fiber laser. As a result, 1 km of electrical steel with a thickness of 270 µm was successfully cut at a feed rate of 200 m/min. In advanced process studies, we have cut grain-oriented electrical sheets, 230 µm thick, at speeds of up to 500 m/min in series quality by means of a 5 kW single-mode fiber laser. The cutting quality is shown in Fig. 4 for 300 µm thick electrical steel for different optical setups and power levels. Notably, the burr on the underside of the sheet could be completely avoided.

Laser for ammunition disposal and dismantling

Introduced in 1978, laser cutting is considered a well-established process in the ammunition disposal industry. The unique features of lasers as a tool ('ever sharp', force and contact free, excellent controllability, highest known intensity and scalability) make them attractive for use in special applications. For example, Fraunhofer IWS has used lasers to dismantle ammunition (Fig. 5) and nuclear power plants. With ammunition it is necessary to separate the metal and chemical components. The hermetic metal cover has to be opened to remove the chemical core. Obviously, activation of the chemical material has to be prevented to avoid life-threatening explosions. The controllability of laser parameters, the potential to work under water and the capability of remote control predestine the laser as the perfect tool for this task. The remote control and the other USPs also make it interesting for dismantling nuclear power plants. Compared with the currently-used plasma cutting, the volume of molten material using a laser is reduced to one tenth, which reduces the nuclear contaminated dust to one tenth as well. The latest investigations have demonstrated reliable separation of thick concrete blocks to defined debris, which can then be handled for intermediate and end storage. The same laser setup is used here as for metal cutting, but in a new process regime.

Laser structuring for the improvement of grain-oriented silicon steel

Laser treatment of grain-oriented silicon steel has already been used to improve its magnetic properties since

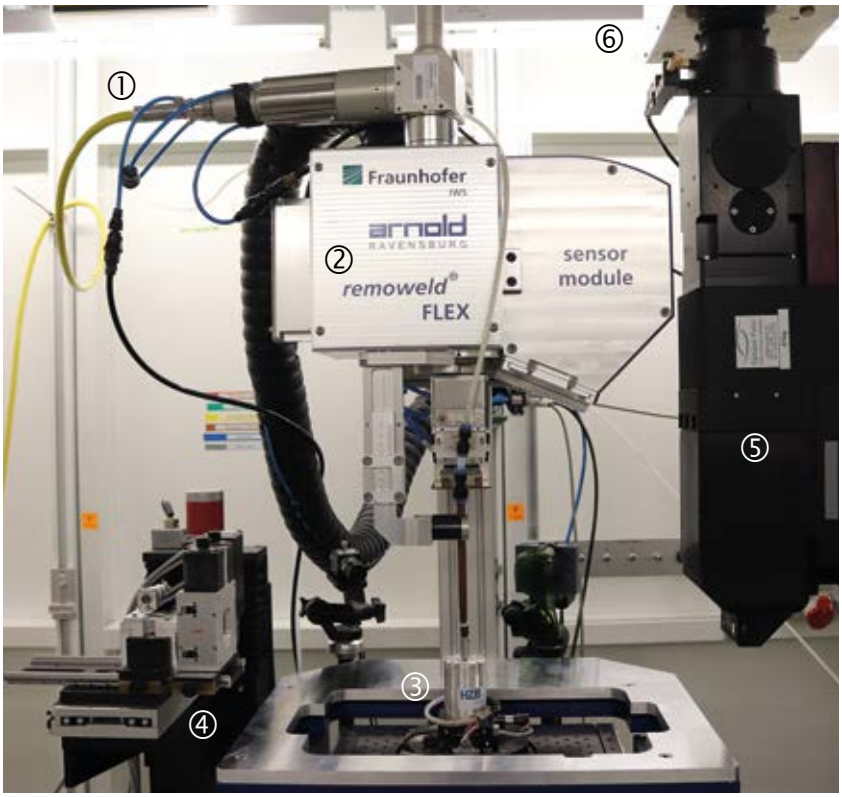


Fig. 3 Experimental setup with laser light cable (1), modular welding head with collimation, focusing unit and integrated x-y scanner (2), rotation stage with sample holder (3), slits/shutter (4), high-resolution microscope, (5) and Gigafrost camera (6).

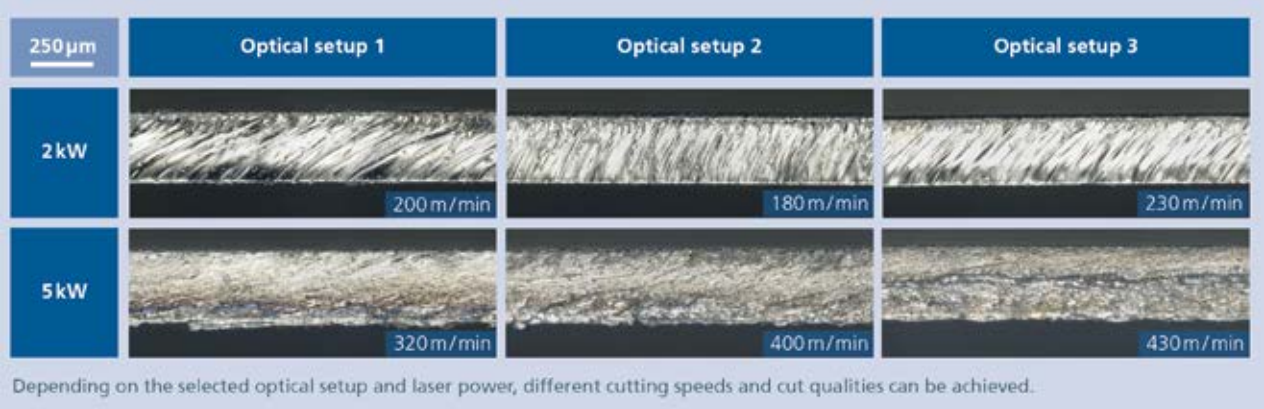


Fig. 4 Cutting quality of different optical and power settings

the late 1980s. However, new demands require a heat resistant or permanent structuring. Grooves with a depth of some ten micrometers and as narrow as possible create the required refinement of the magnetic domains. The combination of laser remote processing, domain refinement and systems engineering knowledge enable the technology development and equipment design of an efficient, high throughput process.

Highly brilliant laser radiation, a specific focusing setup and an in-house developed arrangement of scanner-based deflection elements is used for the removal of the silicon steel to create the required grooves. With the exception of material handling (moving table instead of continuous coil feed), the equipment mimics real production conditions. Grooves with a depth of 20 µm can be scribed at up to 50 m/s scanning speed. The synchronization of multiple laser beams enables upscaling and the provision of relevant production capacities.

The test system is not limited in the laser domain refinement (Fig. 6). Surface removal, large area heat treatment and further high performance processes are already applied using various laser sources and can be provided upon customer request.

Additive manufacturing of pure copper

Creating sophisticated parts with AM is no longer an exotic technique. It has already become established in various industries and even in consumer applications. This is, however, not yet true for copper parts. As a key-material for thermal applications and electrical engineering, copper is an important element for countless components and has contributed significantly to the fast technological evolution of the last two hundred years. AM of pure copper parts in particular is challenging due to its low absorption of the typically used infrared laser radiation. Even if using copper alloys helps to solve this issue, the inherent electrical and thermal properties of the material are then dramatically reduced by the alloying elements. Based on new developments in laser sources as well as in AM technologies, Fraunhofer IWS has succeeded in manufacturing pure copper parts using two different laser-based AM processes, each providing specific benefits:

Laser powder bed fusion (LPBF)

High resolution, complex shaped parts with functional integrations such as inner cooling channels can be manufactured using the well-known LPBF technology. The cooling channels have huge potential for efficient heat exchangers made of pure copper. Increasing the laser power is one option to enable selective melting of the powder to overcome the poor absorption of the typically used infrared laser sources. However, this shows specific disadvantages, such as low overall efficiency, balling due to high energy input and possible damage of the optics system due to the large backscat-

Institute

Fraunhofer IWS Dresden

The Fraunhofer Institute for Material and Beam Technology IWS develops complex system solutions in materials and laser technology. We define ourselves as idea drivers developing customized solutions based on laser applications, functionalized surfaces as well as material and process innovations – from easy-to-integrate custom solutions to cost-efficient solutions for small and medium-sized enterprises to industry-ready, one-stop solutions. Our research focuses on the aerospace, energy and environmental technology, automotive, medical and mechanical engineering, toolmaking, electrical engineering and microelectronics, and photonics and optics sectors.

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Fig. 5 Opening a bazooka missile.

Fig. 6 Laser domain refinement test system

ter of laser light. Switching to a green laser source with a wavelength of 515 nm and 280 % higher absorption results in overall better efficiency. Furthermore, this leads to fully dense parts (99.95 % relative density) with exceptionally good electrical conductivity (> 100 % IACS, International Annealed Copper Standard).

Laser metal deposition (LMD)

LMD has been a well-established technology for the coating and repair of metal components for more than a decade. Pure dense copper parts on substrates as well as complex semi-finished products could be built using a 1 kW green laser source and specialized processing heads. In contrast to powder bed-based additive manufacturing, LMD enables hybrid manufacturing (additive, subtractive) approaches and multi-material processes in new dimensions. Various powders can be applied, exchanged and mixed up in situ to achieve multimaterial components with locally adjusted material properties. This approach was recently applied to significantly increase the performance of mold inserts by the local implementation of copper features, and achieve reduced cycle times.

High-power laser cladding

Laser cladding is widely used in industry to precisely apply tailored surface coatings and three-dimensional deposits for the repair and additive manufacturing of metallic parts. However, the processing of larger components, such as tools for oil and gas production, for the paper industry or for agriculture, is economically challenging due to the typically low deposition rates. Modern, high-power diode lasers offer practical solutions here for large-area laser cladding or additive manufacturing with significantly increased productivity.

At the IWS, a Laserline fiber-coupled diode laser of 20 kW power has been employed for over a decade to develop competitive coating solutions. The deposition rates achieved with this technology equal or even exceed typical values of the common PTA technique while bringing significant advantages at the same time, such as a reduced heat affected zone, low distortion, and savings in material resources. Several coaxial powder nozzles have been designed over the years to address different industrial challenges, e.g. using an annular gap or several powder streams, generating a round spot or a rectangular spot, with a track width from 30 µm up to 45 mm.

The cost of the feedstock material plays a crucial role in an optimized laser cladding coating process, once the initial investment in the equipment has been amortized. This effect can be counteracted by increasing the deposition efficiency to its maximum, by using less expensive feedstock materials (€/kg) or ideally both.

While high-power, powder-based laser cladding is an industrially established coating technology, no high-productivity solution is known for wire-based processes. Fraunhofer IWS, with the intention to close this gap and explore the growing advantages of using wire as feedstock material, has developed a new nozzle for high-power, high-productivity laser wire cladding for coating and additive manufacturing. The COAX-quattro feeds four wires at the same time into the melt pool, reaching deposition efficiencies in the same range as a powder-based process of the same material. Moreover, the feeding of wires of different compositions is possible, as well as the simultaneous addition of powder particles. This opens new possibilities for in-situ alloying and the cost-effective

Fig. 7 LMD with a green laser to build up multimaterial mold inserts (pure Cu / steel 1.2764).

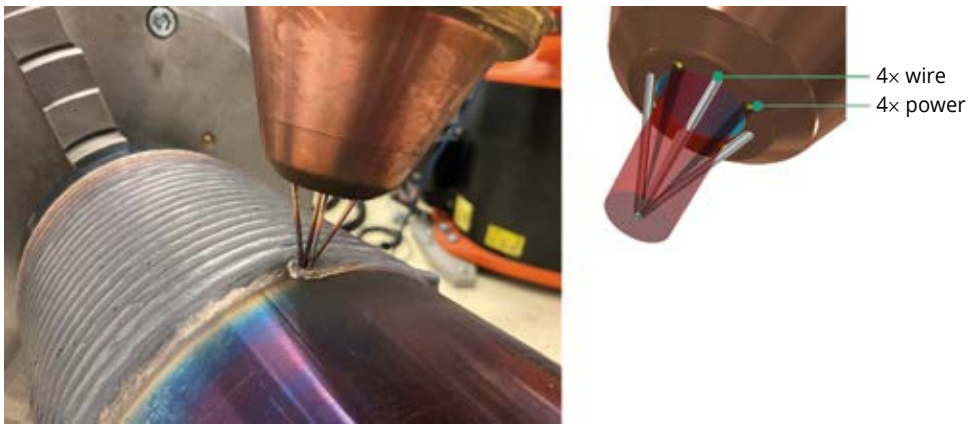

Fig. 8 High powder laser wire cladding with COAXquattro can be used for the resource efficient coating of several components. On the left a detail of a process interruption upon coating of a shaft. In addition to feeding four wires at the same time, the nozzle can also process powder simultaneously or independently (detail of the nozzle tip on the right)

Fig. 9 Demonstrator with complex surface geometry, laser hardened with a TFC system from left to right in one continuous track, track width 45 mm (left); 3D drawing of the new TFC laser head (right).

production of new hard metal compositions for coating and additive manufacturing. Compared to powder-based processes, the use of wires as feedstock material has the advantage of having a lower feedstock price (about one third to one half of powder €/kg) combined with 100 percent deposition efficiency. The process is therefore cleaner and, at the same time, fewer preventive measures are needed for the handling and storage of the material.

Laser hardening with temperature field control

Laser hardening has established itself as a common hardening method in industries such as energy conversion (steam turbines), automotive (car body tools and dies, engine components) and machine manufacturing. Compared to hardening technologies using conventional heat sources such as furnaces, gas burners or induction coils, the laser is a very precise tool for efficient and localized surface hardening with minimal energy consumption. The resulting low distortion of hardened parts reduces the cost and effort of finishing operations and offers great potential to shorten the process chain. By using the self-quenching effect, the laser hardening process is contact-free, clean, and easy to integrate into production lines. The high quality of the hardness zones is ensured by automatic control of the hardening temperature through thermal imaging systems or pyrometers.

There are still limitations when machining extremely complex part geometries. The laser intensity field must be matched to the local heat flow conditions in order to produce the correct hardening temperature and laser interaction time at each location on the heated surface. This can only be achieved by using dynamic beam shaping systems, because fixed, lens-based optical systems only deliver a fixed intensity distribution. It is particularly difficult if the shape of the cross section changes during the process and the part heats up. A potential technical solution has been developed by Fraunhofer IWS: an advanced laser processing system called Temperature Field Control (TFC) that enables uniform heat treatment by combining laser scanning technology, temperature measurement with a thermal camera ("E-MAqS") and a high-speed pyrometer ("E-FAqS"), and multiparameter control. During the laser process, the laser scanning function is adapted and the laser power adjusted in real time to keep the temperature field constant at the optimum level. A controller cycle time down to 50 microseconds is necessary to compensate for the typical temperature deviations. More than ten controller modules work simultaneously to guarantee a good homogeneity of the temperature field. The TFC system enables the production of parts in a new, energy-saving way and using a lean production chain.

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Authors

Christoph Leyens studied physical metallurgy and materials technology at RWTH Aachen, Germany, where he earned his diploma in 1993 and his PhD in 1997. He is currently a full professor for materials science and engineering at TU Dresden, Germany, and director of Fraunhofer IWS, Dresden. With a focus on high temperature and lightweight materials as well as surface and laser technologies, he covers a wide range of research topics.

Further authors:
Jens Standfuß, Andreas Wetzig, Frank Brückner, Maria Barbosa, Jan Hauptmann, Elena Lopez, Marko Seifert, Dirk Dittrich, Patrick Herwig, Holger Hillig, Lukas Stepien, Samira Gruber (all: Fraunhofer IWS)

Prof. Dr.-Ing. Christoph Leyens, Fraunhofer Institute for Material and Beam Technology IWS, Winterbergstr. 28, 01277 Dresden, Germany; e-mail: christoph.leyens@iws.fraunhofer.de, Web: www.iws.fraunhofer.de

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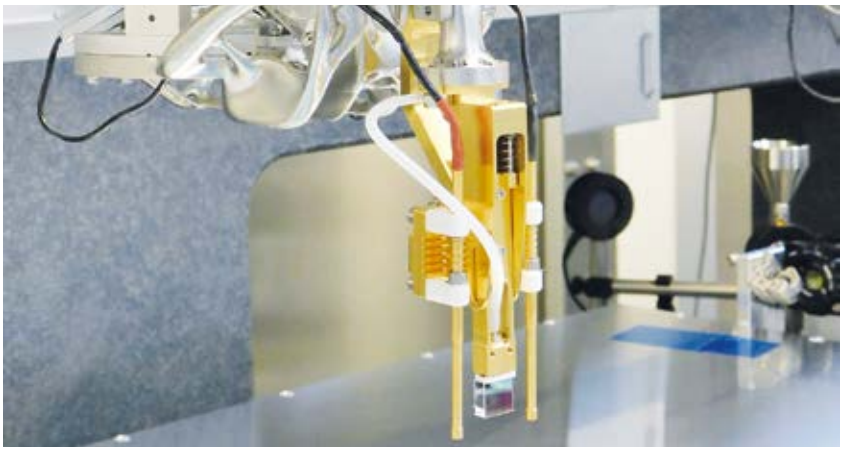
DRESDEN concept

Assemble optical systems with maximum precision

Precision gripper arm made of metal powder using laser powder bed fusion process



The gripper arm consists of a static and a moving part (Source: Fh. ILT)

Vibration tests and climate chambers – these are typical stations used to qualify a laser system for use in space. Despite undergoing the highest loads, the laser systems must remain adjusted with micrometer precision in order to work safely in space.

The experts at Fraunhofer ILT work together with partners such as DLR, Airbus Defence and Space, Tesat Spacecom and Esa to build the optical systems with state-of-the-art technologies. All essential alignment steps are performed with manually guided robots using the 'pick and align' process. A central tool is the gripper arm; it sits on a hexapod and positions the components in the optical assembly with micrometer precision. There they are adjusted to within a few micro-radians and fixed in place by soldering. The design of the gripper arm is decisive for the precision of the assembly and also determines how heavy the optical components can be.

To further improve how well the setup technology performs, Fraunhofer ILT developed a completely new gripper arm. Based on its construction design, colleagues in the professorial group for digital additive production DAP at RWTH Aachen University also dimensioned the bionic structures in such a way that its payload could be increased while having lower dead weight. The topology-optimized gripper arm was finally manufactured via laser powder bed fusion, also at the DAP. Thanks to special post-processing, the gripper arm achieves clean room class ISO5.

This is an absolute novelty – until now, residual powder on the components prevented the use of additive methods for such precision tools in the clean room. The new gripper arm is divided into two parts with a static and a moving part. Supply lines for the required media are integrated into the gripper arm to minimize contamination.

This precision tool can move significantly heavier parts than the previously used tool, while at the same time enabling more stable adjustment. "We are taking a totally new path with this technology. We don't first design the component and then check whether it has the desired properties; instead, we optimize the component geometry for the load scenarios," says Michael Janßen, who has been designing assembly grippers for years, describing the procedure.

The new gripper will be used within the framework of FULAS – a universal technology platform developed by the Aachen researchers to construct laser systems for aerospace projects.

www.ilt.fraunhofer.de

Metal AM at the service of watchmaking

Innovative partnership between Kif Parechoc and AddUp

Kif Parechoc, an expert in watch movement components, has signed a highly innovative partnership agreement with AddUp, a French specialist in industrial metal 3D printing, to use metal additive manufacturing (AM) for very high precision watchmaking purposes.

The workshop (Source: Kif Parechoc)

Located in the Vallée de Joux, one of the cradles of Swiss watchmaking, Kif Parechoc has specialist knowledge of mechanical watch components. The company, a subsidiary of the Acrotec group, supplies shock absorbing systems, ratchets and barrels for famous names in the Swiss and European watchmaking industry. Always looking for innovation, French specialist in metal AM, AddUp, a Michelin and Fives joint-venture, designs and manufactures machines in its own workshops for the production of parts.

The first project resulting from this collaboration is a watch clasp. "For this project, we started with a classic product but integrated new aspects, such as lattice structures, organic shapes and recessed markings," explains Yoann Canon, industrial director of Kif Parechoc. "We are now working on the development of new post-treatment processes, adapted to the requirements of our industry and our production volumes. Between AddUp's mastery of the printing process and our knowledge of the products or their industrialization and our finishing operations, our companies complement each other well."

The watch clasp is made of low carbon 316L stainless steel. "This material, commonly used in watchmaking, is known for its good mechanical properties as well as its high resistance to corrosion,

two essential elements in the making of a watch, comments Dr Maria Averyanova, who is in charge of luxury market development at AddUp. From an aesthetic point of view, 316L steel does not lose its shine or tarnish over time, and it has the added advantage of being fully recyclable."

Kif Parechoc partnered with AddUp to utilize laser powder bed fusion (L-PBF) technology to manufacture the watch clasp. This technology has many advantages: savings in raw materials, geometric complexity, and improved part performance (better heat exchange, for example). In the case of watch parts, Kif Parechoc will be able to take advantage of the ability to print several parts in a single operation, reducing assembly operations. "On the watch clasp, we have reduced the number of components to be assembled by a factor of two compared to equivalent products made using conventional techniques," says Canon.

The work currently being carried out by the two partners could be of interest in the long term. Indeed, even if metallic 3D printing has developed strongly in recent years, it is still most often used for the manufacture of 'classic' mechanical parts in terms of dimensions. Industrialists in the micromechanics sector have been hesitant to adopt metal 3D printing for precision parts and surface finish.

This partnership could pave the way to new applications of metal additive manufacturing in the watch industry and more generally in the entire microtechnology and micromechanics industry.

https://addupsolutions.com
https://kif-parechoc.ch

3D-printing microscopic gas sensors

A new way to fabricate tiny color-changing gas sensors using direct laser writing

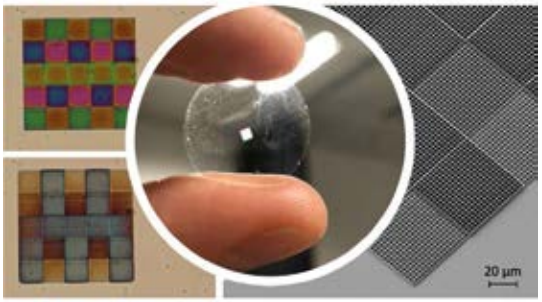
Scientists from Trinity College Dublin and AMBER, the SFI Research Centre for Advanced Materials and BioEngineering Research, have discovered a way to fabricate tiny color-changing gas sensors using new materials and a high-resolution form of 3D printing. The sensors – responsive, printed, microscopic optical structures – can be monitored in real-time, and used for the detection of solvent vapours in air. There is great potential for these sensors to be used in connected, low-cost devices for homes, or integrated in wearable devices used to monitor human health.

The work was led by Larisa Florea, assistant professor in Trinity's School of Chemistry, and Principal Investigator at AMBER, in collaboration with Louise Bradley, Professor in Trinity's School of Physics, and carried out in CRANN, the Trinity Centre for Research on Adaptive Nanostructures and Nanodevices. An industrial collaborator and leader in the field of gas sensing, Radislav Potyrailo from GE Research, Niskayuna New York, has also been involved throughout. Colm Delaney said: "More than 300 years ago, Robert Hooke first investigated the vibrant colors on a peacock's wing. Only centuries later did scientists discover that the effervescent coloration was caused not by traditional pigments but by the interaction of light with tiny objects on the feather, objects which were just a few millionths of a meter in size."

"We have taken this biological design, seen all the way from a magpie to a chameleon, to make some really exciting materials. We achieve this by using a technique known as direct laser-writing (DLW), which allows us to focus a laser into an extremely small spot, and to then use it to make tiny structures in three dimensions from the soft polymers which we develop in the lab", Delaney added. Louise Bradley, a funded investigator at AMBER, said: "The research we carry out between the two groups focuses on design, modeling, and fabrication of these tiny structures in stimuli-responsive materials. Jing Qian, a fantastic PhD student in my lab, has spent a lot of time developing designs, and predicting the response of different structures, which we can have respond to light, heat, and humidity to create systems which can truly recreate the vividness, stealth response, and camouflaging ability found in nature. The tiny responsive arrays, which are smaller than a freckle, can be used to tell us an enormous amount about the chemistry of their environment."

While traditional physical sensors have bolstered a connected-living market, there is a lag in low-cost, adaptable chemical-sensing platforms that can be used. Photonic sensors have made considerable inroads into yielding accurate and robust alternatives, with minimal power consumption, low operating costs and high sensitivity. Larisa Florea, from Trinity's School of Chemistry and AMBER, said: "We have created responsive, printed, microscopic optical structures that can be monitored in real time and used for the detection of gases. The ability to print such an optically responsive material has profound potential for its incorporation into connected, low-cost sensing devices for homes, or into wearable devices for monitoring analytes."

"We spend the majority of our lives inside our homes, cars, or work environments. Models suggest that the concentration of pollutants can be anywhere from 5 – 100× the concentration found outside. This is a haunting thought when we consider that the World Health Organisation suggests 90 % of the world's population lives in areas that exceed acceptable air standard limits. To date, indoor gas sensors have focused almost solely on leak, smoke, and carbon dioxide detection. Even iterative advances could play an enormous role in the development of a domestic environmental monitoring ecosystem.", Florea added. (Source: Trinity Col.)



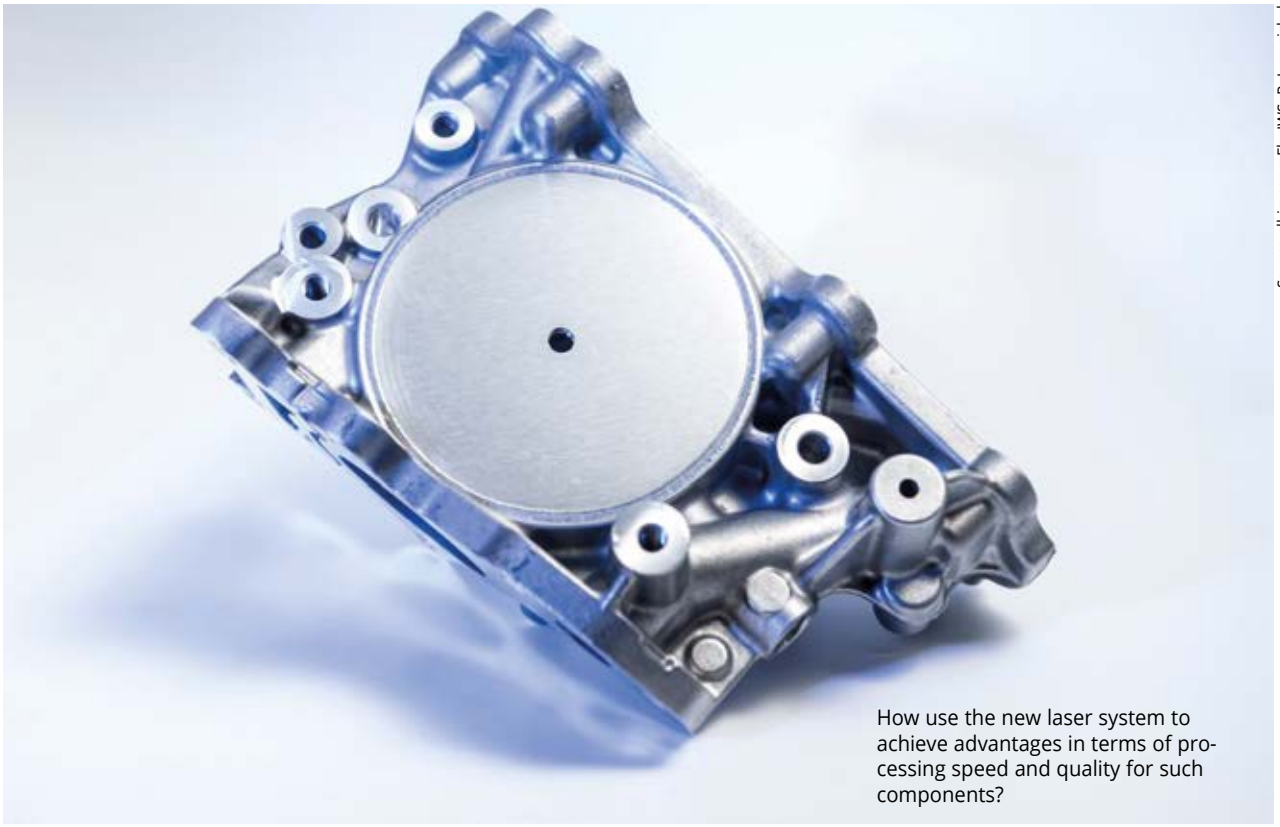
3D-printed microscopic gas sensor: the glass substrate showing the colorful 3D printed sensor. Zoomed-in optical microscopy images (l.) showing the pixelated sensor in response to different vapors. Scanning electron microscopy image (r.) of the pixelated sensor. (Source: Florea, Trinity Col. / AMBER)

Reference: *C. Delanay* et al.: Direct laser writing of vapour-responsive photonic arrays, J. Mater. Chem. C **9**, 11674 (2021); DOI: 10.1039/d1tc01796a

http://ambercentre.ie

Flexible fiber laser for rapid material processing

Coherent beam combining can generate different energy distribution patterns particularly quickly during operation



How use the new laser system to achieve advantages in terms of processing speed and quality for such components?

Source all images: Fh. IWS, R. Jungnickel

Laser experts from Saxony and Israel are jointly testing a novel laser for industrial use at the Fraunhofer Institute for Material and Beam Technology IWS in Dresden. The system is based on the coherent beam combining (CBC) method, which is still new for high-power lasers.

The 13-kilowatt laser can generate different energy distribution patterns particularly quickly during operation and thus process even demanding high-tech materials very precisely and quickly. The Fraunhofer researchers intend to make the innovative laser technology from Israel available to companies worldwide in the near future. Within a European network project, Fraunhofer IWS is already investigating the beam shaping, which is accelerated by a thousand times, for the first time for additive manufacturing together with the laser manufacturer Civan Lasers and A. Kotliar Laser Welding Solutions.

The 'Dynamic Beam' laser from Israel has by now been installed at Fraunhofer IWS in Dresden. The institute is thus the first research facility worldwide to employ such a laser solution. Together with the project partner Civan Lasers from Jerusalem, the scientists hope that the testing in Saxony will provide new application scenarios. "This laser will push the limits of materials processing,

Company

Civan Lasers

Civan Advanced Technologies Ltd was established in 2008 and is the only company to offer Dynamic Beam Lasers. They allow manufacturers to control beam shape, frequency, sequence, and focus steering to eliminate spatter, increase welding power and speed. Through their advanced capabilities, Dynamic Beam Lasers open the door to countless new applications.

www.civanlasers.com

Thanks to CBC, the 13-kW laser can generate energy distribution patterns thousands of times faster, allowing dynamic beam shaping for additive manufacturing of metals for the first time.

The Dynamic Beam laser from Jerusalem has now been installed at Fraunhofer IWS in Dresden. The institute is thus the first research institution worldwide to utilize such a laser system.

for example in medical technology and aerospace," predicts Dr Andreas Wetzig, who heads the Cutting and Joining technology field at Fraunhofer IWS. He refers to the Saxon-Israeli research project 'ShapeAM', started in July 2021 within the European network program 'M-era.Net', in which this new laser will play a central role.

'Dynamic Beam' doubles working speed

In use is coherent beam combining, in which the Dynamic Beam Laser from Civan Lasers combines tens of individual beams into a powerful laser beam with high quality. Through small phase shifts (optical phased array = OPA) of the wave troughs and peaks in the partial beams, the laser can quickly generate completely different energy distribution patterns in the resulting processing laser beam: While a classic laser releases most of its energy only in the center of the beam, the system from Israel can generate energy patterns on the workpieces for instance in the form of a ring, a figure eight or a horseshoe. In principle, this was already possible in the past with beam-deflecting optics or fast oscillating mirrors. But even the fastest oscillating mirrors still need milliseconds to realign the energy patterns in the beam. The Dynamic Beam Laser, on the other hand, accomplishes this a thousand times faster, within microseconds.

This speed makes it possible for the first time to use dynamic beam shaping for additive manufacturing of metals. As part of 'ShapeAM', researchers are testing the new Civan system to achieve improved material properties. Specifically, the aim is the additive manufacturing of titanium and aluminum alloys, such as those needed for space components, implants and lightweight components for mobility. In doing so, the partners plan to use dynamic beam shaping to eliminate defects and thus achieve higher quality 3D printing results. Dr Eyal Shekel, CEO of Civan, is excited about the project: "ShapeAM makes it possible for us to explore the benefits of dynamic beam shaping in metal additive manufacturing." Dr Elena Lopez, department head of additive manufacturing at the IWS, adds: "We plan to use novel beam shapes and control frequencies that are not achievable with other methods to overcome challenges in crack-sensitive materials."

The joint project is expected to develop into a fruitful scientific and personnel exchange between Israel and Saxony: Fraunhofer IWS will forward the test results to Jerusalem. Also, it is planned to temporarily send exchange scientists to Israel. In return, the Civan experts are expected to conduct their own tests in the Dresden laboratory.

The tests at the institute are intended to determine the possibilities and limits of the Dynamic Beam Laser. Basic tests with various beam profiles, materials and processes are initially planned. After that, the researchers will evaluate concrete applications, such as how well the system can cut, join or additively manufacture diverse workpieces from materials and material composites that are otherwise difficult to process.

It is already predictable that the new laser will allow faster and more precise control of the melt pool dynamics in many additive and joining processes – and not only across the surface, but also in depth. Fraunhofer IWS also expects advantages in laser cutting in terms of burr-free cuts with high edge quality – at twice the working speed compared to conventional fiber lasers.

The test phase in Dresden will show whether the new laser will also meet these expectations in practice. In any case, the quality and speed advantages that are already becoming apparent make the technology highly interesting for use in metal-working industry, medical technology and electromobility, as well as in aerospace industry.

Online webinar and conference offer insights into first results

In a webinar on September 14, 2021, Fraunhofer IWS has presented the Dynamic Beam Laser to partners from industry and research who are interested in the project*).

It will subsequently be possible to test the use of the CBC fiber laser for their own applications at Fraunhofer IWS. First findings from their test series the Fraunhofer scientists will present to a broader expert audience at the combined online event Laser Symposium / ISAM 2021 in Dresden from December 7 to 9, 2021.

*) Register for free to watch the recording: bit.ly/3vnYmN3

Dr.-Ing. Andreas Wetzig
Technology Field Manager Ablation & Cutting

Fraunhofer Institute for Material and Beam Technology IWS

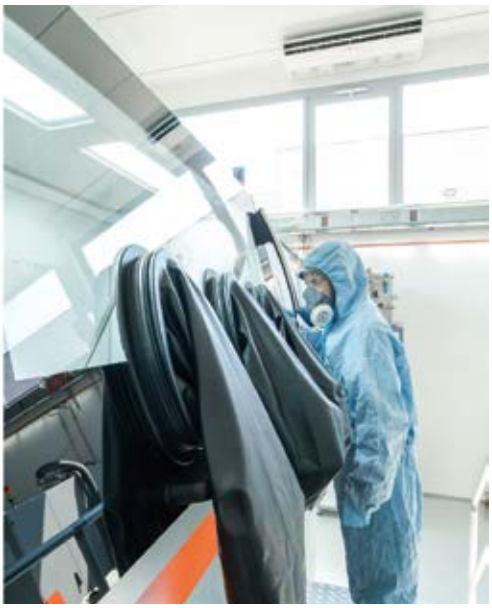
Winterbergstr. 28
01277 Dresden
phone: +49 351 83391-3229
e-mail: andreas.wetzig@iws.fraunhofer.de

www.iws.fraunhofer.de
www.civanlasers.com

Empowering metal additive manufacturing

Laser beam shaping and online process monitoring as promising solutions to the current LPBF challenges

Martina Riccio



Source: BEAMIT

Fig. 1 LPBF production facility of the Beamit Group (Boretto, RE, Italy)

Since metal additive manufacturing, and in particular, the laser powder bed fusion process entered serial production in various highly demanding industries (such as aviation, automotive, medical, and oil & gas), the priority research area of many projects and industrial roadmaps has been to find innovative and efficient solutions to current technology challenges, namely material processability, productivity, and repeatability.

The use of additive manufacturing processes for functional metal component production is increasing greatly in many highly demanding industrial sectors, for example in aerospace, automotive, biomedical and oil & gas. As of now, eighteen different working principles are known with over 140 OEMs supplying machines. However, as shown in the graphs (Fig. 2) provided by [1], with an installed base of several thousand systems, the laser powder bed fusion (LPBF) process is now widespread and used in many applications in production, and has reached the highest maturity index. The single-stage production, the high freedom of design, the good mechanical properties of the resulting parts, their high density and the fine resolution, as well as the availability of different metal alloys are only some of the main strengths that have contributed to the achievement of this maturity level. But among the challenges that the growing usage of these technologies for small batches or series manufacturing entails, there are the material processability and induced residual stresses, productivity, and repeatability.

If the development and implementation of laser beam shaping-based processes can be an interesting technology to investigate for the first two, the development and implementation of online process monitoring systems can be an important element for achieving repeatability and the required quality.

Material processability and productivity challenges in LPBF

In order to overcome LPBF productivity limitations, state-of-the-art technology proposes the use of multilaser systems or lasers with a higher power. Both strategies have some drawbacks: the use of different lasers that work simultaneously on the same building chamber is critical for melting vapor management, thermal management, and laser relative calibration; the price of the LPBF drastically increases with the number of installed lasers; a direct increase in the laser power and scanning speed with the aim of improving productivity results in undesired effects caused by overheating of the molten pool.

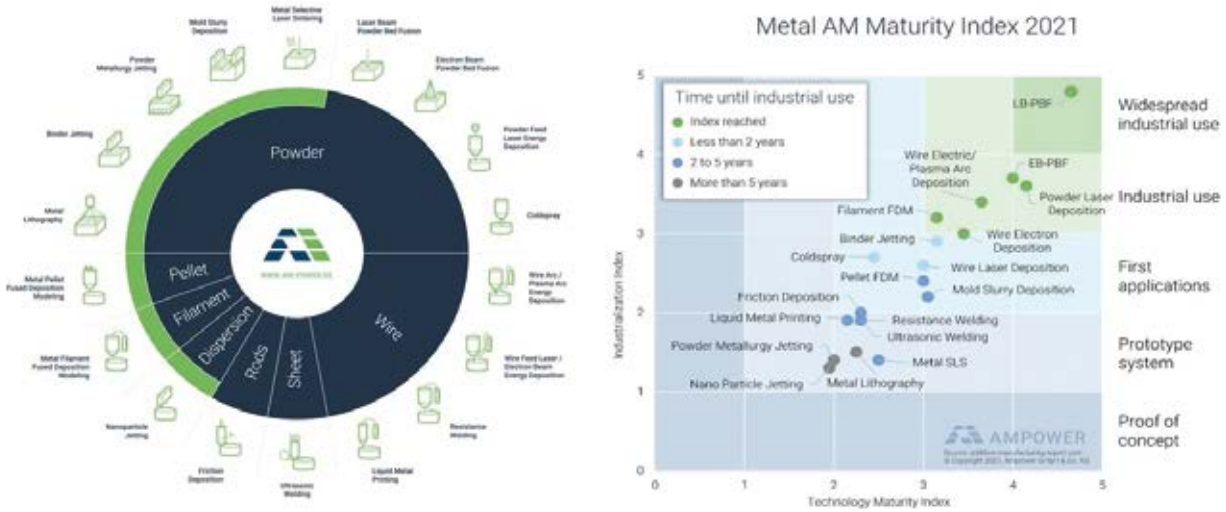


Fig. 2 Technology overview of the Metal Additive Manufacturing and Maturity Index 2021 for metal additive manufacturing (Source: [1])

Indeed, most of the industrial LPBF machines use Gaussian (or TEM_{00}) laser power density distribution which has different negative effects, namely overheating the powder in the center of the molten pool, generating a huge temperature gradient, and the knife-like formation of the molten pool provoking multiple re-melting of previous layers (as noted in [2]), etc. In fact, upon melting, solidification occurs directionally from the fusion boundary. Since the thermal gradients (G) and solidification growth rates (R) experienced with this laser beam distribution are not typically favorable to the nucleation of equiaxed grains (which requires very low G/R), coarse, elongated grains can extend hundreds of microns in the build direction, persisting epitaxially through consecutive layers. This results in anisotropic mechanical properties and can also aggravate solidification cracking in susceptible alloys.

The AMLABS Project

The Additive Manufacturing with Laser Beam Shaping project, AMLABS, was selected among the winners of the 1st TTE (Technology Transfer Experiments) open call made by 'Pulsate'. This 13-month project started in September 2021: Pres-X, an innovative and dynamic Italian company specialized in highly qualified cutting-edge technologies developed and industrialized to make AM processing and post-processing more efficient, cheaper, and green, and Cailabs, a French start-up providing innovative photonics solutions to harness the full potential of optical fibers, enhance space laser communications, and optimize laser material processes, are working together on laser beam shape optimization. They aim to provide a different, smarter, and cheaper solution to the above-mentioned challenges, namely productivity and the material processability of the LPBF process.

The solution envisaged by the project and the TTE refers to the optimization of laser beam spot size and power density distribution that can allow higher productivity and better absorption of energy from the molten pool. Different thermal energy management that can be achieved by shaping the laser beam will provide control of microstructures locally and tailor the mechanical properties of AM parts. In fact, beam shaping has already been proven to greatly improve high-power laser-based processes such as laser beam welding, laser cutting, surface texturing, and also LPBF. For example in [3], the authors demonstrate that elliptical beams result in a modified and improved microstructure for AISI 316L when compared to those obtained using Gaussian (circular) beams (Fig. 3).

A commercial and industrial-sized LPBF machine is used in this experiment and will be equipped with a Canunda HP beam shaping system based on multiplane lights conversion (MPLC) technology. Three different hardware items are in development and will be installed in the machine in order to test the effect of three different beam shapes, namely top hat, donut, and elliptical (Fig. 4), both on material productivity and on processability. The chosen material is a difficult-to-process, nickel-based super alloy that is very interesting for high-temperature applications

Companies

BEAMIT

BEAMIT Group is one of the most integrated and advanced additive manufacturing service providers in the world to serve the most demanding industries. Based in Fornovo di Taro (Parma, Italy), BEAMIT has been operating in the field of AM with metal powders for twenty-four years. With close to sixty dedicated AM systems distributed across seven facilities in Italy and the UK, the Group now counts over 140 employees.

www.beam-it.eu

PRES-X

An innovative company based in Rubiera (Reggio Emilia, Italy), PRES-X is working in the additive manufacturing sector, specialized in highly qualified processes. At PRES-X, a number of cutting-edge technologies are developed and industrialized to make AM processing and post-processing more efficient, cheaper and green, covering all the necessary phases in a single plant through a fully automated digital approach.

www.pres-x.com

Meet us at Formnext, Hall 11.0, Stand C21

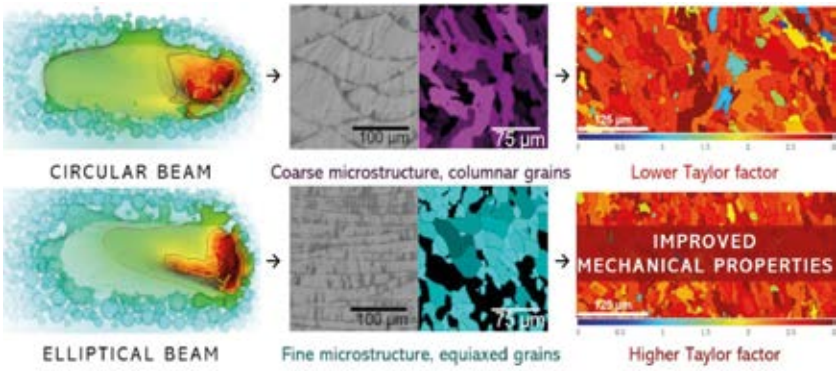


Fig. 3 Example of material processability improvement with elliptical laser beam shape (Source: [3])

mainly in the aerospace, automotive, and power generation sectors. The expected outcome of this experiment is a plug-and-play, machine agnostic solution (hardware + process parameters) that can be easily integrated into existing LPBF machines.

Process Repeatability and Quality Assurance

Metal AM, and in particular LPBF, is entering industrial serial production. Especially in regulated industries such as aviation, medical and oil & gas, the need for internationally accepted standards and proven practices for quality process and product assurance is continuously growing. To meet this demand, different relevant standardization bodies are constantly working on the definition and updating of AM standards (e.g. ISO TC 261, ASTM F42, API20S technical committees), and end-users are also fine-tuning their own technical process specifications.

While on the one hand thorough machine and personnel qualification is the essential foundation for the successful implementation of manufacturing systems in regulated industries, on the other hand, quality controls are fundamental to prove that the components have reached the desired requirements in terms of repeatability, reproducibility, reliability, and precision.

Why is AM process monitoring important?

Despite significant technological advances of metal AM, the defect ratios are still higher than those of more conventional manufacturing processes. Several types of defect can occur in AM processes, ranging from porosities, residual stresses, cracks and delamination to microstructural inhomogeneities and impurities, from surface anomalies to geometrical errors and dimensional accuracy [4, 5].

The many possible sources of defects, combined with the long duration of AM processes, the high cost of metal powders and the high cost and complexity of non-destructive inspections of additively manufactured complex shapes are motivating a rapidly evolving research stream devoted to in-line and in-situ process monitoring. The underlying idea consists of taking advantage of many different sensors that can be installed on AM systems (e.g. photodiodes, high-speed cameras, thermal cameras, acoustic sensors, etc.) to detect anomalies and unstable process states while the part is being produced, measuring relevant quantities, so-called process signatures, layer by layer. This novel capability has the potential to considerably reduce the time and cost devoted to post-process inspections and measurements. It also represents an enabler of scrap and waste reduction, especially if combined with innovative feedback control or in-line corrective actions.

This is why the development of process monitoring methodologies based on in-situ sensing are indicated as a priority research area by many recent keynote studies, projects, and industrial roadmaps [4 – 6]. Nevertheless, there is still a wide gap between several novel solutions investigated in the literature and what is currently available in industry. AM systems, and LPBF machines in particular, are nowadays equipped with various sensors, but there is a lack of intelligent and automated methods suitable to make sense of the huge amount of in-process data and able to detect actual anomalies while at the same time minimizing false alarms.

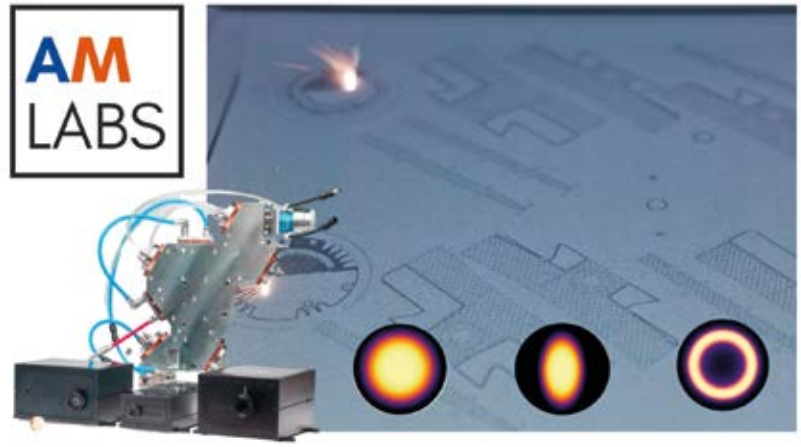


Fig. 4 Pres-X and Cailabs are working together on the AMLABS project (funded by 1st TTE, promoted by Pulsate) and aiming to leverage the use of laser beam shaping in metal AM (Source: Pres-X)

The AMAI Project

The Additive Manufacturing and Artificial Intelligence project, AMAI, aims to fill the aforementioned gap with a novel industrial solution addressing a specific type of non-conformity, i.e., geometrical errors (www.ic.polimi.it/amai). The project is supported by EIT Manufacturing, and co-funded by the European Union within the KAVA2021 program. The project goal is to develop a novel suite of Artificial Intelligence (AI) driven tools suitable for reconstructing the geometry of each solidified layer of the part, exploiting high spatial resolution images acquired on a layer-by-layer basis, and to detect geometrical errors and distortions in a robust and reliable way (Fig. 6).

Although most industrial PBF systems are currently equipped with powder bed cameras that automatically acquire images of the powder bed before and after powder spreading in the layer, there is a complete lack of tools for in-line geometry reconstruction and

Source: PRES-X

Fig. 5 Pres-X materials engineers working in XLab, their state-of-the-art material laboratory in Rubiera, RE, Italy

automated identification of geometrical errors. The quick detection of such defects, in fact, is of primary importance as they may propagate and inflate from one layer to another, leading to critical non-conformities, and they may affect internal features that can be difficult to inspect once the part has been built. The industrial availability of an intelligent tool like the one under development in the AMAI project is expected to help end-users move from product-based to process-based quality monitoring and qualification procedures, enhancing the potential of AM technologies in actual production scenarios.

The 12-month project started early in 2021 and is coordinated by the research group headed by Prof Bianca Maria Colosimo in the department of mechanical engineering at Politecnico di Milano. It involves different industrial and research partners: Beamit – one of the most integrated and advanced AM service providers in the world – which is working on the implementation and validation of the developed solution in its LPBF manufacturing environment, and Avio Aero – a GE Company and one of the largest AM end users in the aerospace sector worldwide – which is working on the implementation and validation of the AMAI's tools specifically developed for the electron beam melting (EBM) process. The research group headed by Prof Lars Nyborg at the Chalmers University of Technology is focusing on in-situ atmosphere monitoring in LPBF and the analysis of chamber environmental conditions on the final quality of AM products, and the CNR Stiima research group, headed by Prof Ettore Stella, is contributing to the industrial software development with its deep expertise in machine vision-based solutions.

*

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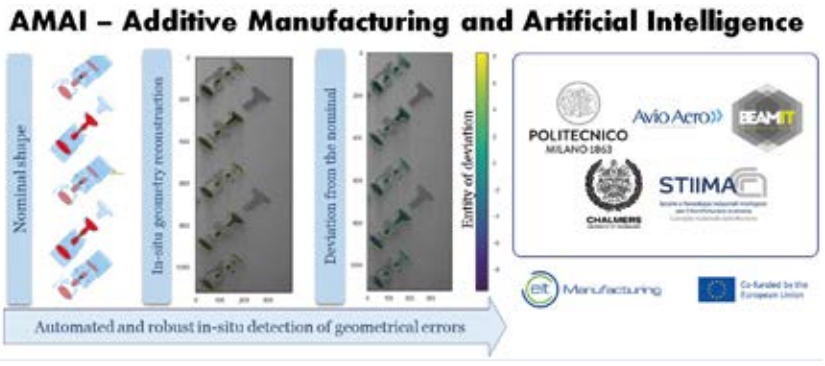

Fig. 6 The AMAI project: an application example of the in-situ geometrical defect detection tool on the LBPF process. (Source: Politecnico di Milano)

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The AMAI project has received co-funding from EIT Manufacturing. EIT Manufacturing is supported by the European Institute of Innovation and Technology (EIT), a body of the European Union.

EIT Manufacturing
Co-funded by the European Union

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Author

Martina Riccio
is R&D manager of Beamit and Pres-X. She received her master's degree in mechanical engineering at Politecnico di Milano, developing her thesis at SITEC – laser application laboratory – converting a laser welding system to automatic laser metal deposition by wire. She joined Beamit as an R&D process engineer and then led the materials and special processes team. She is co-author of various papers related to AM material development and characterization.

Martina Riccio – BEAMIT S.p.A., Strada Prinzera 17, Fornovo di Taro (PR) 43045, Italy; phone: +39 388 951 9805, e-mail: m.riccio@beam-it.eu, Web: www.beam-it.eu, martina-riccio beam-it.eu pres-x-srl

Scaling additive manufacturing for mass customization

How to maximize your efficiency while generating consistently unique output

Ashley Eckhoff

One of the major reasons cited for adopting additive manufacturing (AM) is customization. But customizing products based on AM demands a new business model, with its unique challenges for development and delivery of metal AM products. Products are far less likely to be manufactured in bulk before an order from a customer arrives. Instead, they are manufactured using AM after an order is received, and depending on the production strategy, this can dramatically extend lead times for deliveries. As more products are added to the manufacturing mix, it exacerbates the challenges in the manufacturing process. Ensuring the right product gets to the right customer requires that each order be carefully tracked throughout the manufacturing process.

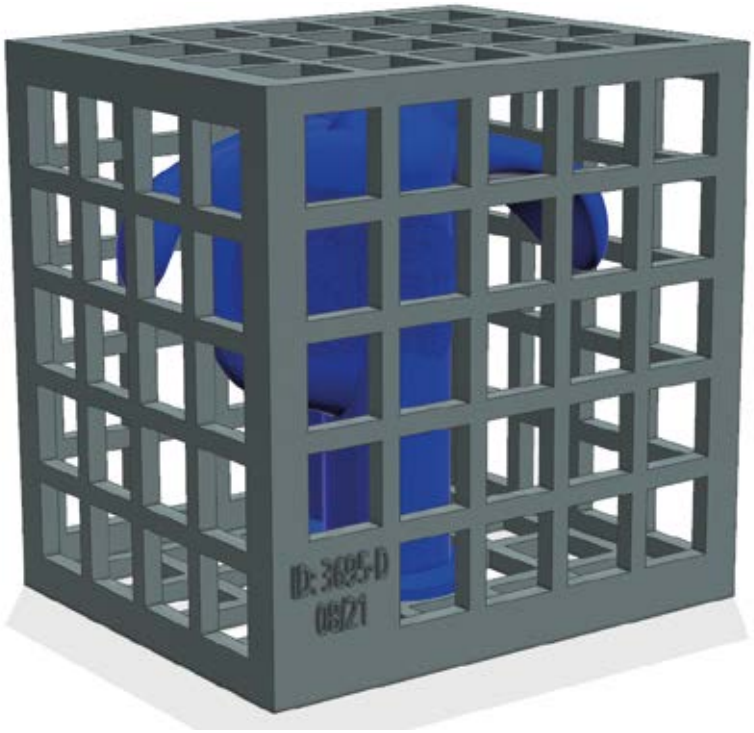

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Fig. 1 A sinter box surrounding a set of custom bicycle handlebar grips

Increasing the complexity of the additive workflow, it is crucial to print every custom metal AM product right the first time. Printing mistakes and the necessary rework can be expensive in terms of time, capital and even reputation. The final product must meet the performance requirements of the customer: whether it is a bicycle crank arm's reliability, a performance bicycle's specific weight or the personalized fit of a printed bicycle helmet. The customer expects a custom, optimized experience from your product, so getting it wrong is not an option.

These hurdles can be discouraging but can be surmounted at each major step in the process with the right solutions as they can become a part of the normal additive manufacturing production process. Approaching these challenges with care and precision from concept to delivery, custom product manufacturing can become a rewarding long-term business proposition.

Product traceability for additive manufacturing

Implementing a robust tracking system, based on serialization, is critical to the success of any custom printing application and there are two important reasons. The first is to ensure quality in the process and we will refer to this as "process traceability" for the purposes of this article. This is true for all product manufacturing, not just AM. The second is more relevant to customized product manufacturing – tracking an individual item from order to delivery, or "product traceability". Both are intertwined and absolutely necessary to deliver the right product to the right customer.

Process traceability provides assurance that, during each step in the development process, the product receives the correct set of operations. It is knowing exactly where the product is going. If it needs to be finished in a secondary process after printing, that information is associated with the serial number. To make the process as efficient as possible, a manufacturer needs to be able to segment large lots of products that all need to go through similar processes. This increases parallelization because it would be far too time consuming having a single component go into an electroplating bath on its own. Some of this organization will need to be conducted through classic logistic operations. An option specific to additive manufacturing is the use of sinter boxes or build tray segmentations. The latter implements small geometric elements

to define boundaries between groups of parts printed on the same build tray, this technique can be implemented across many different materials, including metal. Sinter boxes on the other hand are primarily used in polymer printing and are essentially a printed cage that acts as a separator in a print bed. The technique physically groups printed parts so that they can move through the post-processing steps as a single unit and reduce the complexity of tracking many smaller components.

Sinter boxes are perfect for semi-personalized product manufacturing. When one version of a printed part can be almost indistinguishable from another it is critical to know which part is being dealt with without visual cues. Molded bicycle grips for example would be printed in small lots of identical parts inside of a sinter box and moved onto post-processing steps as a single unit. Another important aspect of this technique is the reuse of support geometries, when necessary, and print orientations. Once an optimal combination of supports and orientation is achieved, all geometries can be exported for use in sinter box prints. The technique removes quite a bit of complexity from manual printing processes, but it also improves a business's capabilities to track parts from concept through delivery.

Product traceability relies on much of the information from process traceability, but the end goal is to deliver the right product to the customer. For the most customized products, the personalized metal printing may require individual fitment. This could be a 3D scan of a rider's head to provide the perfect helmet fit or a cycling pedal cadence tracking session to understand their riding dynamics. Providing a product built to the wrong requirements can have a drastic impact on performance, especially for high-tier cyclists where a few grams can make a difference on a hill or provide enough strength to reliably finish the race at peak output.

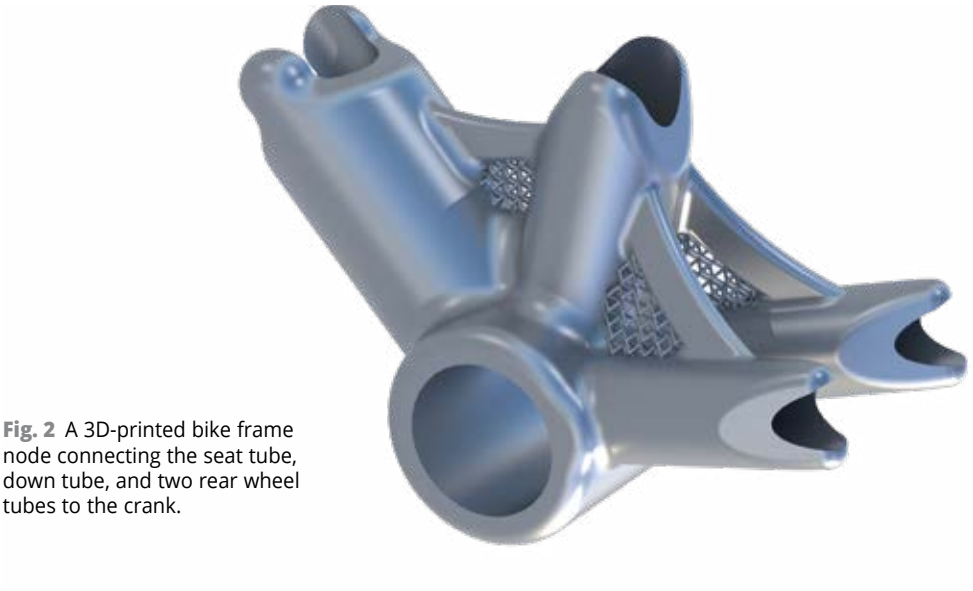

Fig. 2 A 3D-printed bike frame node connecting the seat tube, down tube, and two rear wheel tubes to the crank.

Once the ordering process for a custom part is complete, all the geometric data specific to that part is attached to a serial number and imported into the process traceability environment where it ensures the right product is manufactured for the customer. From here, the individual product will follow the prescribed manufacturing process as discussed around process traceability. In the case of a custom printed bicycle helmet, once the product is off the manufacturing line, it is time for delivery. Organization in this phase is crucial, because correctly matching order requests and finished products is essential to customer satisfaction as well as reducing rework and shipping corrections. Depending on the customization extent of a product, it may not be apparent to the customer if they receive the wrong order. Cycling components could be customized with internal geometries to enhance a rider's specific riding dynamics and getting the wrong order could lead to the assumption the technology does not work.

Intelligently leverage simulation

Simulation is an important aspect of any additive manufacturing workflow, but especially so for customized product workflows. It could take the form of topology optimization, final product validation or printer process simulation, depending on the application. Advanced simulation enables printed parts to be lighter than ever before while retaining the required strength and rigidity. Simulation even provides an insight into the impact of the printing process itself on the structural integrity of the final part.

Fully custom additive manufacturing leverages as many aspects of a simulation environment as possible to deliver the most value to the customer, but when moving towards mass customization it is difficult to justify the time required to set up and run each of these simulations for every print. Instead, a cost benefit analysis may lead to a piecewise solution. For relatively similar custom parts, where they share a majority of their respective geometries, performance simulations may only be run on a representative sample of parts within a target range. Then any outliers can be simulated on a case-by-case basis, reducing the amount of simulation required to cover the entire range of customized parts. As an example, custom frame geometries for bicycles still need to adhere to the sizing standards of the industry. A bottom-bracket drop-

Fig. 3 A custom shaped bicycle crank with internal lattice structures

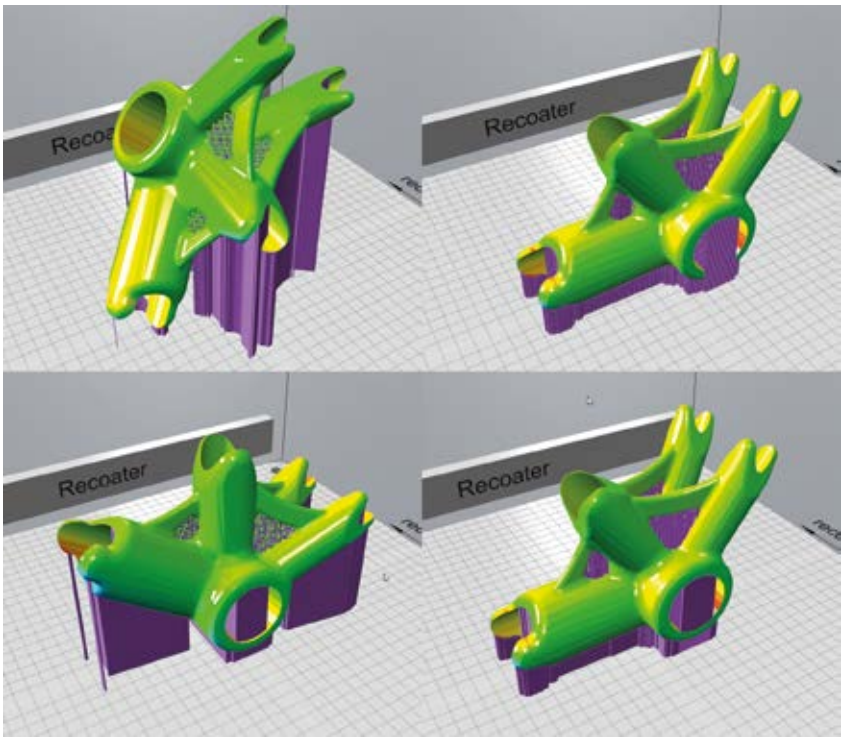

Fig. 4 Simulation-based orientation optimization for easy support removal, minimum supports, minimum distortion, and minimum print time, respectively.

out would retain the same inner diameter to fit the customer's cranks while providing a range of angles between the down tube, seat tube and chain stays. By sharing this geometry and using consistent material composition across custom geometries, simulation time can be optimized on a per unit basis. This can be accomplished by first identifying a size range within which, say, ninety percent of riders fit. A simulation can be run for each end of this range, with a few samples within the range to ensure that the product will meet specs throughout the 90 % range. Then, simulation will only need to be run on the individual parts that fall outside this selected range to ensure that they also meet the product specifications.

When the standard deviation from the average part, is low enough, separate simulations may not be needed. However, the design team must keep in mind that if they vary the part too much without simulating the effects, it can lead to a deformed part but even worse could also damage the printers if, for example, a deformation impacts the recoater. It takes experience and time to understand how much allowable change can be tolerated. AM manufactures should therefore rely on increased use of simulation in early runs of the custom products until they gain enough experience to make confident decisions about when simulation is required and when it is not.

The promise of reduced simulation is not the same for every product, however. Articles like printed metal joints for carbon fiber frames or custom printed bicycle cranksets will have a greater impact on the rider and will likely require more performance simulation on a per unit basis than would a customized water bottle cage. Many of these adjustments will be accounted for in the design of the product for the customer, but in the case of the carbon fiber frame added insight may be needed as they reach manufacturing. When customizing a bike frame, even the smallest tweaks to geometry matter. For example, a printed bottom bracket joint connects to the seat post tube, two chain stays for the rear triangle and the down tube, for a total of four points of possible misalignment. Complex parts such as these may require a larger sampling of simulation than less complex parts, so part complexity can also play a role in the need for simulation.

Overall, part simulation is an important element of a custom printing workflow, but simulation is not free and that must be considered when moving towards mass production of lot sizes of one. Depending on the breadth of customization and the products being manufactured, a variety of techniques could be adopted to counteract the cost of the simulation process. The techniques discussed above are only a few options. Other simulation strategies could rely on trading simulation accuracy for speed to get a broad idea of how changes impact the product without incurring the cost of a more granular simulation. Regardless of the final solution, it is important to deploy part simulation strategically, understanding the costs and benefits of using such powerful capabilities.

Simulating the process

After designing a custom product and then simulating and performing a multitude of engineering tasks to prepare it for production, it is time for manufacturing. This is where simulation of the process comes into play. As we have seen, part customization means that every part printed is different to the last. This naturally leads to every build tray being different from the last, so techniques for mass production that generate efficiencies of scale will often not work in a customization scenario. This means we need to think deeply about how to maximize our efficiency while generating consistently unique products.

Again, the decision about when to simulate the print process comes down to an analysis of failure probability vs. the cost of simulation and how to bring the average cost down. The uniqueness of each build tray containing customized prints means that this decision must be made with care and that additional techniques are required to maintain efficiency in the printing process without greatly impacting first article quality. Simulation of the printing process is becoming one of the recommended techniques for improving first article quality. However, as with part simulation, the simulation of the build process

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can be expensive with regard to time, so simulating every build tray would likely have a large impact on production performance. This means that strategies for when to simulate and when not to simulate the process must be designed.

One way to aid in this decision might be to define a change threshold beyond which simulation would enter the process. For example, if more than 50% of the parts in a build tray have surfaces that deviate from the nominal by more than 40%, then simulation of the build is performed. Just as with part simulation, the thresholds for making these decisions come from experience with the print process and an understanding of what changes and what magnitudes of change are acceptable without negatively impacting print quality.

If we look at the example of a custom molded bicycle grip, the only portions of the component that are customized are the portions that interface with the rider's hands. The overall size of the grip is limited by the standardized sizes of handlebars, so the deviance in part structure from the nominal geometry is minimal. In such cases, it may be possible to simulate a representative build tray with a set number of parts in a desired orientation. If the results of the simulation are positive, then you may be able to create future trays with the same number of parts in the same orientation and be successful without simulation of each future build tray being necessary, even though technically each future build tray would be unique. Looking at our custom bike crank example, the problem may be more complex, however. Custom crank arms will most likely have a much wider range of size variation than would be present with grips, so different techniques might be required to minimize the need for simulation. One might embark on a policy of 'like part grouping' where an attempt is made to print crank arms whose sizes all fit within a given range as a single batch. If the size ranges for each batch are chosen carefully, it may be possible to simulate build trays of nominal parts within a given size range to identify areas of concern. Simulating these build groups as representative samples, one could theoretically reduce the overall number of build simulations required.

Just as with part simulation, the definition of the ranges, the overall deviance allowance, etcetera are values that must be designed from print experience. Each printer, process and material will require a slightly different set of groupings and what works and what does not can only be found through experimentation.

Fig. 5 The only customized geometries on the handlebar grips above are the palm extension and the finger guard, the rest relies on industry standard sizing

It is worth noting that as new simulation techniques are developed, as existing techniques become more refined and efficient, and as computation becomes less expensive from a cost and time standpoint, the cost of simulation tends to decrease over time. We expect this same trend to apply to both part and process simulation in the additive manufacturing realm as well. Simulation of the build process in particular is a relatively new process, so it can be assumed that there are efficiencies still to be gained in that process as the tools mature and the knowledge about the printing process expands. One can imagine a future point where the cost of build simulation will be minimal, and a simulation of every build tray can be run before production. While in most cases this is not yet advisable, it certainly is possible if the cost/benefit ratio is favorable.

Accelerate and manage custom printing

Additive manufacturing is showing great promise for providing custom products to customers on a mass market basis. But to do so successfully requires the process to be organized efficiently by implementing an end-to-end solution that encompasses design, simulation and manufacturing. When every order is different from the last and the next, it is important to understand how the development and production cycles are impacted. Manufacturing on-demand forces companies to adopt efficiencies in production and to parallelize workflows to deliver the products in a reasonable timeframe. Product traceability helps to ensure that the right product gets to the right customer, and process traceability ensures that the part goes through the proper processes during design and manufacturing. Throughout the design-to-manufacture process, simulation needs to be judiciously utilized to optimize quality *and* throughput.

Additive manufacturing is a technology uniquely positioned to capitalize on the potential of customized products. However, making mass customization profitable will require a wide and deep understanding of the custom manufacturing process and the wider business implications. A well-regulated process, driven by acquired knowledge and appropriate software, can ensure the viability of customization through additive manufacturing so that your business can create the parts of tomorrow, today.

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Author

Ashley Eckhoff has a background in engineering and has been with Siemens for over 20 years in various capacities. He has spent the past few years deep-diving into additive manufacturing in both product design and marketing roles.

Ashley Eckhoff, 329 Magnolia Valley Dr, OFallon, MO 63366, USA; phone: +1 636 439-1096; e-mail: ashley.eckhoff@siemens.com; Web: www.sw.siemens.com

Tomography and lasers meet on a knife's edge

Tomographic beam profilers drive industrial laser measurements with groundbreaking accuracy over a large spectrum of lasers

Oren Aharon

Source: ihorsvetiukha © 123RF.com

Many new generation lasers, having a spectrum which is out of the sensitivity response of typical camera detectors require different technologies to be examined. Tomographic knife-edge technology offers a feasible solution. Multiple knife-edges scanning from different directions provide beam profiles dependent on scanning angle. By reconstruction techniques used in tomography, an image-like profile can be reconstructed and analyzed. Various detectors are used to provide a wide spectral range measurement capability.

Originally, Wilhelm Röntgen discovered X-rays and enabled insights of the human body. In October 1963, Oldendorf received a US patent for a "radiant energy apparatus for investigating selected areas of interior objects obscured by dense material". But the story did not stop there.

In 1972, Godfrey Hounsfield found a solution when he invented computerized tomography (CT) scans, thereby a technology for creating an image of sectors of the human body was created by using a rotating ring to project X-rays at different angles and reconstructing the inner image of the human body. Based on this original advancement in tomography, an inspiration for processing profiles of lasers perpendicular to the propagation axis was developed by Duma Optronics. This technology – computerized knife-edge tomography (CKET) generates profiles by mechanically scanning across the beam. The scanning is performed in an orthogonal direction to beam's propagation, thus showing the profile at one location along the propagation axis.

Similar to CT scanners, which use a rotating ring to take images from different angles, the CKET generates different profiles from multiple knife-edges slanted at numerous angles relative to the center of the beam. A computer then combines these profiles to create a 3D image of the scanned laser location. This creates image-like footprints of the laser power distribution at the specific scanned location and allows reconstruc-

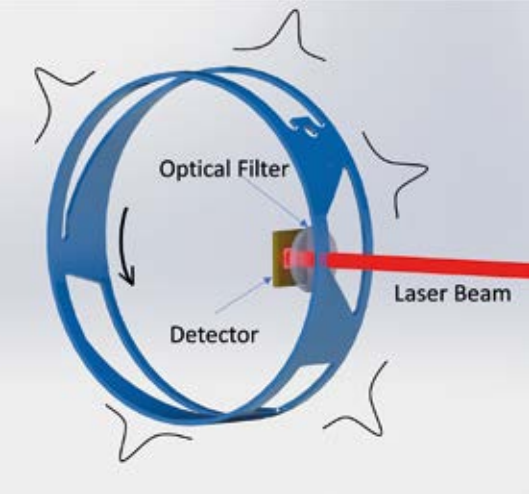

Fig. 1 Multiple scanning knife, each generating a different profile (Source: Duma Optronics)

tion of the beam's power distribution along this area.

The described instrument will generate the profile by using a single detector, sensitive to the appropriate wavelength. The mechanical scanner will obstruct the light striking the detector as a function of its rotational speed. The amount of light reaching the detector is modulated by mechanical means while adequate data processing measures the laser beam profile. Our company developed an enabling mechanical scanning technology, presenting a 3D reconstruction of the beam based upon a combination of computer and knife edge tomography.

The result is an instrument capable of 3D measuring of minute beams (down to one micron) and currently up to 10 mm, without any optical magnification or reduction. The outlines of this technology create clear power distribution along the laser propagation axis at wavelengths where mosaic images devices are not available. For example, a new 10 mm single detector size of indium gallium arsenide enables measurement of small and large beams at a wavelengths range starting from 600 nm up to 2.7 µm in special cases. Sub-micron measuring resolution is achieved by this technology.

Beam profiling and beam measurement importance

A laser propagating through space has a different width and spatial intensity distribution along its propagation path continuously changing as a function of its laser cavity, divergence, interaction with optical elements and electronics driver characteristics. Beam profile intensity distribution is an important parameter that indicates how a laser beam will behave in an application and will dictate the overall system performance in a specific setup. Although existing theory accurately predicts laser propagation in a real-world involving engineering specification, it is crucial for researchers, system designers, and laser manufacturers to be able to measure accurately these parameters. ISO standard 11146 defines approaches to be used in measuring such beams.

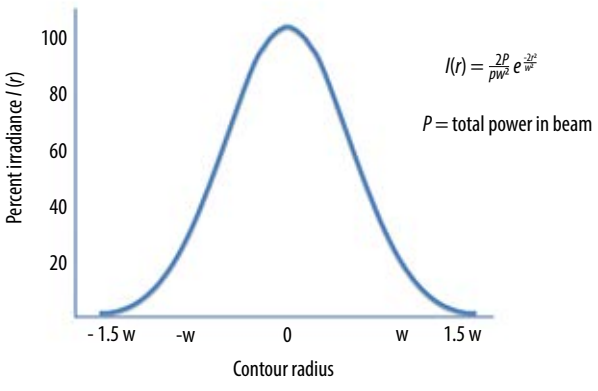

Fig. 2 Beam profile definition (Source: Duma Optronics)

Beam profile definition

Laser beam profile in a perpendicular direction to its propagation axis is not defined, and in theory extends to infinity. The commonly used definition of beam width is the width at which the beam intensity is $1/e^2$ (13.5 %) of its peak value. This value is derived from the propagation of a Gaussian beam and accurately describes the beams distribution for lasers operating in the fundamental TEM_{00} mode.

However, many lasers are close enough to a Gaussian approximation and applying this simple definition is a common practice in the industry. Another more accurate definition is found as well in the IS011146 standard which specifies the beam width at the second moment. The point of the second moment is a value that is calculated from the raw intensity data and it is very sensitive to measurement noise as well as to random laser noise. A third way is

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Duma Optronics

Duma Optronics specializes in photonics-related instrumentation, with a lineup of several categories:
– Beam analysis systems (beam profilers, M^2 meters, divergence meters)
– Optical beam positioning
– Alignment measurement systems
– Electronic autocollimators
– High power laser beam profiling
We combine a vision of innovation, a wide spectrum of technical disciplines, and custom-made capabilities. Everything can be done!

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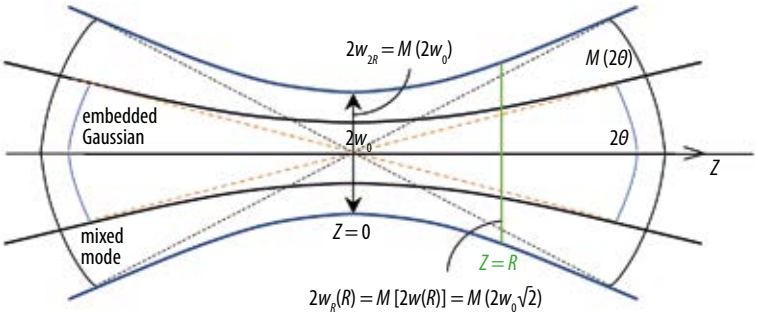

Fig. 3 Embedded Gaussian concept (Source: Duma Optronics)

calculated from the beams integral and it is free of noise problems and known as the knife edge method.

Fig. 2 describes a beam profile at a certain position at a cross-section perpendicular to the propagation axis. Fig. 3 describes the propagation in space of a laser beam and the embedded Gaussian concept.

Measuring beam width technologies

There are four main types of beam-profiling measurement instruments, and a proprietary technology introduced by Duma Optronics completes the lineup by introducing a technology that combines between knife edge technology and a camera-based system. The basic four are: camera-based systems, knife edge scanners, slit scanners, and pinhole scanners. Each has specific advantages and disadvantages. Different measurement techniques may result in slightly different results. As rule of thumb measuring pulsed laser is best when performed with CCD beam profilers which offer superior performance when compared with CMOS technology, on the other hand measuring cw lasers is best using knife edge technologies especially tomographic reconstruction as offered by Duma.

Scanning knife edge in-depth

Knife edge profilers use an aperture large enough to pass the entire beam. The aperture has one sharp, straight edge (knife edge). As the aperture traverses the beam, the system measures the portion of the beam that is not blocked by the blade (see Fig. 1) and plots the differential (rate of change in intensity) vs. position of the power through the aperture. As the knife edge passes through the beam the system approximately calculates the beam size and a sophisticated electronic circuit samples across the beam 12,000 times per sweep, to be further processed to yield over 1,000 useful points per profile regardless of beam size. Very small beams in the micron region are sampled with lower resolution. This auto zooming procedure offers highest possible accuracy independent of beam size. This is advantageous when compared to a slit or pinhole scans: The beam intensity is not limited by the size of the pinhole or slit; resolution is not limited by the size of the aperture, allowing beams of a few microns in diameter to be measured. Moreover, accurate power measurement is also provided since at some point the full unobstructed power incidents the detector surface. A special power scope function will analyze power stability at high bandwidth of a few megahertz and will display in real time calibrated power values.

The scanning technology is advantageous for its wide dynamic range of beams from less than 3 µm up to 9 mm. Using special sensitive detectors, it can measure beams up to a wavelength of 2.8 µm.

Using CKET technology for M^2 measurements

We would like to focus our point of interest on CKET technologies, which offer a broader wavelengths sensitivity compared to camera systems, and are responsive from deep UV to far IR. Furthermore, due to their flexibility in direct measurement of micron beams up to large beams, they are more suitable to implement into M^2 systems where there is a need to measure the laser beam along the propagation axis, scanning various beam sizes. The CKET solution is free of pixelization or pixel size, which usually limits the performance of camera-based systems.

The beam propagation factor M^2 is a common single parameter that characterizes the whole beam as it propagates through space. According to ISO standard 11146, this parameter could be defined by several measurement techniques based on beam profiling along several points of the propagating beam. The standard defines several measurement techniques, all of which are based on beam profiling measurements using devices such as cameras, knife edge and slits.

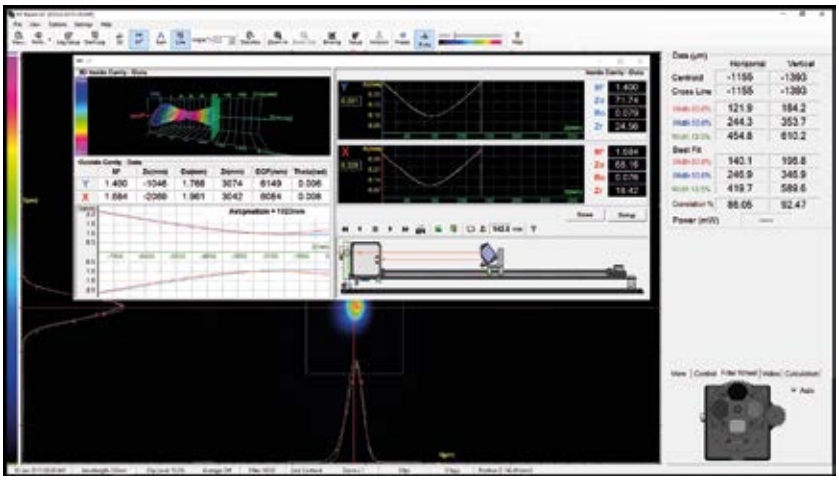

Fig. 4 2D/3D M^2 reconstruction of real measurement (Source: Duma Optronics)

Multiple instruments have been developed to measure the propagation factor and M^2 on production lines and in the laboratory. There are two main measurement requirements: One is the measurement of focused beams, and the second is measurement of collimated laser beams. For the latter, the fundamental operating principle is the focusing of the incoming laser beam by a lens, creating a waist position and a divergent beam on its two opposite sides. By scanning and calculating the beam waist W_0 at a focal point and the divergence in a far region many times the Raleigh range, one can determine an accurate value for M^2 measurement. For focused beams, the principle is similar and the focal point of the system is scanned along with its divergence angle to create the focal beam characteristics such as beam size, depth of focus, M^2, etc. A popular technique for M^2 measurement is to scan the beam along its propagation axis including the waist position area by a mechanical linear motor and measuring the beam distribution at several locations by a beam profiler or by the CKET technology. A dedicated software will reconstruct the beam propagation and its M^2 value.

Frequently on certain applications, especially in high power ones, the M^2 term is replaced by the beam parameter product (BPP) i.e. the product of beam radius at the beam waist and the far field beam divergence angle. The M^2 factor, as will be shown on the following formulas, will also include the wavelength. The best possible beam quality is a diffraction-limited Gaussian beam having an M^2 equal to 1.

$$M^2 = \frac{\theta \cdot \pi \cdot W_0}{\lambda}$$

wherein: BPP = $\theta \cdot W_0$.

M^2 could be derived from the second formula by dividing the BPP by that of an ideal Gaussian beam at the same wavelength.

An intuitive and user-friendly software will not only calculate the tomographic features along the scanning aperture, but will also provide full 3D reconstruction of laser beam propagation through space.

A typical measurement cycle, as shown by Fig. 4, will display W and V directions along the propagation axis, as well as 2D/3D reconstruction. Moreover, the software will continuously show the folding optics location in real time.

A full set of accessories will enable measurement of low and high power as well as various wavelengths up to 2.7 µm.

Conclusions

In conclusion, adapting this technology to well-known knife-edge beam profiling enables laser beam profiling characterization perpendicular to the propagation axis, providing an image-like laser footprint with adaptable resolution from less than a micron to large beams. Moreover, this technology creates image-like beam profiling over a wide spectral range and special beam sampling accessories will allow measurements of high power lasers as well.

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Author

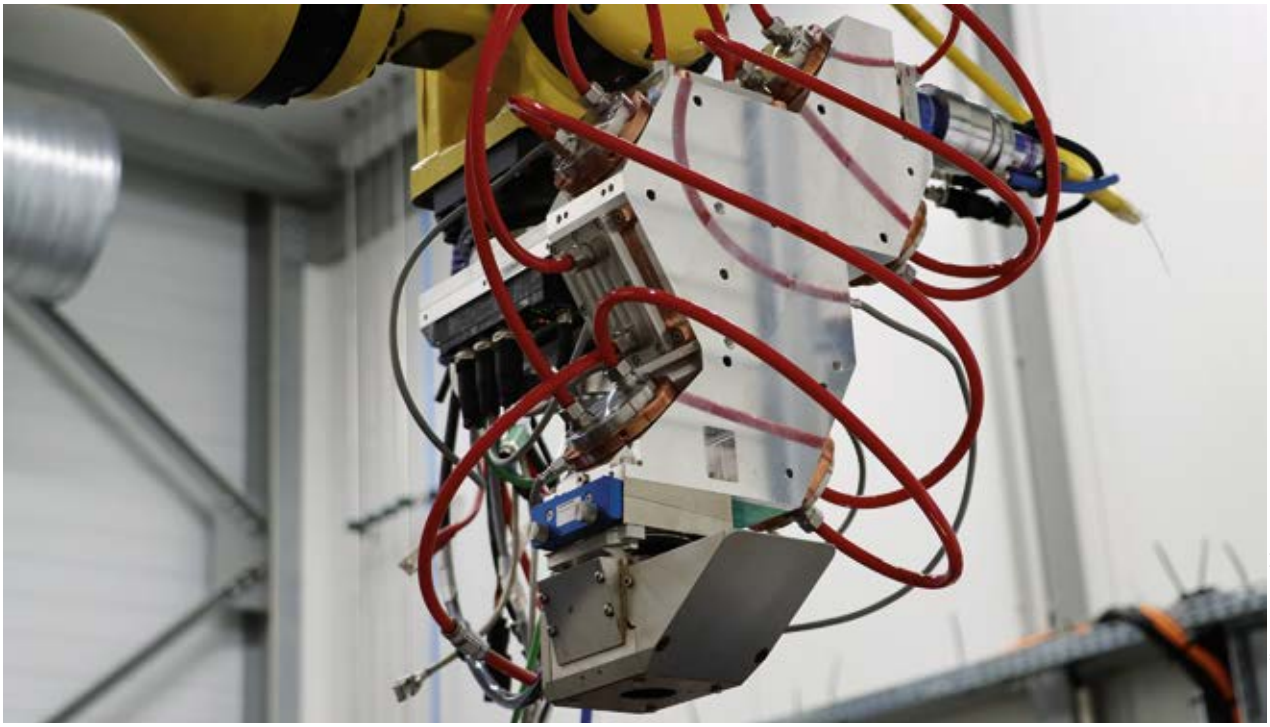
Oren Aharon has several decades of experience in the electro-optical field, including start-up initiations based on his own patents. He founded Duma Optronics 25 years ago to offer advanced enabling technologies for the industry. He owns thirty patents and graduated from Technion with a BSc in nuclear engineering and an MSc in industrial engineering. He has written numerous articles and has served as a technical assistant to the Israeli Minister of Energy. He is the inventor of the CKET technology.

Oren Aharon, Duma Optronics, Hazait 1st, Nesher 3675018, Israel; phone: +0506443001; e-mail: oren@duma.co.il; Web: www.dumaoptronics.com

Development of an MPLC-based laser head

Advances in beam shaping applied to laser beam welding

Julien Bayol



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Beam shaping has already often demonstrated its benefits when applied to laser material processing. It is used in laser beam welding to optimize the energy input on the part and then improve quality and yield. A laser head using multi-plane light conversion (MPLC) beam shaping technology has been developed, dedicated to steel welding. The performance of this laser head paves the way for the development of new welding techniques such as laser-arc hybrid welding, or on materials such as copper.

In recent years, the availability of multi-kilowatt, continuous-wave laser sources has increased greatly. Fiber or disk lasers now allow laser processing at powers above 20 kW. In the case of laser beam welding, it has enabled more capabilities, potential deeper penetration, and higher speeds. But this high power also brings two new challenges. Firstly, welding quality has to be preserved, and secondly, optical systems that deliver the laser to the part, such as welding heads, have to be able to handle it. Beam shaping is a way to take up the first challenge. Typically for steels, an annular beam shape has demonstrated improvements in the welding process. An example of a technology that fulfills this by the ability to generate a ring shape is double core fiber. However, this technique is often combined with refractive laser heads that have the role of focalizing the beam onto the processing plane. These refractive optics struggle with the second challenge: when the lasers are used at high power, they heat up and their optical properties vary, and result in unwanted phenomena such as focus shift or thermal lensing. Therefore, in order to bring a solution to those two challenges, a reflective welding head using multi-plane light conversion beam shaping technology has been developed.

Implementation of the MPLC in a reflective welding head

MPLC is a patented beam shaping technology that provides control over the amplitude and phase of the light. It consists of a succession of phase profiles, comparable to highly complex lenses, separated by a specific propagation distance. In practice, it can be implemented in a reflective and passive way, the light going back and forth in a cavity composed of a reflective phase plate and a mirror. This technology allows the generation of any beam shape and beam combination.

Indeed, an MPLC based welding head has been designed in order to shape

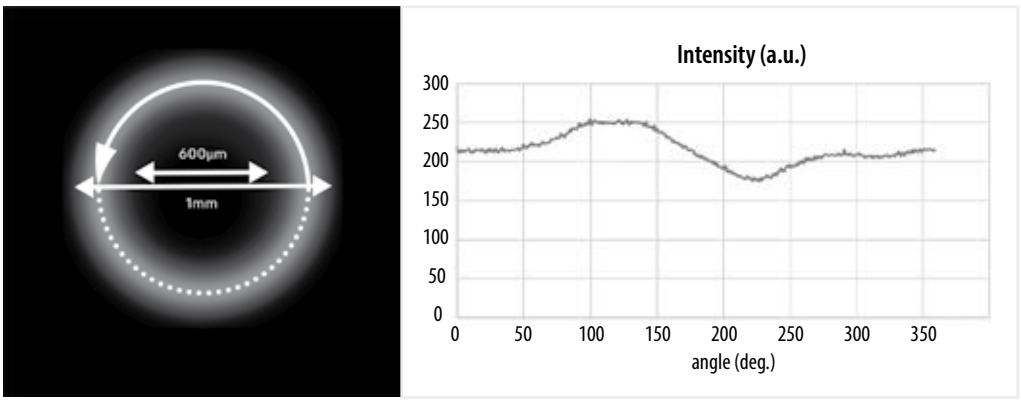

Fig. 1 Intensity homogeneity around the average diameter of the ring shape

a ring beam profile, with a 600 µm inner diameter and a 1000 µm outer diameter. This technology delivers high-quality beam shaping with an intensity homogeneity equal to 10 % RMS along the average diameter of the ring. This is very important, since the ring shape is useful in the welding process to encircle and widen the keyhole. Any intensity inhomogeneity may provoke instabilities of the keyhole. (Fig. 1)

Moreover, the depth of field of the generated beam has been measured using a Primes system. The ring shape remains the same over ±3 mm relative to the best focal plane, which is unique compared to other shaping methods such as double-core fiber lasers. This makes the system less sensitive to process variation and therefore more robust.

The optical performance of the MPLC-based laser head has also been evaluated at high power. System transmission has been measured at 99 % at 16 kW, the maximum power of the laser that was used to conduct these tests. Also, a Beam Watch was used to evaluate the focus shift of the laser head at different power over fifteen minutes. Whatever the power, a maximum 1 mm focus shift was measured after one minute, which corresponds to the stabilization time required by the cooling system integrated into the welding head to cool down the optics. This is a huge improvement in comparison to standard refractive laser heads, which generate focus shifts in the order of magnitude of centimeters. This good performance at high power is due to the reflective implementation of the MPLC, which allows uniform and efficient cooling at the back of the optics. (Fig. 2)

Process results

Welding tests were conducted at the Institut Maupertuis, a partner of Cailabs, where the MPLC-based laser head was connected to a Trumpf TruDisk 16002 via its integrated LLK-D connector. It was mounted on a 6-axis robot arm, and combined with a shielding gas system (100 mm trailing shield, Argon 40 L/min). Full penetration and butt-joint welds on 6 mm thick 304L stainless steel plates were carried out. A first parameter optimization of laser power showed that 7 kW was the optimum power to achieve full penetration without oxidation (6 kW was too low to ensure full penetration; 8 kW generated oxidation). Other fixed parameters were the welding speed (1 m/min) and the focal point (2 mm below the upper surface; Fig. 3)

Afterwards, the influence of focal point variation was evaluated at the optimal power of 7 kW and a welding speed of 1 m/min. Full penetration was achieved with the focal point from 1 mm above the surface to 5 mm below the surface. This confirms the very good performance previously measured on the depth of field, because full penetration was completed with a focal point variation amplitude of 6 mm, corresponding to the depth of field.

So using the optimal parameters resulted in a very good quality weld bead, according to NF EN 13919-1 standards. It has a large and regular width, which is a sign of good quality. Moreover, it was compared to welds carried out using a classical unshaped beam and

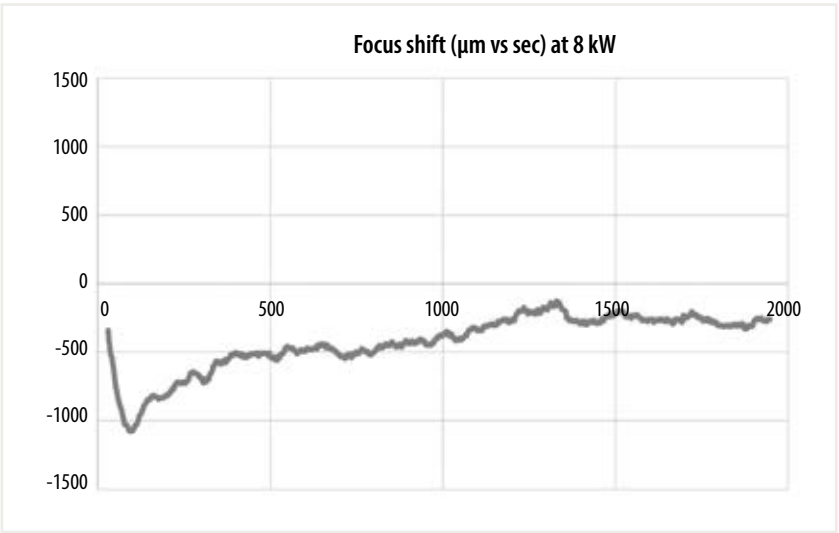

Fig. 2 focus shift in µm as a function of time (sec) at 8 kW

Company

Cailabs

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

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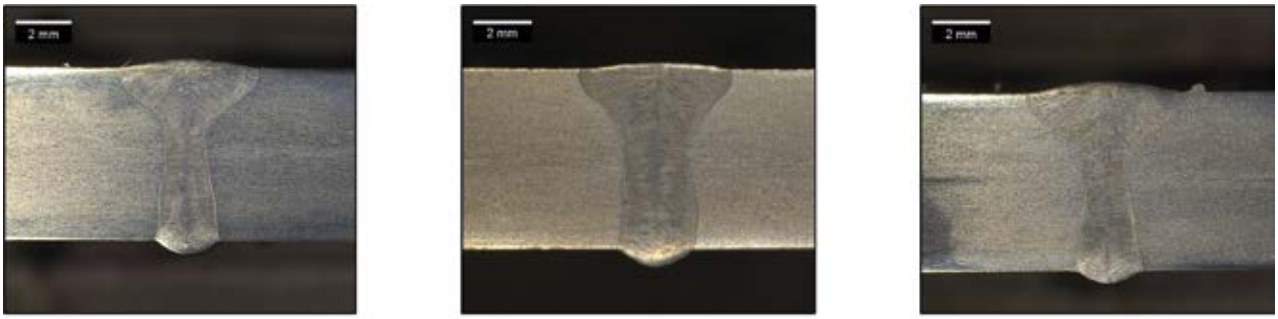

Focus at -5 mm below the surface | Focus at -2 mm below the surface | Focus at 1+ mm below the surface

Fig. 3 Evaluation of the impact of the focus point position on the welding process

also a double-core fiber system at the same power, welding speed and focus point position. With the double-core fiber, two configurations were tested: the first was a single ring shape (0.3 mm inner diameter, 1.05 mm outer diameter) with 100 % of the energy within the ring; the second was a ring shape with a spot inside, with a repartition of the energy between the two, the spot being more intense.

The widest weld beads were obtained using the MPLC laser head (5 mm), which represents an increase of 25 % compared to a classical spot, and even more than 50 % compared to the ring shape of the double-core fiber. The aspect of the weld seam is also more regular and smoother compared to both shapes generated with the double-core fiber. Finally, it is important to note a drastic reduction of spatter, particularly when we compare the two ring shapes made by the MPLC-based laser head and the double-core fiber. To conclude this part, the MPLC-based welding head enabled an increase of the weld bead quality and a reduction of defects such as spatters at the same time. (Fig. 4)

Transpose the head to other laser sources

This welding head has been designed to work with a specific laser source: a Trumpf TruDisk 16002 which has specific characteristics (wavelength: 1030 nm, numerical aperture: 0.10, beam parameter product: 8 mm · mrad, input fiber diameter: 200 µm) and a particular modal content. As shown previously, the MPLC-based laser head generates a ring shape with particular dimensions (average diameter 800 µm, thickness 200 µm). A study was conducted to evaluate the usability of the laser head under off-nominal conditions, and the impact it would have on the beam shape in the processing plane.

The modal content of different laser sources of the industry was numerically modelled, and the output of the MPLC-based laser head simulated using a Python program. Modelled lasers were a Trumpf TruDisk 8001, a Coherent-Rofin FL8000 and an IPG YLS 30000 (the specifications of these lasers are given in Table 1. Their optical properties are rather different, with various input fiber diameters and BPPs, and a higher numerical aperture for the Coherent-Rofin FL8000.

For each of these sources, the results of simulation showed that the laser head generates an annular profile, with slight dimensional variations compared to nominal conditions. While the average diameter of the ring remains the same, the thickness changes. It decreases with the Trumpf TruDisk 8001 (150 µm) and the FL8000 (130 µm) while it increases using the YLS 30000 (300 µm). Despite these variations, it is important to note that the MPLC-based welding head preserves a good quality final annular shape whatever the laser studied. This study paves the way to process-oriented tests using these various sources. Specifically, a test campaign is planned with the IPG laser for the next few months. (Fig. 5)

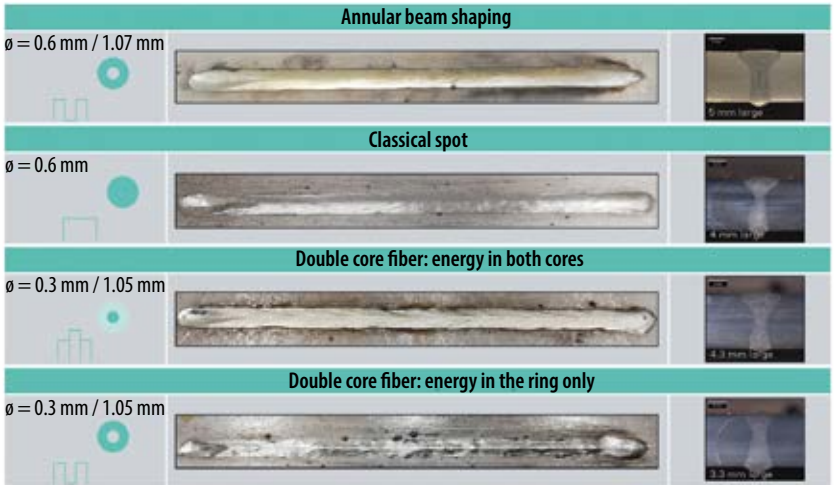

Fig. 4 Comparison of welding tests using an MPLC-based laser head vs. a double core fiber and a classical spot

	Trumpf TruDisk 16002	Trumpf TruDisk 8001	Coherent-Rofin FL8000	IPG YLS 30000
Wavelength (nm)	1030	1030	1070	1070
Numerical Aperture	0.10	0.10	0.20	0.10
BPP (Beam Parameter Product) (mm · mrad)	8	4	3.3	11
Input fiber diameter (µm)	200	100	100	300

Tab. 1 Studied laser specifications

Next development steps: hybrid laser-arc welding

Autogenous laser welding is perfectly adapted to realize butt joint welding with no gap between the parts, or lap joint

welding. However, in industry, sometimes other types of assembly have to be made. For example in the case of butt joint welding, it is not always possible to get a small enough tolerance on the gap distance between the two parts. To answer these needs, one solution could be laser-arc hybrid welding that offers the advantage of combining the strengths of both techniques. The laser provides deep penetration while arc welding is able to handle the gap tolerance, especially when filler metal is used. Theoretically, every arc welding technique is compatible, but MIG/MAG or TIG are the most widespread. This hybrid technique can be particularly useful in the automotive industry because of the potential high welding speed that it offers, to match the high volume targets of this sector, and thanks to the greater fit-up tolerance. Other industries such as shipbuilding or rail transport can also benefit from this technique because of the low distortion induced by the laser, due to the more concentrated heat input.

Beam shaping using the MPLC-based laser head can bring even more advantages to hybrid welding. Firstly, the process will benefit from the advantages brought by the ring shape, that is to say, widening and stabilizing the keyhole. In addition, as shown previously, the absence of focus shift is definitely a benefit. The distance between the arc welding head and the part has to be kept constant during the process since the electrode has to stay close to the part to keep generating an electric arc. In the case of hybrid welding, the presence of laser focus shift could face this constraint and lead to a non-optimal process because the laser would not be focused on the welding plane. So without focus shift and with a large depth of field, the MPLC-based laser head seems to be perfectly suitable for hybrid welding. Some tests in collaboration with the Institut Maupertuis are planned to evaluate the benefits and performance of a laser-arc hybrid welding head. The first results at 16 kW laser power showed penetration depth up to 18 mm and the absence of critical defects in butt joint welding.

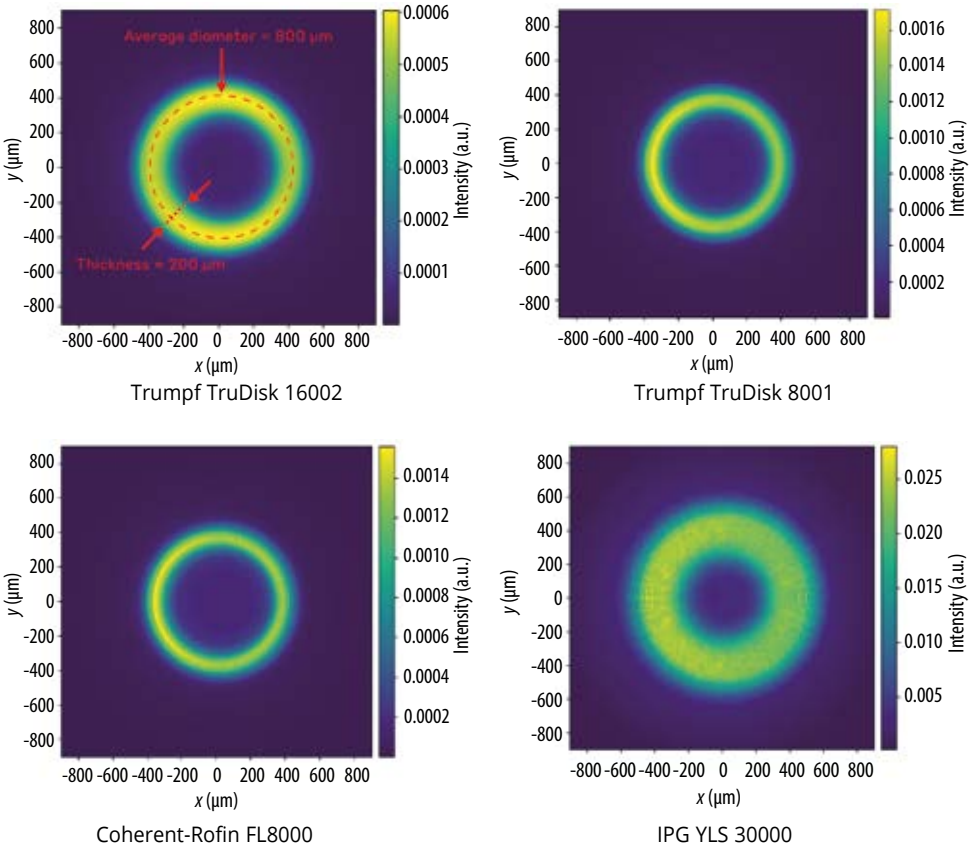

Fig. 5 Simulation results of the use of the MPLC-based laser head with different laser sources

Next challenges: copper welding

In addition to answering the needs of the laser beam welding of steels, MPLC technology could be used for other materials. One of them is copper, which is driven by the very dynamic market of e-mobility. Indeed, the needs in welding this material are increasing fast with the growing use of electrical components and batteries in electric vehicles. But to weld this material is a technical challenge because of its physical properties: high thermal conductivity, low viscosity and low absorption in near infrared wavelengths. The first two properties lead to unstable weld pool behavior and consequently to an unstable process, with the apparition of defects such as spatters or an irregular weld bead.

The third property divides the laser community, since blue and green wavelengths are absorbed more by copper, but sources emitting in these wavelengths are less common and energy efficient, as well as more expensive compared to near-infrared ones. This question is even more complicated when we add the fact that the absorption of liquid copper at infrared wavelengths increases compared to solid copper, leading to a more efficient process, but also to a gap of absorption that could result in instabilities.

Here again, the capabilities of MPLC technology in beam shaping could solve some of these problems, particularly for near-infrared lasers. The typical beam shape that could be used for copper welding is composed of a central

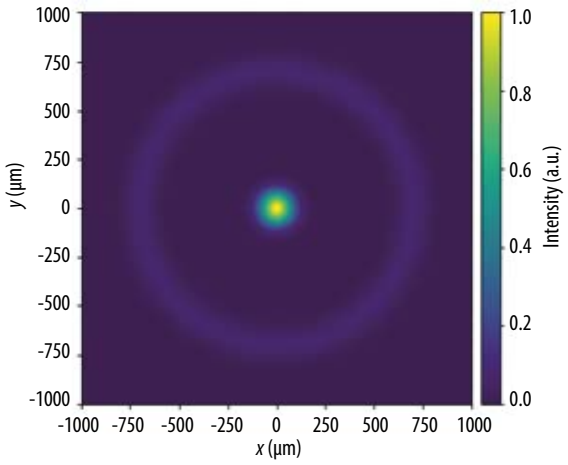

Fig. 6 Simulation of a beam shape adapted for copper welding

Author

Julien Bayol holds a master's degree in mechanics from INSA and has completed a master's degree in Management at Toulouse Business School. Very interested in advanced manufacturing techniques through the use of innovative optical solutions, Julien is assistant product manager at Cailabs. He contributes to the development and commercialization of Canunda products that optimize the quality and performance of laser-based material processes.

Julien Bayol, Cailabs, 38 boulevard Albert 1er, 35200 Rennes, France; phone: +33 673 392351 ; e-mail: julien.bayol@cailabs.com, Web: www.cailabs.com, julien-bayol-insa-toulouse cailabs CAILabs

intense spot, surrounded by a ring of lower intensity. In addition to stabilizing the keyhole as previously explained, it also allows the preheating of the part, and so an increase of the absorption of the material before the laser penetration, which is ensured by the intense central spot (Fig. 6).

Conclusion

This article has shown how beam shaping, using MPLC technology can enhance various laser beam welding processes. Firstly, it has demonstrated its ability to produce high quality autogenous welds on stainless steel, under the nominal conditions of the welding head. The results were compared with a double-core fiber system and showed the better performance of the MPLC-based laser head. Then a study was carried out to evaluate the ability of this laser head under off-nominal conditions, using different lasers. This has shown that it could be used with various sources and still produce a ring shape, which is essential to maintain good process quality. Finally, some development perspectives for the use of MPLC technology have been highlighted, showing its potential for laser-arc hybrid techniques and copper welding. As a conclusion, we can say that this article has shown how laser beam welding could benefit from high quality and versatile beam shaping technology, the MPLC.

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Cailabs was presenting eight papers at ICALEO (18 – 20 October 2021) and will attend Photonics West 2022.

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Lasers for compact & fast LIBS systems

Compact, self-contained, pulsed lasers expand capabilities in LIBS applications

Elena Vasileva and Mélina Gilbert Gatty

Source all images: Hübner Photonics

Laser-induced breakdown spectroscopy (LIBS) is an atomic-emission spectroscopy technique that enables rapid chemical analysis of a wide range of materials, including metals, semiconductors, glasses, biological tissues, plastics, soils, thin and paint coatings. The technique relies on focusing short high-energy laser pulses onto the surface of a target sample, which in turn generates a plasma containing a small amount of the sample (typically, a few nanograms).

The high temperatures generated within the plasma cause the ablated material to dissociate into excited atomic and ionic species that emit characteristic spectral lines upon relaxation. The spectrum of the investigated sample is then detected by a spectrometer and is converted into a quantitative reading of the material content. LIBS analysis is now being adopted by industry as an attractive technique in a wide range of applications: from sorting recycled metals to identifying future mining areas. In this article, we introduce a very compact, air-cooled, pulsed laser and show that it can be used successfully in conventional LIBS experimental setups to identify metals.

LIBS basics

For quite a while, laser-induced breakdown spectroscopy was a spectroscopic technique mostly applied in academic research environments. However, in recent years, significant further development of LIBS system components, such as the lasers, spectrometers and optical fibers, has revealed a great potential for the technique to be used not only in research laboratories, but also in industrial and in-the-field applications. This includes metal content analysis, mining prospecting, plant and soil analysis, forensic and biomedical studies, explosives and biological warfare detection [1, 2]. The simplicity of the LIBS analytical method together with the absence of sample preparation requirements makes LIBS a powerful non-contact (or stand-off) optical technique for material analysis. The versatility of the LIBS technique means that a broad range of application areas can be addressed.

▲**Fig. 1** Cobolt Tor XE laser head (144 × 50 × 70 mm) with integrated electronics

For example, compact, hand-held LIBS devices are suited to fast material identification in the field while larger tabletop systems can be used for routine material quality monitoring and research, and even larger industrial LIBS

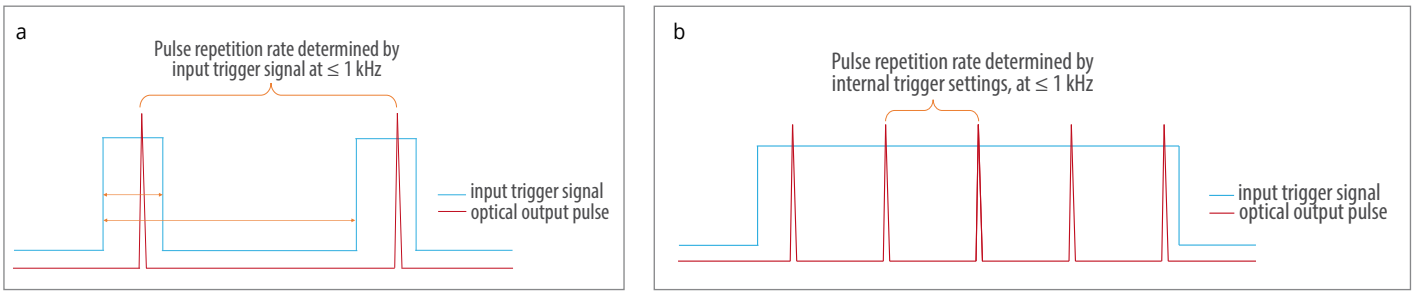


Fig. 2 Schematic illustration of the operation modes of Tor XE: in external (a) and gated trigger modes (b). The blue line shows the external trigger signal, and the red line indicates an optical pulse.

systems address the need for the in-line analysis of metals (e.g. in scrap metal sorting systems, aluminum and steel production processes, slag and lime-mud). The laser requirements for each of these types of LIBS systems can also vary. For instance, portable, handheld systems require compact and power-efficient lasers by nature whereas larger industrial LIBS systems require high-energy pulse lasers and are not necessarily concerned about the dimensions of laser sources, neither beam quality.

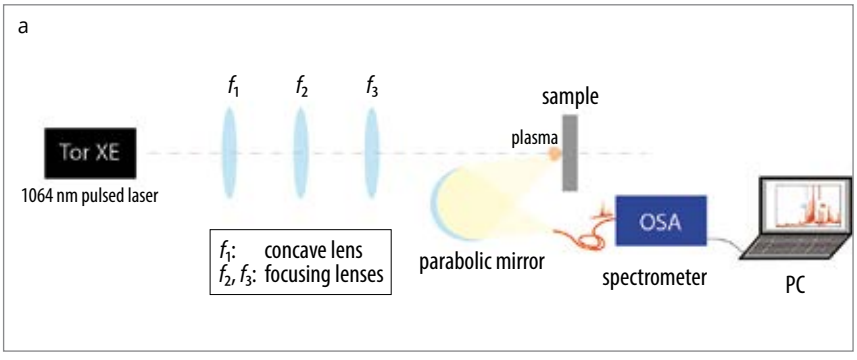
Large scale industrial LIBS are usually made using nanosecond lasers with a few hundred mJ of pulse energy at repetition rates of either tens or hundreds of Hz (typically Q-switched Nd:YAG lasers) or a few mJ pulse energy at repetition rates of tens of kHz (fiber lasers). Some of those lasers, however, are often quite bulky due to the size of the laser heads, drive electronics and cooling systems. They also sometimes provide low-quality beams that are difficult to focus into small spots, and also consume a fair amount of electrical power. For these reasons, they work well for larger scale LIBS systems with a large focal depth and fast-moving samples, but they are less suited for portable devices or compact tabletop systems.

Lasers for compact and fast LIBS systems

As an alternative for smaller but still powerful LIBS systems, the Cobolt Tor XE laser can be used. This laser is a compact, air-cooled, passively Q-switched, diode-pumped solid-state laser (DPL) providing 0.5 mJ pulse energies at 1064 nm up to a kHz repetition rate and in a high-quality beam ($M^2 < 1.3$). The most critical parameters for LIBS applications are the energy density of the laser pulse and the peak power, which must exceed the ablation thresholds of the analysed material [3 – 5]. Due to the excellent TEM_{00} beam quality of all lasers in the Cobolt Tor series, and the XE in particular, it is possible to focus the nearly diffraction-limited beam onto a small area, and thereby reach a sufficiently high pulse energy density (peak power) to ablate the material and produce a plasma of excited atoms and ions without melting the material.

To achieve high signal-to-noise ratios in LIBS measurements, it is important that the recording of the LIBS spectra is well synchronized with the laser pulses. The Cobolt Tor XE laser has the advantage that the pulse repetition rate can be freely chosen and changed by the user from a single pulse up to 1 kHz pulse trains, which can help improve the signal-to-noise ratio. Moreover, the user can choose between three different trigger modes: internal, external, and gated. In the internal trigger mode, the drive electronics, integrated into the laser head, trigger the laser pulses at a repetition rate set by the user, for example with the use of a graphical user interface of Cobolt Monitor software. In the external mode, an external signal source is required to trigger each optical pulse, allowing the user to control the arrival of each laser pulse, at a maximum repetition rate of 1 kHz (Fig. 2a). In this way, the internal and external trigger modes differ by the origin of the trigger signal being either an internal or an external signal source. In the so-called gated trigger mode, both signals (internal and external) are applied to generate a train of optical pulses (burst). The pulse repetition rate is set by the internal trigger signal, generated by the drive electronics inside the laser head, while the pulse burst is triggered by an external trigger signal (Fig. 2b).

The variety of available trigger modes allows easy synchronisation with other equipment used for LIBS measurements. In addition, the unique cavity



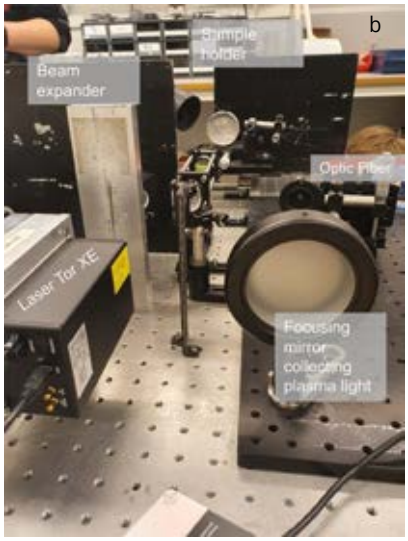


Fig. 3 Schematic of the experimental LIBS set-up (a); Photo of the experimental set-up (b)

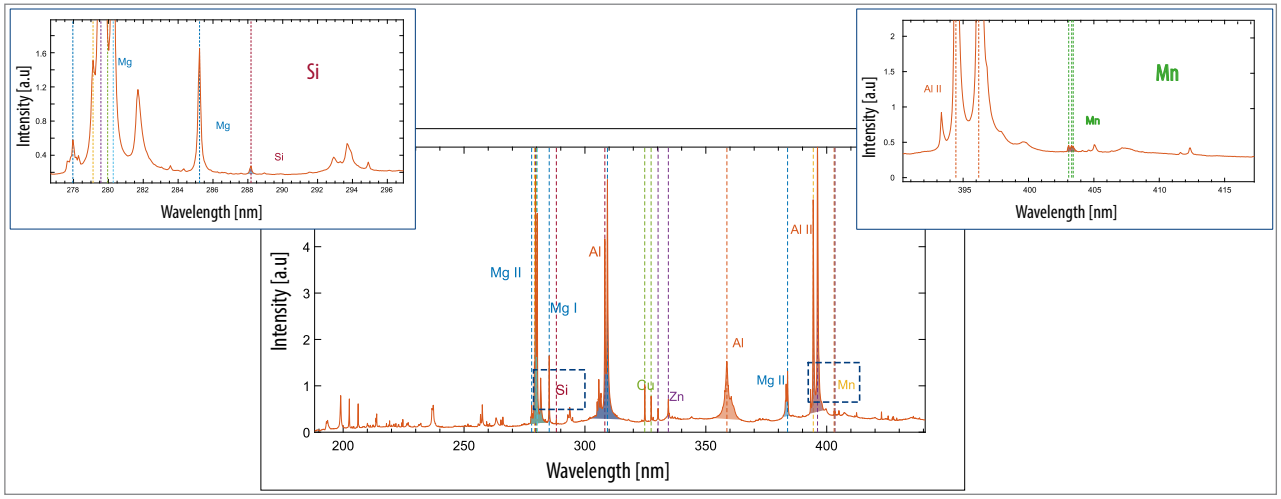


Fig. 4 LIBS spectrum of an aluminum reference sample obtained with the Cobolt Tor XE laser at 1 KHz and 100 ms exposure time. Inset: Si emission line with concentration of Si down to 0.12 % and the Mn emission line with concentration of Mn down to 0.06 %.

design of the laser provides a very stable pulse train, where the timing between the pulses is especially well defined for passively Q-switched laser. The pulse-to-pulse timing jitter is <2 µs, even at kHz repetition rates.

With all the drive and control electronics integrated into the laser head and requiring only a small-scale air-cooled heatsink, the Cobolt Tor XE package is very compact, making the laser attractive for integration into portable devices or compact tabletop systems. The pulse repetition rate of the laser (up to 1 kHz) determines the speed of the LIBS analysis; the Cobolt Tor XE can therefore be used for applications requiring both a compact system and fast analysis, for example as a mapping 'microscope'. The laser is manufactured into hermetically sealed with the use of patented HTure technology, which ensure a long lifetime and robust performance under varying ambient conditions and harsh environments.

Industrial testing of the laser's capabilities

In collaboration with Swerim, a leading industrial research institute for mining engineering, process metallurgy, material science and manufacturing engineering, the Cobolt Tor XE (0.5 mJ, 1064 nm, <3.5 ns) was evaluated for metal analysis using the LIBS technique. The experimental setup included the Cobolt Tor XE laser to generate a plasma, a set of optical components for beam shaping and light collection into an optical fiber, and a spectrometer for the spectral material content analysis (Fig. 3). The laser was operating in the internal trigger mode at a repetition rate of 1 kHz, and the spectrometer integration time was 100 ms. The laser beam was expanded by a factor of 3 before being focused onto the sample to an estimated spot size of about 100 µm. The

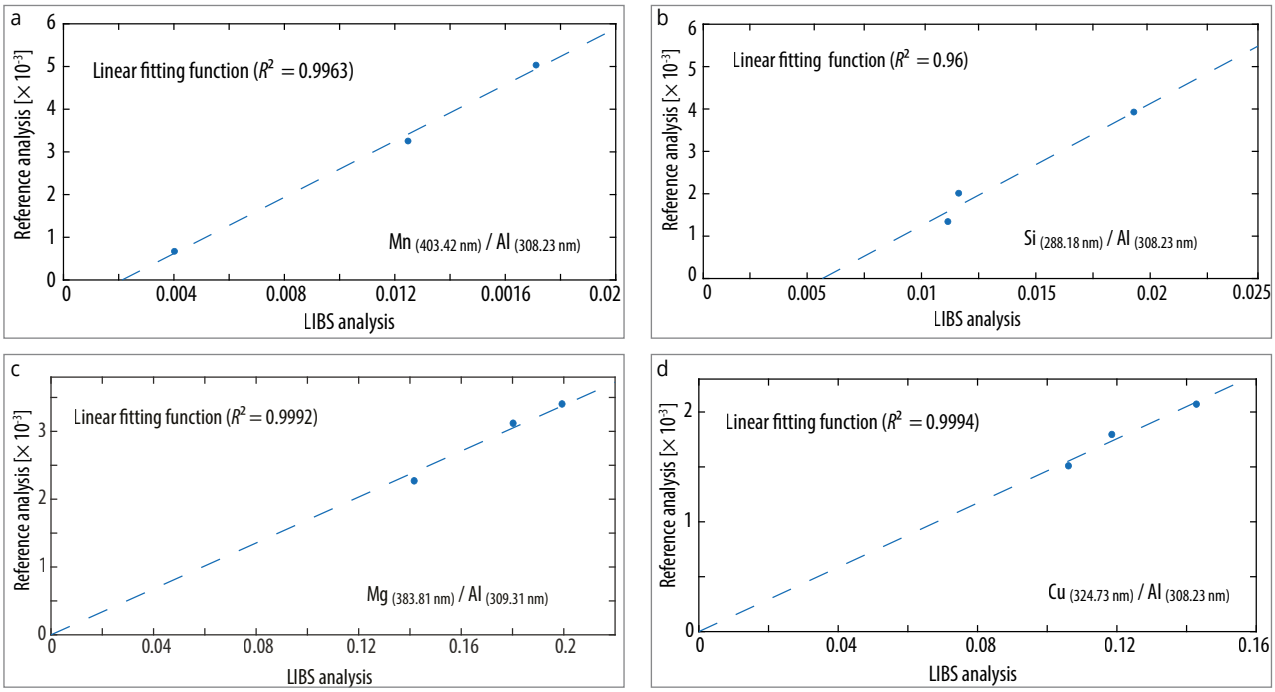


Fig. 5 Calibration curves for material content analysis of Mn, Si, Mg and Cu (a – d), where the x-axes shows the ratio of the measured LIBS intensities of spectral lines of an alloying element to matrix element (Al), so-called LIBS analysis, and the y-axes shows the ratio of the known concentration of an element to aluminum, so-called reference analysis. The number of data points on each figure corresponds to the number of the samples.

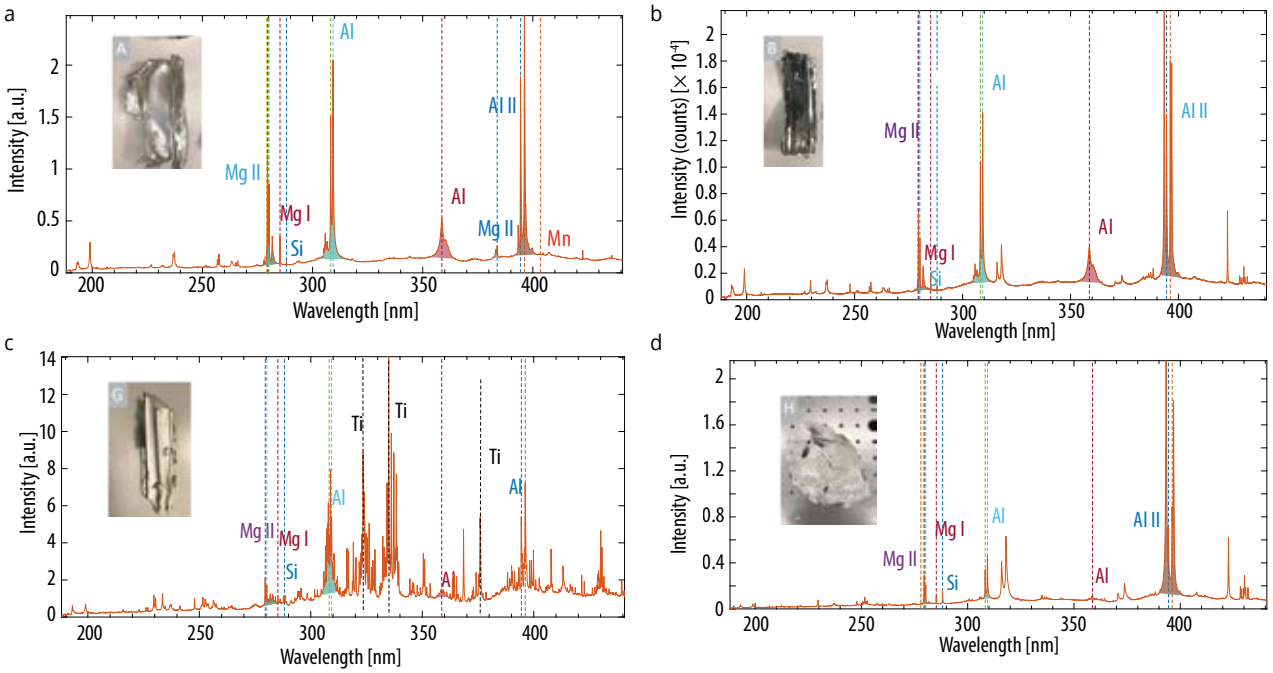


Fig. 6 LIBS spectra of aluminum scrap samples. Samples in (a) and (b) have different alloying content. Samples in (c) and (d) show the presence of surface contamination: Ti from paint (c) and Ca from dust or dirt (d).

sample was placed on a rotating holder to get a representative analysis of the material content and to avoid plasma fading due to material destruction. The light from the generated plasma was collected by a focusing mirror placed ≈50 cm from the sample surface into a multimode optical fiber (with the core diameter of 600 µm), connected to an Ibsen UV-CMOS spectrometer.

An example of the measured LIBS spectrum for an aluminum-based sample containing Si, Mg, Mn, Cu as alloying elements is shown in Fig. 4. The measurements of the LIBS signal for a series of aluminum reference samples demonstrated that the limit of detection, or the concentration sensitivity of the experimental setup, lies below the lowest concentration detected for the reference samples, that is 0.12 % for Si and 0.06 % for Mn.

For quantitative analysis of samples, the LIBS system needs to be calibrated with the use of reference samples for which the element content is known from alternative methods (e.g. X-ray fluorescence (XRF), glow discharge optical emission spectroscopy (GDOES)). Calibration of the LIBS system is done by first measuring the LIBS signals of the reference samples, which are then correlated to the known element contents.

Since the LIBS signals can fluctuate due to different factors (for instance, surface inhomogeneity, energy density fluctuations), it is common to consider the intensity ratios of the LIBS signals of alloying components to the matrix element (i.e. main material element) in the calibration. For instance, in the LIBS spectrum shown in Fig. 4, one identifies the emission lines corresponding to the alloying elements Si, Cu, Mg and Mn in the aluminum matrix. So for each element to be analyzed (in this example Si, Cu, Mg and Mn), the LIBS intensity ratio is the ratio of the intensity of the individual spectral peak of that element to the intensity of the spectral peak of the matrix (Al in this case).

The correlation between the LIBS intensity ratio and the ratio of known element concentrations of the reference samples constitutes the calibration curve that can then be used to determine the concentration of alloying elements in unknown samples. Typically, to ensure accurate and quantitative measurements, the LIBS system is calibrated with the use of several (minimum ten) reference samples with a known concentration of constituent components. An example of the correlation is presented in Fig. 5. In this study, however, the number of reference samples was limited to three and therefore it was not possible to make an accurate calibration, and hence a quantitative analysis of samples of unknown composition. Nevertheless, Figs. 5a – d can be seen as pseudo-calibration curves for alloying elements (Mn, Si, Mg and Cu correspondingly). Fig. 5a represents the correlation of the LIBS intensity ratio of 403.42 nm spectral line of Mn to the 308.23 nm spectral line of Al (matrix element) to the ratio of element concentration measured in the reference analysis (Mn / Al), where the number of data points corresponds to the number of the samples tested. Figs. 5b and 5d represent the intensity ratio of Si (288.18 nm), Cu (324.73 nm) to the same spectral line of Al (308.23 nm), while Fig. 5c shows the intensity ratio of Mg (383.81 nm) to another spectral line of Al (309.23 nm).

It is important to note that each element in the material analyzed might have several emission lines that might be considered for calibration. For accurate

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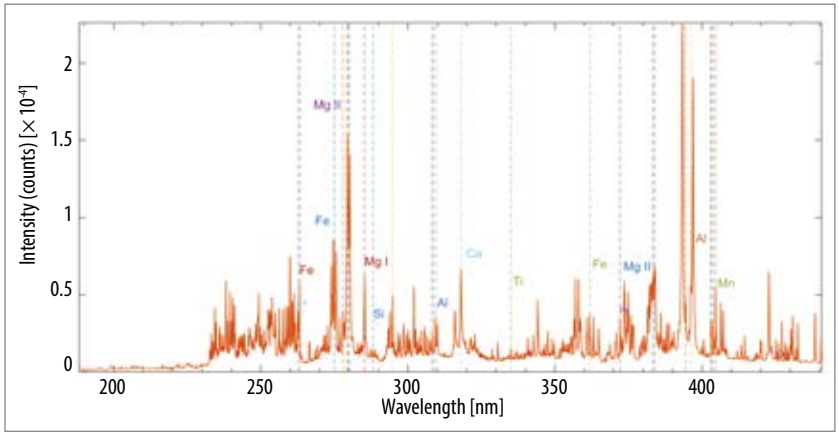

Fig. 7 LIBS spectrum of slag material obtained with the Cobolt Tor XE

quantitative LIBS analysis, it is crucial to choose emission lines for which phenomena such as self-absorption and line interferences are minimal. For example, Mangan in Fig. 4 has three emission lines at 403.08 nm, 403.31 nm and 403.42 nm. In the calibration curve in Fig. 5a, this is the emission line at 403.42 nm, which gives a better calibration curve (i.e. higher R^2, the goodness-of-fit measure). The curves in Fig. 5 are linear for all elements (Si, Mn, Cu, Mg) .with high *R*2, which is satisfying and indicates the correctness of the choice of the spectral lines for LIBS analysis.

Similar LIBS measurements were performed on aluminum scrap samples with a rough (not planar, thickness variation of ca. 5 mm) and dusty surface with unknown alloying elements. Detectable LIBS signals were achieved (Figs. 6a–d) while rotating the scrap samples. The spectra presented are integrated over the ten measurement points (i.e. 100 ms exposure time). The spectra of the samples in Figs. 6a and 6b clearly indicate the presence of different alloy content, for example Mg and Mn. A high sensitivity to surface contamination was observed for the samples in Figs. 6c and 6d. The LIBS spectrum in Fig. 6c shows clear spectral lines of Ti, which originate from a paint on the surface and are superimposed on the Al spectrum. Fig. 6d indicates that the sample surface is contaminated with dirt, as spectral lines of Ca (at around 320 nm) overlap with the aluminum spectra. The sensitivity of the LIBS signal to the surface contamination can be considered as an advantage for studies related to surface analysis.

Using the same experimental setup, a representative LIBS signal was also obtained for a slag sample, which typically has a rough surface and is quite inhomogeneous (Fig. 7). The spectral lines of typical slag elements (Ca, Mg, Si, Fe, Al) are clearly observed and show that this setup could be used for slag analysis. The slag composition is often a key parameter in both process and product development in steel and iron-making.

Outlook

The LIBS technology has great potential for applications in various tools for industrial and in-field material analysis. This study has demonstrated how a compact, high-repetition rate, ns pulsed, 1064 nm laser with 0.5 mJ pulse energy in a high-quality beam enables detailed analysis of metal samples using a conventional LIBS set-up. Despite the small number of reference samples, the results obtained are promising and confirm the practical applicability of a LIBS system based on this compact, self-contained laser for quantitative LIBS analysis. The high-quality laser beam with short nanosecond pulses and low pulse-to-pulse jitter results in high energy densities and efficient synchronization with detection, thereby providing strong LIBS signals that enable analysis with a high level of sensitivity and specificity, all with sub mJ pulse energies. The compact size of the air-cooled Cobolt Tor XE laser with all electronics integrated into the laser head can drastically reduce the size of the LIBS system, making it suitable for use in bench-top analytical instrumentation.

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Authors

Elena Vasileva is the product manager for pulsed lasers and regional sales manager at Hübner Photonics. Elena holds two MSc degrees in technical physics from the Lappeenranta University of Technology (LUT) and in electronics from Saint-Petersburg Electrotechnical University (LETI), and a PhD degree in laser physics from the KTH Royal Institute of Technology in Stockholm, Sweden.

Mélina Gilbert Gatty is a project leader at Swerim AB. She holds an MSc in materials science from the European School of Chemistry, Polymers and Materials (ECPM) in Strasbourg, France. She obtained a PhD at Chalmers University of Technology (Gothenburg, Sweden) in 2015 in laser-based spectroscopy techniques.

Dr Elena Vasileva, Cobolt AB, a part of HÜBNER Photonics, Vretenvägen 13, 171 54 Solna, Sweden; phone: +46 8 545 912 30; e-mail: elena.vasileva@coboltlasers.com, Web: https://hubner-photonics.com ■ Dr Mélina Gilbert Gatty, Swerim AB, Box 7047, 164 07 Kista, Sweden; phone: +46 10 489 09 70, e-mail: info@swerim.se, Web: www.swerim.se

Source: Wiley

Source: Palexpo

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Positive results – "first victory" scored

Review: 19th EPHJ, Geneva, Switzerland

Source: Palexpo

In a delicate event context during a period of health crisis, the satisfaction and attendance indicators at the end of the EPHJ trade show are encouraging. The exhibitors were present and the exhibition recorded 12,200 visitors.

As the doors of the EPHJ trade fair – the largest international one for the high-precision sector and the largest in Switzerland for medical technology – close after four days of activity, the organizers draw a positive balance sheet for this edition. "We had to wait 27 months before we could finally get together," explains Alexandre Catton. "This is a long time for the companies we are promoting. Much too long because digital technology will never replace human contact. We have verified this during this week and the testimonies of the exhibitors, as well as the visitors, all point in the same direction!"

These exhibitors knew, as did the organizers, that this edition of EPHJ would be smaller with slightly fewer visitors. However, the 12,000 visitor mark was passed, compared to 20,000 in a normal situation. "This is a first victory for EPHJ," says Alexandre Catton. "From now on, if the pandemic will leave us alone, we will concentrate on our 20th edition, which will be held in June 2022, to return to our traditional format."

The 530 exhibitors present appreciated the high quality of the visitors who came to sign deals or with encouraging prospects of concluding them soon.

In the current health context, it is worth noting that 25 % of the 530 exhibitors present came from abroad, representing 13 countries. The Swiss cantons most represented among the exhibitors were, in order, Neuchâtel (94), Jura (66), Bern (64), Geneva (55), Vaud (45) and Zürich (16). Another revealing statistic: while 90 % of exhibitors declared a watchmaking activity and 59 % a microtechnology activity, nearly 50 % of them now had a medtech activity. Proof of an increasingly strong medical diversification.

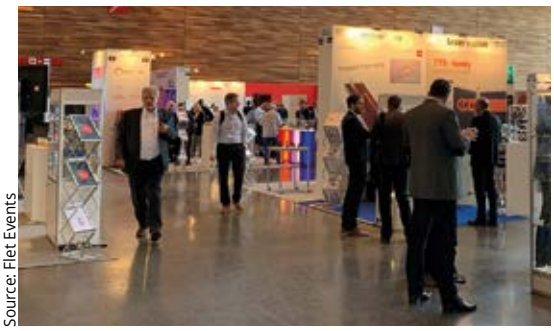
It should also be remembered that the 2021 Exhibitors' Grand Prize was won by the company STS. Elected by its peers, STS was rewarded for its alternative solution to rhodium, which has become the most expensive metal in the world: an innovative alternative developed with white platinum that allows certain parts of the watch movement to be covered with the same properties and the same look as rhodium.

After the closing of this 19th edition, the EPHJ trade show returns from 14 – 17 June 2022 at Geneva-Palexpo.

https://ephj.ch

#WeOpenAgain

Review: W3+ Fair Rhine Valley, Dornbirn, Austria



Source: Fleet Events

On 23 September 2021, the two-day network fair for enabling technologies, came to an end in Dornbirn, Austria. A successful restart after the lockdown: the live event attracted many interested trade visitors from the Rhine Valley to the exhibition center, where they were able to discuss the latest technological developments with approximately 120 exhibitors, partners, sponsors and speakers. Big players like Swarotec, Bruker, Swiss Optic, Materion Balzers Optics and OptoTech but also many SMEs used the interdisciplinary meeting to position themselves for the future with new contacts and partners. In total, companies and networks from seven countries were represented at the event. More than 35 top-class expert speakers, including speakers from Thyssenkrupp Presta, Fraunhofer, CSEM, SIE Solutions, EOS, Zeiss Industrial Quality Solutions, Fisba, ACM Coatings and FH Ost shared their knowledge at the accompanying N-Tec Talks conference as well as at the EPIC TechWatch. The special area for 'Additive Manufacturing / 3D Printing' also attracted interest, where AM pioneers presented a world first with the Wizard 480+, the industrial 3D printing system from APS Techsolutions.

The W3+ was opened by Marco Tittler, Vorarlberg's state councillor for economic affairs, and Andrea Kaufmann, mayor of Dornbirn. Dr Heinz Seyringer, CEO of Photonics Austria, and Werner Kruesi, president of the photonics industry sector at Swissmem, spoke at the opening of opportunities and possibilities for cross-disciplinary and cross-national co-operation and thus the potential of the fair. In its second year, the trade show and conference has secured the support of politicians and business leaders in the high-tech region. In the future, it is expected to be the central knowledge and exchange platform for resident companies in the four-county region, as well as the gateway for experts seeking access to the high-tech location.

The exhibitors also took the opportunity to network intensively among themselves. The networking aperitif, hosted by Swissphotonics, provided a good opportunity for this. Afterwards, the invitation was made by organizer Fleet Events with the support of Swissmem to the exhibitors' evening W3+ and Friends, which was very popular after the Corona break.

The photonics networks Photonics Austria, Swissphotonics as well as EPIC supported the W3+ Fair Rhine Valley as gold partners. A total of 16 trade associations and sponsors contributed their expertise and contacts.

In 2022, the W3+ Fairs will be held in Wetzlar, Germany, on 16 – 17 March, and in Dornbirn on 30 November – 1 December.

https://w3-messe.de

'The Days' are back!

Review: Photonics Days 2021, Berlin, Germany

The Photonics Days 2021 from 4 – 7 October were organized by OpTecBB eV, Cluster Photonics Berlin Brandenburg, and Enterprise Europe Network Berlin-Brandenburg in Berlin Adlershof at the premises of Wista. The Berlin Brandenburg region is a start-up hotspot for digital and photonic technologies and an innovation hub for the key technologies of tomorrow. This year, 26 different sessions of different durations were organized, some just online and some hybrid. About 520 participants were registered for the whole event. Leading international experts gathered information in numerous English-language seminars on the latest findings from all areas of photonics. The contributions covered optics, quantum technologies and microsystems technology.

A new important part of optical analytics and optical spectroscopy is a cross-sectional technology with a steadily growing stake in the global market: hyperspectral imaging. It is a combination of two-dimensional imaging and optical spectroscopy. Additional spectral information becomes available for each pixel or area. Prof Dr Martin Roth (Leibniz Institute for Astrophysics) gave a lecture on high-resolution hyperspectral technologies, from astronomy to medical technology. Prof Dr Stephan Reitzenstein (TU Berlin) demonstrated entirely new concepts of quantum-enhanced sensing, information processing, and secure communication. Various seminars were held and co-designed by scientists from Berlin universities and research institutes, including Prof Dr Ronald Freund, Fraunhofer Heinrich Hertz Institute (HHI) and Dr Markus Krutzik (HU Berlin). The Ferdinand Braun Institute, Leibniz Institute for High Frequency Technology (FBH) presented the latest developments in diode lasers and UV LEDs.

The conference reviewed promising developments in quantum technology and focused on entrepreneurship to provide a platform for the efficient and fruitful exchange of information between academia and industry. The Third European Workshop on Optics for Solar Energy, organized by the Helmholtz Excellence Network SolarMath reviewed current

Source: OpTecBB

trends and recent developments in optics and nanophotonics for solar energy conversion devices. A new technology was recently developed with the PolyPhotonics Berlin technology platform that is superior to the established approaches in many ways.

The goal of the Photonics Days Berlin Brandenburg was to bring the regional and international photonics community together again – helped considerably by Wista GmbH and Berlin Partner für Wirtschaft und Technologie. The conference was sponsored by a number of companies, including Fisba and Exfo. *cb*

https://photonics-days-berlin-brandenburg-2021.b2match.io

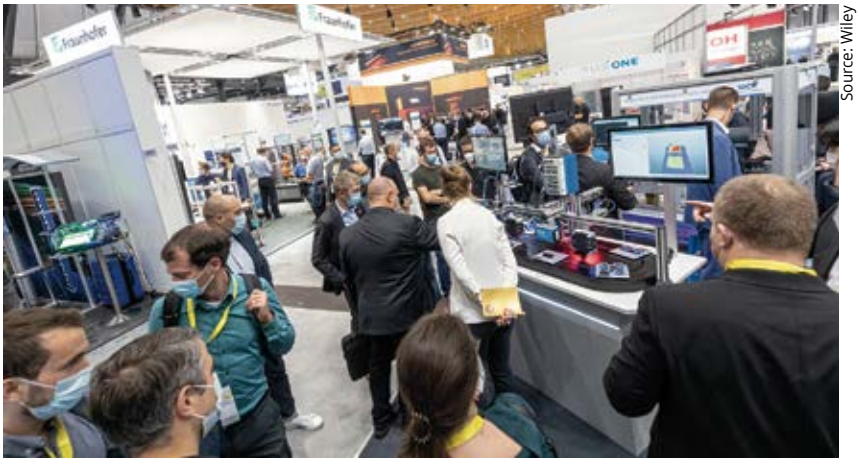
"Brilliant restart"

Review: Vision 2021, Stuttgart, Germany

For the first time in three years, the machine vision industry made its pilgrimage back to Stuttgart for Vision. It all took place on a smaller scale – fewer exhibitors and visitors than in 2018 – but the joy in view of the reunion outshone everything.

Some 5,400 trade visitors attended the new start after two years without the Vision event, about half as many as in 2018. Proportionally more represented were the exhibitors, of whom around 300 came instead of 470 before, almost two-thirds. And logically, the visitors came mainly from Europe: the top ten nations of origin, apart from Germany, were Italy, Switzerland, France, Austria, the Netherlands, Belgium, Spain, Poland, the UK and Sweden. Contrary to expectations, visitors also came from the USA, Korea, Japan and Taiwan, despite travel restrictions and quarantine regulations.

In Stuttgart, they met representatives of the exhibiting companies who



Source: Wiley

were in excellent spirits. Even on the last set-up day before the start of the trade show, there was a cheerful euphoria that lasted for the entire duration of the trade show. Also fed by the high meeting quality, as the enterprises stressed throughout: "Yes, there are noticeably fewer visitors there, but almost without exception potential customers and customers speak to us because of concrete projects," was a conclusion, which one heard in many variants from nearly all companies.

This fits in with the results of a flash survey conducted by the European Machine Vision Association EMVA in the run-up to the trade show. This confirmed the importance of trade fairs for

the companies, because sixty percent of the participants stated that they had only been able to reach new customers to a limited extent in the last twelve months without personal meetings. These use the trade fair precisely for this purpose.

Incidentally, according to a survey conducted by Messe Stuttgart among visitors, 95 percent confirmed that they always felt safe with the corona measures in place – 3G plus distance and hand disinfection. The fact that the trade fair was now divided between the two halls 8 and 10 instead of the one large Hall 1 certainly also played a significant role here. This – in combination with the smaller number of exhibitors – allowed for significantly wider aisles and a relatively airy stand construction overall. For their part, the high ceilings and daylight helped to convey a sense of openness and airiness to attendees.

VDMA forecasts strong industry growth

This positive mood was also matched by the hard facts provided by the VDMA Machine Vision, the conceptual supporter of the trade fair at its opening, it confirmed that the order books of the machine vision industry were full to bursting and that demand for components and systems was constantly high. Looking back at 2020, sales in the European machine vision industry did fall by four percent compared to 2019, but the VDMA expects sales in the European machine vision industry to have grown by seven percent again in the current year 2021.

Only the persistent chip shortage worldwide is causing anxiety among those responsible: "Camera manufacturers and system integrators alike – there is virtually no company that is not suffering from the chip shortage. While this is not causing a market decline, it is dampening growth prospects," says Mark Williamson, managing director of Stemmer Imaging Ltd and the new chairman of the VDMA Machine Vision department (cf. 'Organizations' section, p. 20).

Highlight: the Industrial Vision Days

In addition to the trade show itself, the Industrial Vision Days, organized by VDMA Machine Vision, once again took place. On all three days of the show, the forum offered numerous presentations as well as two panel discussions that complemented the input from exhibitors.

Of particular note was the panel discussion on "Deep Learning: Much ado about nothing, again?", which featured five distinguished experts: Dietmar Ley (Basler), Jens Hülsmann (Isra Vision), Olaf Munkelt (MVTec Software), Mark Williamson (Stemmer Imaging) and Donato Montanari (Zebra Technologies). The entire Industrial Vision Days were recorded and are available on demand at www.messe-stuttgart.de/vision/besucher/industrial-vision-days/

The next Vision will take place from 4 – 6 October 2022, again in parallel with the Motek trade fair. From then on, the machine vision trade show is again scheduled to take place every two years.

www.messe-stuttgart.de/vision

Preview: SPIE Photonics West

SPIE. PHOTONICS WEST

22 – 27 January 2022, San Francisco, United States

SPIE is delighted to be planning the in-person return of Photonics West to San Francisco's Moscone Center on 22 – 27 January 2022. Highlights of the symposium – which include Opto, Lase, and Bios conferences – will feature a plethora of social and networking sessions; the SPIE Startup Challenge; the glamorous, industry-oriented Prism Awards; a translational research forum; the new industry-focused Quantum West; and two world-class exhibitions.

Bios Expo will run 22 – 23 January, featuring the top global biomedical and biophotonics solutions and innovations. Premier photonics and laser exhibition Photonics West will run 25 – 27 January and welcome attendees with the best lasers, components, instruments, and system providers from around the world.

The ever-popular Bios Hot Topics will help kick off the weekend with Wei Min of Columbia University, Osamu Matoba of Kobe University, Dan Zhu of Huazhong University of Science and Technology, Irina Larina of Baylor College of Medicine, Aydogan Ozcan of the University of California, Los Angeles, Maria Angela Franceschini of Massachusetts General Hospital, Harvard Medical School, and Lihong Wang of Caltech. Other confirmed plenary speakers include Stanford University's Hongji Dai for Nano/Biophotonics, as well as Nagoya University's Hiroshi Amano, Nokia Bell Labs' Andrea Blanco-Redondo, and Stanford University's Jelena Vuckovic for Opto. Further plenary speakers will be announced soon.

In addition, SPIE Photonics West paid attendees have complimentary access to the co-located SPIE AR | VR | MR conference, which runs 23 – 25 January. SPIE AR | VR | MR is the leading XR hardware event, inviting the latest, visionary perspectives from technology leaders working in the largest AR, VR, and MR companies, startups, and suppliers.

The exciting SPIE Photonics West industry program – sharing and addressing the latest industry insights for everyone from engineers to CEOs – will showcase a job fair, a Photonics Cluster reception, and sessions that cover a wealth of technologies, applications, and developments, from microLEDs and the ongoing evolution of OCT to the latest in industry trends and initiatives.

"We're excited to bring the international photonics community back to San Francisco to reconnect at Photonics West in January," says SPIE senior director of technical programs Marilyn Gorsuch. "We are looking forward to connecting face-to-face and providing opportunities for networking and collaboration to support the world-class research and applications, industry developments, and technology innovations that are presented at Photonics West."

SPIE, the international society for optics and photonics, prioritizes the health and safety of its staff and global community. Following the guidance of government and public health professionals, everyone who attends Photonics West will be required to submit proof of Covid vaccination. SPIE will be carefully monitoring local, state, and national health regulations for any updates and changes.

For the latest information and updates please visit

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Editorial:
Dr. Oliver Dreissigacker (od; responsible)
Phone: +49 (0)6201 606-181

Boschstr. 12, 69469 Weinheim, Germany
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Contributing Editors:
Dr. Christel Budzinski (cb)
Carsten Heinisch
Jan Oliver Löfken

Copy editing: Matthias Erler, David Jayne

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

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

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

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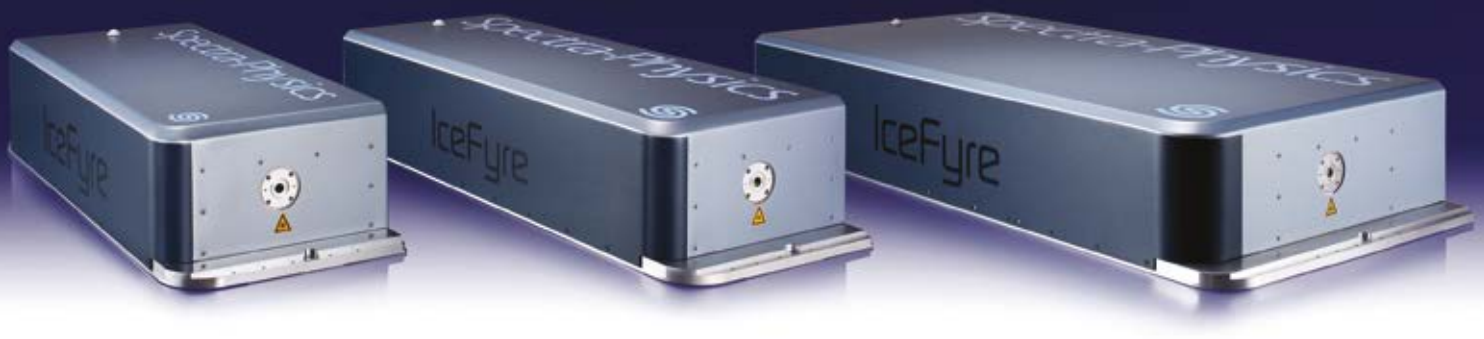

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