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Advanced Fiber Technology
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Photonics: Science to Market

Pushing the frontiers in photonic physics (now often called "quantum"), SMEs translate this knowledge through innovation into products

Photonics is recognized as a key technology for the 21st century, as evident with 17 Nobel laureate prizes to 33 scientists since 2000 and its omnipresent use in modern equipment, production, or communication tools. Photonics has become so dominant in pushing the frontiers of physics that photonics-related Nobel prizes now cover the fields of solid-state physics, quantum physics, astronomy, time measurement, and general relativity. There is so much momentum that additional discoveries and related Nobel prizes can be expected in the future, and the industry will collect the fruits by translating these discoveries into products, revenue, and profit.

With Photonics, completely new technologies and combinations of technologies are available that are important for various growth markets. Photonics is very interdisciplinary and a fundamental driver of technologies, processes, and applications. Photonics technologies play an essential role in solving the big challenges of the global society, such as health, ecology, and digitalization.

Photonics is the basis for the success of big technology companies producing the solid state components, lighting, solar cells, displays and cameras that have delivered ever improved performance at ever lower prices to our society. All these products are based on novel, artificially engineered materials that efficiently transform light into current and vice versa. But even more important are the applications based on these technologies, be it smartphones or autonomously driven cars with an abundance of data driving the field of digital signal processing and artificial intelligence.

Photonics is such a diverse enabling technology that only a limited range of applications can be driven by big companies, and so the most fruitful field is in the hands of highly skilled and very flexible small and medium-sized companies covering a tremendous range of markets. SMEs that have a close connection to leading scientists at universities, and professors who work as consultants at SMEs are key to driving this innovation. The speed from science to market is key for success as the first on the market can profit from higher prices.

There will be many opportunities for companies to reap the fruits of applying our continuously increasing knowledge in science to the market.

Yours truly

Christoph Harder

Dr. Christoph Harder
president
SwissPhotonics
CEO Harder & Partner

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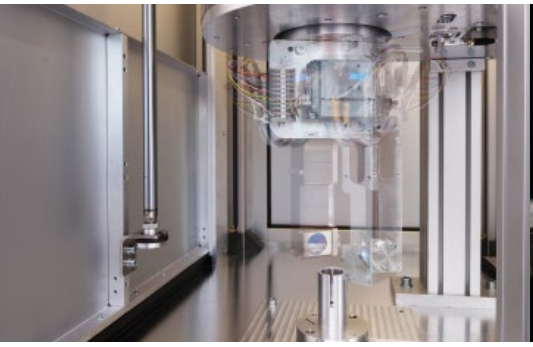

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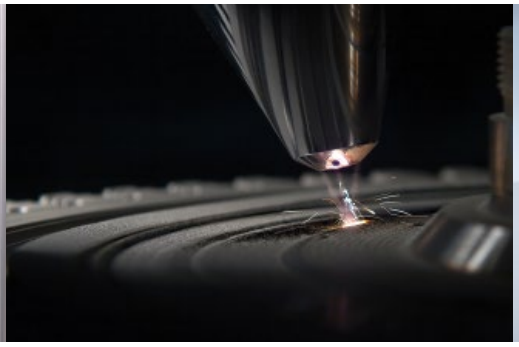

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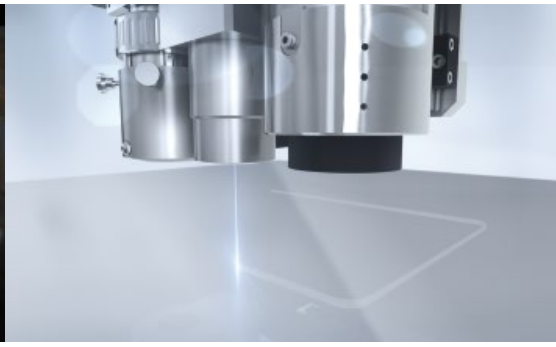

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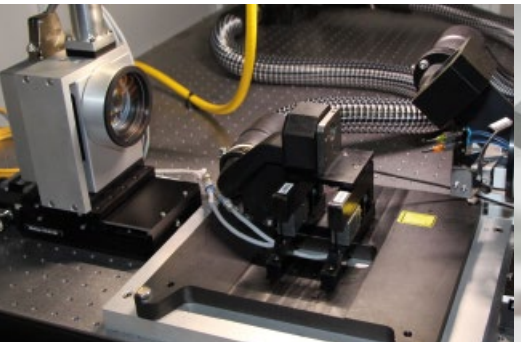
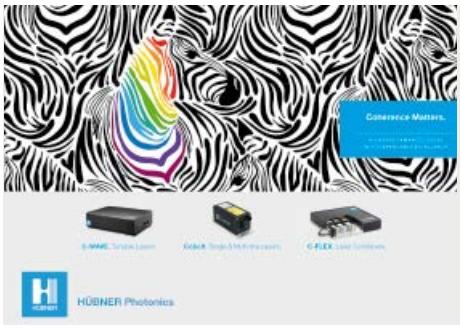




Cover:

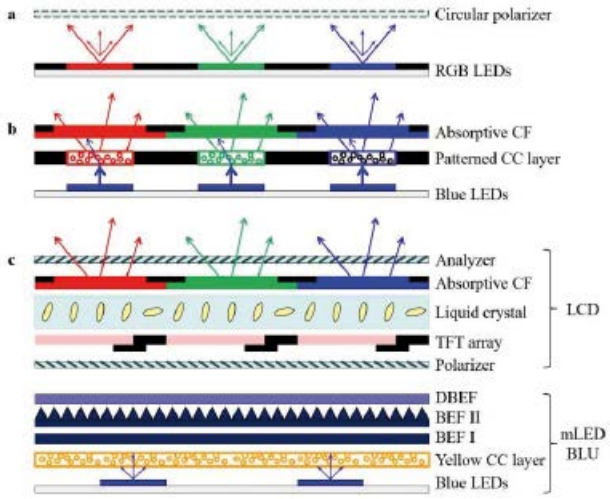
Coherence Matters! Making light work in superresolution microscopy with the new Hübner Photonics Cobolt Rogue 640 nm laser, p. 22

Mini-LED, Micro-LED and OLED Displays: Present Status and Future Perspectives

Display technology has become ubiquitous in our daily life; its widespread applications cover smartphones, tablets, desktop monitors, TVs, data projectors and augmented reality/virtual reality devices. A team of scientists, led by Shin-Tson Wu from the College of Optics and Photonics, University of Central Florida, USA, has conducted a comprehensive analysis of the performance of emissive displays and mini-LED backlit LCDs. This group evaluated the power consumption and ambient contrast ratio of each display in depth and systematically compared the dynamic range, motion picture response time, color gamut, and adaptability to flexible and transparent displays.

Each display technology has its strengths and challenges: conventional LCDs have a long lifetime and low cost, but their contrast ratio and flexibility are limited. OLED displays offer unprecedented dark state and an ultrathin profile, but their lifetime and burn-in issues remain to be overcome. Lately, mLED/µLED displays are promising to provide high luminance, a long lifetime and compatibility to flexible and transparent displays, but the chip size effect puts the performance on high-resolution density AR/VR displays into question, not to mention the low manufacturing yield and high cost. Technology development and manufacturing readiness fall years behind every time a new method springs.

"After investigating, we found all of these display technologies support superior performance in a number of criteria except for several trade-offs," the scientists summarized. "(1) In achieving high luminance for HDR, mLED-LCDs require careful thermal management, and OLED displays would compromise the lifetime. (2) Transparent display is not the best stage for non-emissive LCDs. (3) The power efficiency and ambient contrast ratio depend on the mLED/µLED/OLED chip size. To achieve the same ambient contrast ratio, mLED backlit LCDs require a comparable power consumption to OLED displays, while the polarizer-free mLED/µLED emissive displays could be three times more efficient." In the coming years, mLED/µLED emissive displays could gradually move toward the central stage as their cost becomes more acceptable, the scientists forecast.



RGB-chip mLED/µLED/OLED emissive displays (a), color conversion mLED/µLED/OLED emissive displays (b), mini-LED backlit LCDs. CF: color filter; CC: color conversion; TFT: thin-film transistor; DBEF: dual brightness enhancement film; BEF: brightness enhancement film; BLU: backlight unit (c; source: Y. Huang, E. Hsiang, M. Deng and S. Wu)

Reference: *Y. Huang, E. Hsiang, M. Deng* et al.: Mini-LED, Micro-LED and OLED displays: present status and future perspectives. Light Sci Appl **9** (2020) 105; DOI: 10.1038/s41377-020-0341-9

http://english.ciomp.cas.cn

InnoLas Solutions Trust Scanlab Service

InnoLas Solutions, specialist for laser systems in micromaterials processing, has announced its collaboration with Scanlab, a manufacturer of scan solutions to guide and position laser beams. The joint expertise lays the groundwork for the realization of extremely complex customer projects for laser micromaterials processing.

Large-surface laser micromaterials processing comes with particular challenges. Together with Scanlab, InnoLas Solutions has conceived the Infinity Scan. The accuracy in processing and throughput in production are increased by integrating both companies' technologies, which creates added value for the customer.

"We are delighted by our partnership. Together, we can meet the specific demands customers place on highly integrated laser systems for micromaterials processing and especially serve the European market," explains Dr Holger Schlüter, head of business development at Scanlab.

The flexible Infinity Scan technology builds on the XL SCAN by Scanlab. Among other things, it is used in the processing of large surface micro materials to cut glass or foil or to drill PCBs. No stitching errors occur by processing the pattern as a whole, while pulse on demand (POD) guarantees extreme precision.

www.scanlab.de
www.innolas-solutions.com

MVTec Opens New Subsidiary in China

MVTec Software, an international provider of machine vision software, is strengthening its presence in China. The Munich-based company has opened a branch near Shanghai, named 'MVTec Vision Technology (Kunshan)'. MVTec has been operating successfully in the Chinese machine vision market for more than ten years. Together with its proven Chinese sales partner, Daheng Imaging, it is increasing its presence and support in China to capitalize on the enormous growth potential of that market.

As in many other countries, MVTec will establish a dual distribution model in China – serving its customers through its trusted distribution partner Daheng as well as serving customers directly – in order to take advantage of synergies on both sides. In this way, the two companies complement one another and gain even better market access to other industrial sectors.

The subsidiary is based in the German industrial park in Kunshan. It serves as a sales and technical support office, thereby providing closer relationships with local customer companies. Businesses and users in China will benefit from even easier access to new technologies and features, such as deep learning, embedded vision, 3D vision, matching, identification, and measuring.

www.mvtec.com

SPI Lasers Rebrands under Trumpf Banner

Source: SPI Lasers

High-technology company Trumpf has announced a close business cooperation between Trumpf Laser- und Systemtechnik GmbH and SPI Lasers UK Ltd., which are both wholly-owned subsidiaries of the Trumpf Group. Trumpf Laser will combine the business operations of SPI Lasers to bring advantages in industrial applications by employing both disk and fiber technology and enhance customer service offerings. As of the 1st July, SPI Lasers products began to be available through the Trumpf sales channels.

SPI Lasers has been operating since 2000, with its major business operations, including R&D and manufacturing, in the UK and its headquarters in Southampton. It has been a wholly-owned subsidiary of Trumpf since 2008 as experts fiber laser design and manufacture. With fiber lasers becoming important laser sources for material processing, both companies agree that "joining forces and integrating SPI Lasers into Trumpf is a sensible move for both companies." This value-enhancing step ensures that SPI customers will benefit not just from high quality fiber laser products but also first-class standards of customer service. In addition, both companies are expecting synergy effects and an improved cost structure, for example in R&D.

The relevant steps are expected to be completed in the third quarter of 2020.

www.trumpf.com
www.spilasers.com

Materion Acquires Optics Balzers

Source: Optics Balzers

On June 8, 2020, the US-based Materion Corporation announced it has entered into a definitive agreement to acquire Optics Balzers AG in an all-cash transaction.

"We are serving one of the most attractive growth markets and the key factor of success is growth," Detlev Haeusler says. He is CEO of Optics Balzers which has headquarters in Liechtenstein and sites in Germany and Malaysia, generating a total revenue of $ 67 M per year. It is a privately held industry partner for the development and production of coated optical components and subassemblies and a leading provider of optical thin film coating solutions. To consistently follow its growth strategy, Optics Balzers' shareholders decided to sell to Materion, a leading a provider of precision coatings and advanced materials from Ohio, USA, which generated total sales of $ 1.2 B in 2019.

Materion will take over 100 % of the shares, expected in the third quarter of 2020. "We assume that all employees in all sites will be taken over because the focus of the company's acquisition is on growth rather than on cost reduction. With this acquisition, Materion significantly expands its geographic reach in the optical coatings market, extending beyond its core of North America to include Europe and Asia.

www.opticsbalzers.com
https://materion.com

Bystronic Takes Over Weber Laserservice


Source: Bystronic

Increased know-how, a pooling of forces, and an even stronger focus on the requirements of the customers: on May 1, 2020, Bystronic Benelux BV, based in Meerkerk in the Netherlands, took over 100 % of Weber Laserservice BV, located in the Dutch village of Heteren.

"With the acquisition of Weber Laserservice, which has an excellent 15-year track record on the Benelux and German markets as well as in other countries and specializes in Bystronic machines, we are achieving several goals at once," says Marco de Jong, managing director of Bystronic Benelux: "This move will make us a large service and support organization in the increasingly dynamic market, and this both on-site with our customers and in the back office." Patrick van den Berg and Martin van de Weg, former owners of Weber Laserservice, add: "We are delighted that we will now be an integral part of our preferred partner Bystronic."

Weber Laserservice specializes in the maintenance, training, installation, and sales of Bystronic laser cutting machines and also plays an important role in the second-hand market for laser cutting systems. "There will be no staff layoffs, because customer support is of the utmost importance to us," de Jong emphasizes.

www.weberlaserservice.nl
www.bystronic.nl

Berliner Glas Group Becomes Part of ASML


Source: Berliner Glas

Berliner Glas and ASML, an international manufacturer of chip-making equipment, have signed an agreement whereby ASML acquires all shares of Berliner Glas KGaA including all subsidiaries. With this transaction, ASML will acquire technical capabilities that are important to support the future roadmap for its EUV and DUV products. Business units that operate in other markets will also be acquired.

"We are proud to have contributed to the success of ASML's lithography technology over the past thirty years, and our collaboration with ASML is already very close", said Herbert Kubatz, owner of the group. "We are excited by the opportunity to make a bigger contribution to innovation in the semiconductor industry as a part of ASML, while we retain the focus to be successful in the other markets that we serve," added group CEO Andreas Nitze.

"We intend to manage Berliner Glas in a way that allows these businesses to remain focused on serving their customers with products that are tailored to their needs," said Frits van Hout, ASML's chief strategy officer.

The management team of the Berliner Glas Group will continue to run the company. The acquisition should be completed before the end of 2020. Financial details were not disclosed.

www.berlinerglas.com
www.asml.com

Nanoscribe Opens Microfabrication Experience Center

Located in the Zeiss Innovation Hub at the gates of Campus North of the Karlsruhe Institute of Technology KIT, the Nanoscribe Microfabrication Experience center offers state-of-the-art equipment, with the capability of

The Microfabrication Experience Center is a high-end facility with equipment for nano, micro and mesoscale additive manufacturing. (Source: Nanoscribe)

hosting events for up to one hundred people in a total of 270 square meters. Visitors can experience all aspects and facets of 3D microfabrication. The Demolab is equipped with both printer lines – a Photonic Professional GT2 and a Quantum X maskless lithography system – and other production and characterization equipment, representing the heart of the center. The center bundles the company's offerings to provide the best possible opportunities to test and validate the feasibility of applications.

The center is also the place for training sessions where new and experienced users practice working with the hardware and software of the 3D printers. In addition, the center connects customers, partners and interested parties in 3D microfabrication with experts to discuss current challenges, developments, and emerging trends. Topics of interest include 3D printing, prototyping, mastering and replication, as well as many more aspects of high-precision additive manufacturing.

www.nanoscribe.de

Eagleyard Photonics Rebrands into Toptica Eagleyard

Toptica Photonics has decided to rebrand its daughter company Eagleyard Photonics into Toptica Eagleyard. It became part of the Toptica group in February 2013 and has since continued to operate separately under its own marketing brand and sales organization.

Dr Thomas Renner, CSO Toptica Photonics, comments: "We have enjoyed the cooperation with our friends and partners in Berlin for many years now. The new common brand will reflect both strong market positions and create even more synergies."

The sales and distribution structure and website toptica-eagleyard.com will remain unchanged and independent. The legal address and company leadership of Eagleyard Photonics will also remain unchanged.

Michael Kneier, VP sales at Eagleyard adds: "We are very happy to combine our two strong brands. This gives us the opportunity to address even more markets with our strong technology and OEM capabilities for laser diodes."

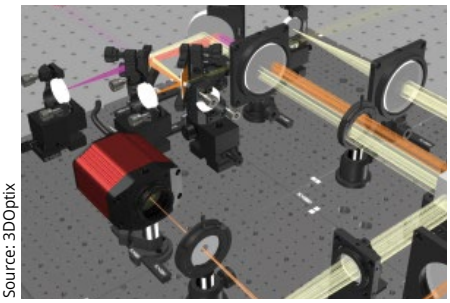
Eagleyard focuses on laser diodes (components) such as DFBs, single-mode, multimode, gain chip and tapered amplifier laser diodes for industry, life science, aerospace, defense and research.Toptica Photonics creates lasers for quantum technology, biophotonics, materials inspection and processing.

Eagleyard, with almost fifty employees, is located in Berlin Adlershof near the Ferdinand Braun Institute, a close cooperation partner.

www.toptica-eagleyard.com

"The Future of Optical Design"

3DOptix, a spin-off company founded in 2017, from the Femto-Nano laboratory at Tel Aviv University, has launched a free, cloud-based optical design and simulation platform into private beta testing. No software installation is needed – the application runs on a standard browser.



Source: 3DOptix

The platform provides remote access to a virtual lab with optomechanics, lasers and detectors. Both professionals and students can run an optical simulation with off-the-shelf optical components from leading vendors or any customized optical elements. The optical design and simulation platform was developed from a deep need to reduce the multiple trial and error iteration in the lab.

Currently, the platform has about one thousand beta testers, more than 20,000 optical elements from 15 different vendors available in the database and off-the-shelf optomechanics with built-in mechanical functionalities.

"In the next twelve months, we are going to launch premium simulation modules. Those modules will not be free of charge," 3DOptix' CEO Gil Noy explains and continues: "In the future, we might develop an enterprise version with enhanced security functions."

https://3doptix.com

New Framos Branch in Zagreb

Framos, a global partner for vision technologies, opened a new branch office in Zagreb, Croatia on May 4th, 2020. This is in addition to its existing research, development, and production facility in Čakovec. The new site places the company closer to the local expert scene, and promises better opportunities to recruit highly skilled specialists for the local team.

For Framos' customers, the expansion of the branch network means even better support for their projects. The new site allows a wider range of products offered and shorter project durations can be achieved.

With headquarters in Germany, Framos has branch offices in Canada, France, Italy, Israel, Russia, the UK, and Croatia. The existing site in Čakovec, the largest city in the Međimurje region, is being retained and developed. Damir Dolar, embedded engineering director and responsible for branches in Croatia, expects the opening to bring exceptional growth opportunities.

The new location is designed for growth. Depending on the situation, approximately twelve people could be employed there by the end of this year. This is an ambitious goal given the currently tight job market where it is hard to locate highly-skilled image processing specialists. The opening will only take place virtually for the time being due to the Covid-19 situation. Framos plans to host a grand celebration later.

www.framos.com

Partnership Provides Fast and Easy Access to Optical Filters


Source: Schott

Edmund Optics and Schott have formed a strategic partnership to enable customers to have access to the highest quality of polished optical glass filters from Schott, with the exceptional customer service and fast shipping of EO. "We are now working even closer together," said Marcus Knöbel, executive vice president of Schott's advanced optics business unit and Samuel Sadoulet, president and COO of Edmund Optics.

Both companies have been working together for more than thirty years and this new partnership will ensure a globally optimal solution to respond to customer needs, especially for small quantities of customized polished optical glass filters. Inquiries for Schott's standard portfolio of optical filters can now be more easily processed through EO. This expansion will also significantly increase the service profile of EO's German manufacturing facility ITOS, that has had a long-term partnership with Schott for over twenty years.

Sadoulet: "We will now be able to offer additional flexible solutions to our customers by applying our leading customer service to an even larger product range."

Edmund Optics and Schott officially expanded this partnership on June 17, 2020, with a 'virtual handshake'.

www.edmundoptics.com
https://shop.schott.com

Well-Positioned for Laser Technology's Fourth Decade

Source: Scanlab

Scanlab's management, Christian Huttenloher, COO (left), and Georg Hofner, CEO

Scanlab is marking its 30th anniversary as an OEM manufacturer of scan systems that guide and position laser beams. Located in the Greater Munich area, Scanlab began small in 1990: for its first five years, the worked from a subleased hundred square meter office with fewer than ten employees. A broader audience saw its self-developed scan head and associated control electronics for the first time at Munich's 1995 Laser World of Photonics – and a success story commenced. By 1999, the company had already hired its 30th employee.

Meanwhile, Scanlab developed into a system supplier, offering a diverse range of galvanometer-based scan solutions. Suitable control electronics and assorted software products rounded out the product palette. Today, Scanlab employs some 380 employees from 38 nations, and supplies customers across countless countries.

Solid fundamentals and financial independence also contribute to the company's favorable prospects. Despite major challenges, like the current Covid-19 pandemic, only limited course corrections were necessary. The only 'downer', as the management call it, is that it cannot celebrate its anniversary in 2020 as it had wanted.

www.scanlab.de

Trumpf Wins Hermes Award 2020

The machine tool manufacturer has won this year's Hermes Award for its Omlox open location product. The award ceremony took place on July 14 at the Hannover Messe Digital Days.

A jury under chair Reimund Neugebauer, president of the Fraunhofer Society, honored 'Omlox – open location standard' as a global and location-technology independent solution. More than sixty industrial companies participated in the Omlox project, which provides the first open standard for location services. It unites all location services available on the market and transfers these into a uniform coordinate reference system, making them available for internal use on edge platforms or for global use in a cloud, bundling position data to enable targeted optimization of process flows. It is an interoperable ecosystem that harmonizes heterogeneous technical infrastructures, making IIoT and Industrie 4.0 affordable for SMEs.

www.omlox.com
www.hannovermesse.de

Omlox team representatives remotely unboxing their Hermes Award 2020 (Source: Deutsche Messe)

Winners of the 3DPC 2020 Awarded Online

Fuel-cooled oil cooler FCOC, using nTop Platform and Ansys CFX, printed in aluminum 7A77.60 alloy from HRL Laboratories. (Source: nTopology / 3DPC)

The 3D Pioneers Challenge 3DPC 2020 took place digitally in its fifth year, with submissions from 28 countries, from 6 continents and the interest of the participants that unites students, young professionals and established companies alike. The 3D Pioneers Challenge was continued as a digital format after the Corona-related cancellation of the RapidTech 3D trade fair in May 2020.

The finalists and winners were selected by the 21 members of the international jury in a multistage selection process. The prize money of 35,000 euros was donated by the Thuringian State, making the 3DPC one of the highest endowed design awards for innovation in 3D printing.

The 1st Prize Winner of the 3DPC 2020 was the University of Toronto's Revere-Tome Handheld Bioprinter, a handheld surgical instrument that uniformly delivers skin precursor sheets over large full-thickness burns to improve wound healing. The team around Richard Cheng was awarded with the prize money of 10,000 euros.

The other eight winners could look forward to prize money of 2,500 euros each.

www.3dpc.io

New Managing Director of Evosys Service

Stephan Nickisch became the new managing director of Evosys Laser Services GmbH on 1st July. This step is considered to be important for the future orientation of the laser systems maker's subsidiary.

He was previously key account manager for the expansion of the systems business at the machine manufacturer Evosys Laser and has been involved in the laser welding of plastics for more than a decade. As managing director, he is now responsible for the further development of the service company, which offers commissioning and maintenance of laser plastic welding systems as well as contract manufacturing and consulting in this field.

Nickisch fits in perfectly with Evosys' corporate concept with its high level of customer orientation, Frank Brunnecker, managing director of the parent company

Source: Evosys

Stephan Nickisch

Evosys Laser, is pleased about this step: "We would like our service subsidiary to continue to be as successful as it has been in recent years and we see Mr. Nickisch as an experienced specialist in the market. Due to his strong commitment he is the ideal manager to further expand this important service. In particular, the customer satisfaction of Evosys Laser Services is to be increased through even better support."

Evosys Laser develops and manufactures tailor-made systems for the laser welding of plastics (cf. p. 30).

www.evosys-services.com

Further Expertise for Photonics Systems

Photonics Systems Group, a provider of laser systems for micro material processing, added further expertise to its management team in July: Eckhard Schäfer assumes responsibilities for the service business of the group. As the senior vice president customer service and after sales, he will head all after-sales activities and take charge of the further development of the service concept. He will report directly to the group's CEO, Markus Nicht.

Schäfer will prioritize the development of the service portfolio and align it with global customer demands to optimally position the group for the fulfillment of customer needs. In addition to comprehensive customer support as well as a modular service concept, the experienced manager will invest in the continuous growth of the service portfolio.

Schäfer looks back on over 25 years experience in

Source: Photonics Systems Holding

Eckhard Schäfer

service and sales. He started his career in 1993 as a service and commissioning technician at the high-tech mechanical engineering company Manz. In 2019, he joined group company InnoLas Solutions to become its vice president sales Asia.

In parallel with his position as the senior VP service and customer support of the Photonics Systems Group, Schäfer will continue to act as the VP sales Asia for InnoLas Solutions, being responsible for the photovoltaic business of the company and its growth.

photonics-systems-holding.com

Alltec/FOBA Appoints New Managing Director

Foba Laser Marking + Engraving (Alltec GmbH), a producer of laser marking systems, has a new managing director since June 1. Sebastian Blösch, the previous finance director and deputy managing director, succeeds Stefan Heczko.

"With our team at the Selmsdorf location and our colleagues worldwide, we want to further consolidate our international success," says Blösch. "The focus will be on expanding the company's strategy with a view to technical innovations that will help our customers move forward." As head of finance at Foba, Blösch already had growing responsibility for the strategic orientation of the company. Originally from northern Germany, he has been working with Foba's

Source: Alltec

Sebastian Blösch

global parent company Danaher Corporation since 2015 as a business economist. The marking lasers, workstations and vision-assisted workflows by Alltec GmbH with its Foba Laser Marking + Engraving brand can mark a variety of materials and parts, not least in the key markets of automotive and medical but also in electronics, plastics and tools, metal and also mold making.

www.fobalaser.com

Vision Ventures Appoints Chris Yates

Independent M&A advisory firm Vision Ventures announced an expansion of their team with the appointment of Chris Yates to the role of director within the company. In his new position, Dr Yates will support corporate transactions for both buy and sell side client projects, working in tandem with the existing team. This appointment further strengthens the capability and breadth of Vision Ventures to address the increasing strategic interest in vision tech from many sectors and industry verticals.

Previously, Yates held the role of director, advanced technology at Rockwell Automation within the safety & sensing business, with responsibility for strategic technology develop-

Source: private

Chris Yates

ment and partnerships. This position followed the acquisition of Odos Imaging in late 2017, where he was founder and CEO since incorporation in 2010.

Yates is also the current president of the European Machine Vision Association, a not-for-profit association representing over 125 members in the vision tech sector, having served on their board of directors since 2018.

https://vision-ventures.eu

Changes in the Management Board of Technotrans

The supervisory board of Technotrans SE, an international technology and service company that concentrates on customer-specific applications in the field of liquid technology including cooling systems for diode, fiber and CO_2 lasers, has appointed Mr. Michael Finger as spokesman of the management board, effective August 1, 2020. In his new function, he succeeds Dirk Engel, who held the position on an interim basis from 2018 to 2020. Mr. Engel remains with the company and will focus more strongly on his role as CFO in the future.

Furthermore, Michael Finger will simultaneously take over responsibility for all sales units, service, quality management and marketing. This is due to the resignation of Hendirk Niestert from the management board. Mr. Niestert has informed the supervisory board that he will not extend his mandate on the management board, which he has held since February 1, 2018, beyond January 31, 2021. He will pursue a new professional challenge outside Technotrans in the future.

The supervisory board thanked Mr. Niestert for his many years of successful work for the Company over the past years and wishes him all the best. Mr. Niestert has held various management positions in the Company since 2007.

The management board of Technotrans now consists of three persons: Michael Finger (CEO), Dirk Engel (CFO) and Peter Hirsch (CTO / COO).

"I am looking forward to my new role. As a strong management team, we will continue to execute the strategic reorientation of Technotrans. Especially under the influence of the Covid-19 pandemic, we are aware of the current and future challenges and will not lose sight of our growth targets," said Michael Finger.

Peter Hirsch, Michael Finger and Dirk Engel (left to right; source: Technotrans)

www.technotrans.com

Rockley Photonics Appoints Andy Parker to the Board

Integrated optics solutions provider Rockley Photonics has announced the appointment to its board of directors of Prof. Andy Parker, founding science partner of Ahren Innovation Capital and head of the University of Cambridge's Cavendish Laboratory. This follows the announcement of Ahren's recent investment in Rockley Photonics. Ahren is an investment fund that focuses on transformational companies at the intersection of deep tech and deep science.

"Rockley's bespoke fabrication process is ideally suited to high-volume production of low-cost sensors. Its platform is highly versatile, and I am looking forward to working with the team to further develop this technology in a range of sectors including data center connectivity, autonomous vehicles and medical sensing," said Parker.

Source: Rockley Photonics

Andy Parker

"His work in developing silicon detectors, fast electronics and computational radiotherapy fully complements the board's existing expertise," said Andrew Rickman, chief executive at Rockley Photonics. "Andy's insight will be invaluable as we drive forward applications of our technology in multiple markets including high-density communications, machine vision, environmental sensing and healthcare."

https://rockleyphotonics.com

Laser diode for industrial sensors

Manufacturer: QD Laser. Distribution: IMM Photonics.
Product: New Fabry-Perot laser diode "QLF063D-60C0-GM" of 660 nm that has been specially developed for use in sensors and for industrial laser-projection systems.
Features: In cw operation, the maximum output power amounts to 130 mW, in pulse operation up to 300 mW at 500 ns pulse width and 50 % duty cycle. At 30 ns pulse width and 1 % duty cycle, the laser diode can be operated at up to 400 mW pulse power. The new diode in particular is characterized by its high operational temperature (up to 70 °C) and long life cycle (over 50,000 hours). The laser diode is offered in a TO56 casing without monitor diode.

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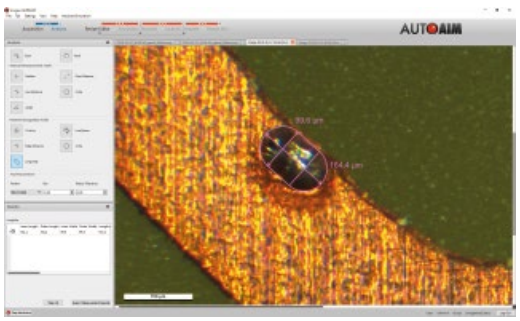
Upgrade Package Transforms Microscopes into Digital Measurement Systems

Manufacturer: Invigon.
Product "AUTOAIM" microscope upgrade package for the upgrade of almost every microscopy system into a modern digital system. The system consists of a powerful industrial camera from *Baumer*, the microscope software "AUTOAIM", and the matching accessories.
Features: A digital camera offers notable advantages for microscopy applications – instead of looking through an ocular lens, microscopic images can be viewed on a monitor and microscopic structures can be measured on the PC. Subsequent image processing is also possible. However, to make full use of a microscope camera, users additionally require a software that controls the camera and that includes the functions required for the corresponding application. This is what the "AUTOAIM" microscope upgrade package offers. It contains everything users need to upgrade their existing microscope system into a modern digital system. This includes both the powerful and intuitive microscope software "AUTOAIM" as well as a high-performance, 5-megapixel CMOS camera of the "CX" series from *Baumer* including all accessories required for connection to the PC and calibration. The cameras provide users with high-resolution live images that are smooth and highly responsive at the same time. In combination with the modular and flexible software, this allows users to digitize their microscopy solutions and to automate their measurements. In less than an hour all upgrade package components are installed and the software is customized to allow digital measuring and documenting to commence quickly and easily.



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Example for Custom-made Optics: Observation of Trapped Ions

The third main pillar of *Sill Optics*, beside laser optics and lenses or illuminations for machine vision, is custom made optics. With highly proficient optical designers and developers of mechanical housings, the company offers outstanding experience. As mechanical and optical precision production are located in one place in Germany, they are able to provide prototypes or small and medium sized batches of optics specifically designed for customers' or research institutes' applications. A very current example can be found in the field of trapped ions. Those cold ions are a research topic with increasing interest over the last few years because of their possibility to store Qubits and the related use for quantum computers. In order to learn about their behaviour in detail via various basic experiments, *Sill Optics* has designed lenses for both observation alone and observation combined with laser focusing for such experiments. Those lenses are exceptional for their high NA and adjustment to specific wavelengths. As the vacuum cryostats differ in dimension (e. g. the window thickness), every lens has to be designed specifically for the existing conditions.

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Optical Filters in Special Sizes

Distributor: AHF analysentechnik.
Product: Optical filters for signal filtering in various imaging technologies, like machine vision or AI. The portfolio ranges from very small filters (e.g. 2 × 4 mm or 3 mm diameter) to filters with large dimensions (e.g. 280 × 280 mm).
Features: The multitude of filters and shapes is made possible by well-established hard coating processes which allow to cut filter into different shapes. These hard-coated filters show very high durability, very low scattering and absorption, imperviousness to humidity and very low shifting of central wavelength when temperature changes. This opens a wide field of applications.

AHF has been working for many years with various well-known filter manufacturers and can therefore offer the most suitable filter configuration for the imaging system or imaging application in question. Consultation and selection are independent of manufacturers. For prototypes, smaller quantities can also be made available for testing. Due to the broad product portfolio of available filter designs, it is often possible to provide filter varieties with adapted optical parameters in a short time.

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Dichroic Filters for Optical Oxygen Sensing

Manufacturer: Optics Balzers.
Product: Dichroic filters for optical oxygen sensing, e.g. in medical ventilators. These filters and optical oxygen sensors are not FDA-approved, but they are used in this area nonetheless due to the 2020 Covid-19 pandemic which led to a severe shortage of medical ventilators.
Function: The sensing element in optical oxygen sensors is an oxygen-sensitive fluorophore which emits fluorescence in the presence of oxygen molecules. The oxygen is measured by comparing the excitation light from a light source to the emitted light by the fluorophore.
Features: The dichroic color filters and mirrors are ideally suited to separating the excitation and emission wavelengths of optical oxygen sensors, as well as providing robust measurement results with good signal-to-noise ratios. For many of the commercially available oxygen-sensitive fluorophores, there are suitable dichroic filter designs. These cover specific wavelengths and can efficiently separate excitation from emission wavelengths. The environmentally stable and shift-free dichroic filters provide excellent performance thanks to their high transmission values.
Applications: The filters are used in water monitoring, fermentation process control in bioreactors, and oxygen sensing.

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Coherent Passes 50,000 Laser Milestone for "Sapphire" OPSLs

Coherent has now passed the milestone of 50,000 units shipped for the company's "Sapphire" family of compact CW visible lasers. As the first solid state alternative to bulky and energy inefficient gas lasers at the critical 488 nm wavelength, these lasers enjoyed early strong success mainly in life sciences and related instrumentation since their introduction more than 20 years ago. However the unique power scaling and wavelength scaling inherent to the optically pumped semiconductor laser (OPSL) technology has enabled the company to continuously expand the product lineup with new wavelengths and power levels to meet the demands of new and changing applications. The series is currently offered with a choice of nine different standard wavelengths between deep blue (458 nm) and orange (594 nm) to support new applications in metrology and other techniques in diverse industries including semiconductors. Yet all of these compact lasers still feature exactly the same form and fit, which has proved a particularly popular advantage for OEM customers with products often tied to quite different life cycles. In addition to standard products, custom versions of Sapphire with unique wavelengths and other output properties continue to be developed for OEM customers.

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Simultaneous Control of the Degree of Overlap and Melt Pool Size for Laser Powder Cladding

Dieter Tyralla, Henry Köhler, Thomas Seefeld, Claus Thomy, Frank Vollertsen, and Ryuichi Narita

Laser powder cladding is a well-established process in industry for the reconditioning of machine components or for the modification of surface properties. It is also increasingly used in additive manufacturing. Observation and control of the efficient and high-quality process are necessary to ensure constant results.

Two factors have an especially strong effect on layer quality. On the one hand, this is the energy input, which influences dilution and is important for the properties of a functional layer. On the other hand, this is the degree of overlap, which describes the distance between neighboring weld beads in cladding of surface areas. The smaller the degree of overlap, the higher the distance between neighboring weld beads and the smaller the net clad height, but the higher the clad area per unit of time of the process. A high degree of overlap increases the usable clad height, but reduces the clad area per unit of time. Consequently, the optimum degree of overlap results in a layer with a height as even as possible in order to minimize the amount of post-processing machining that is necessary.

To date, it has been necessary to look closely at the parameters in order to find the optimum dilution and degree of overlap.This can be very challenging, as especially when reconditioning, the batch size can be very small, and the first item already has to fulfil the requirements.

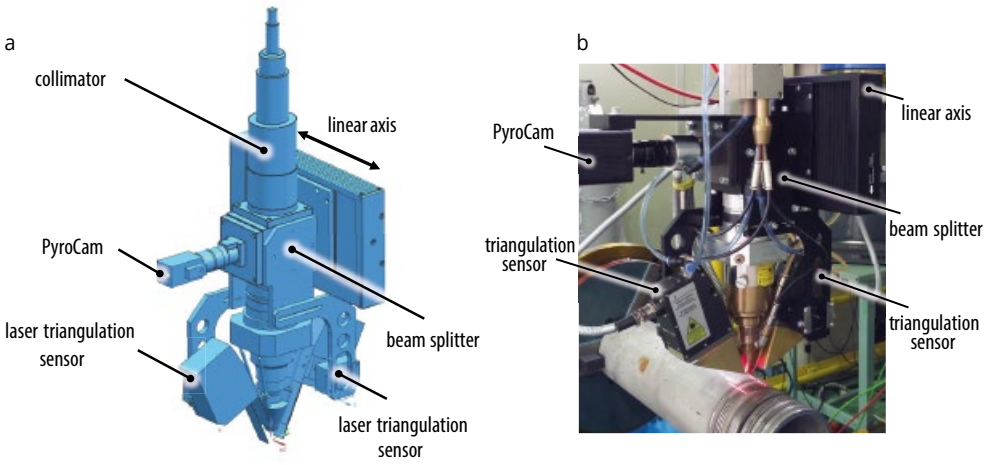

Fig. 1 Design of the cladding head with laser triangulation sensors and linear axis for controlling the degree of overlap and novel temperature measurement system for controlling melt pool size (a: Tyralla 2020, BIAS ID 200271). Complete system as implemented for controlled laser powder cladding of rotationally symmetric parts, such as cylindrical or conical tubes (b: Tyralla 2019, BIAS ID 200269).

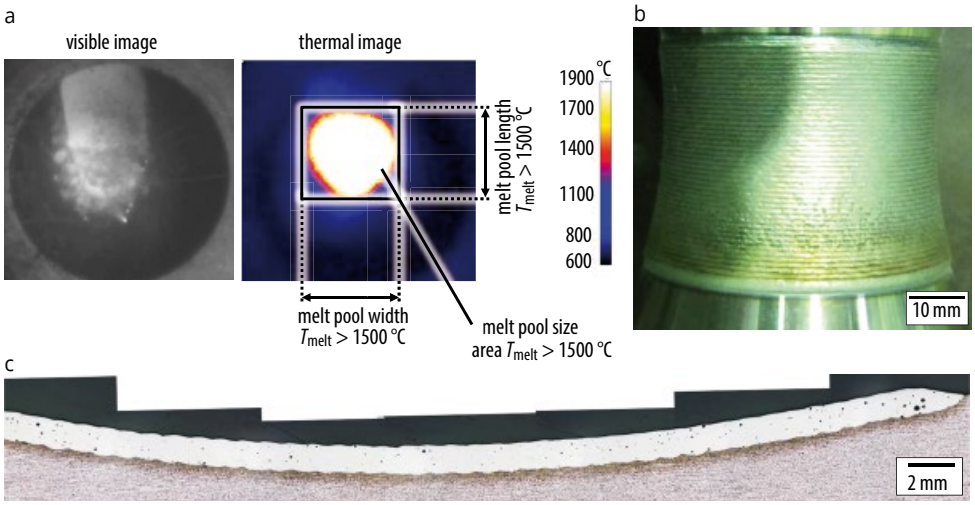

Fig. 2 Coaxial temperature field measurement by PyroCam through the cladding head (a: Tyralla 2020, BIAS ID 200271). Laser powder clad specimen with curved surface. Substrate SS400 (similar to 1.0038), filler material Inconel718 (2.4668), deposition rate approx. 1.2 kg/h (b: Tyralla 2020, BIAS ID 200275). Cross section of the welded specimen from 2b (c: Tyralla 2020, BIAS ID 200275).

Consequently, BIAS, in cooperation with Mitsubishi Heavy Industries Ltd. (MHI), has developed and implemented a system allowing control of the degree of overlap and melt pool size (depending on the application) whilst complying with set values for dilution and net clad height in the laboratory of MHI. Fig. 1 shows the setup. Laser triangulation sensors measure the position of the weld beads relative to each other and laterally displace the cladding head by a linear axis such that net clad height is close to weld bead height whilst achieving maximum clad area per unit of time. Even curved (e.g. concave) surfaces are thus possible with constant quality without extensive path programming of the robot system, as Fig. 2 shows. At the same time, the process zone is monitored with a novel temperature measurement technology. The emissivity-corrected Q-PyroCam (IMS Chips) records the temperature field in the process zone, thus allowing the melt pool size to be controlled by adjusting laser power. Thereby, energy input can be kept at a constant level during the whole process, and no parameter adjustments by the user, such as for cladding of long thin-walled tubes, are required.

No presetting is necessary for the geometrical control. The control system automatically measures the initial weld bead to establish the optimum parameters. A fixed degree of overlap can be set for geometries with a constant diameter. Only a suitable melt pool size has to be set for thermal control. So only minimum prior knowledge is required to meet the net clad height, surface smoothness and degree of dilution requirements, even for the first batch. This delivers a 'first time right' result.

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Goodbye Absorbers

High-precision laser welding of plastics – project SeQuLas completed

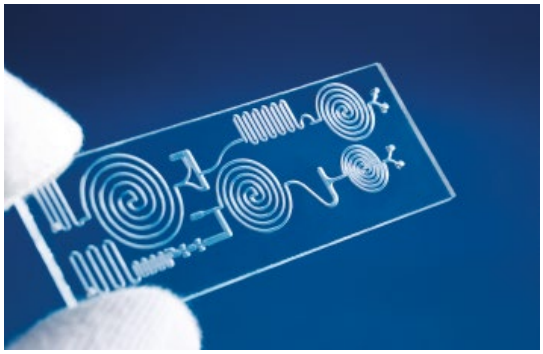
In the successfully completed NRW project SeQuLas, the Fraunhofer Institute for Laser Technology ILT and three industrial partners have developed a joining process that can be used to produce the smallest weld seams in transparent plastic components.

In the life science sector, microfluidic chips have proven their worth since they can transport, mix and filter even the smallest amounts of liquid efficiently. They still pose a major challenge, however: the media-tight encapsulation of the microchannels integrated in the chips. Conventional joining technology reaches its limits in the micrometer range. In its place, absorber-free laser transmission welding LDS – with beam sources in the near-infrared range – allows high precision and flexibility, making it the ideal solution here.

This is why Fraunhofer ILT launched the SeQuLas project in 2017, together with Amtron from Aachen, Ortmann Digitaltechnik from Attendorn and Bartels Mikrotechnik from Dortmund. The acronym stands for "segmental quasi-simultaneous laser irradiation". Here, a thulium fiber laser with an emission wavelength of 1940 nm was used as the beam source; plastics have a natural absorption in this wavelength range. Since additional absorber material such as soot is not necessary, the transparency of the chip is not affected during laser processing.

However, this form of absorber-free laser transmission welding has a problem: volume absorption creates a heat-affected zone (HAZ) that extends vertically over the entire cross-section of the component. The thermal expansion during the melting process promotes the formation of blowholes and cracks, which cause leaks in the seam structure. In addition, there is a risk that the material will warp, especially in flat components.

Quasi-simultaneous irradiation can be used to prevent the heat-affected zone from expanding vertically. In this process, a laser beam is guided along the weld contour several times at high speed with the aid of a scanner system. Thanks to this, the entire seam contour is heated simultaneously, which would otherwise melt sequentially in contour welding. In tests with polycarbonate components, Fraunhofer ILT has demonstrated that the heat is dissipated at the outer surfaces during the welding process while heat accumulates inside the material. The increasing number of passes and the high scanning speed even reduce the vertical expansion of the heat-affected zone by up to thirty percent compared to contour welding.



Source: Fh. ILT

Microfluidic chip from Bartels Mikrotechnik

www.ilt.fraunhofer.de

ROMY's Proof of Concept

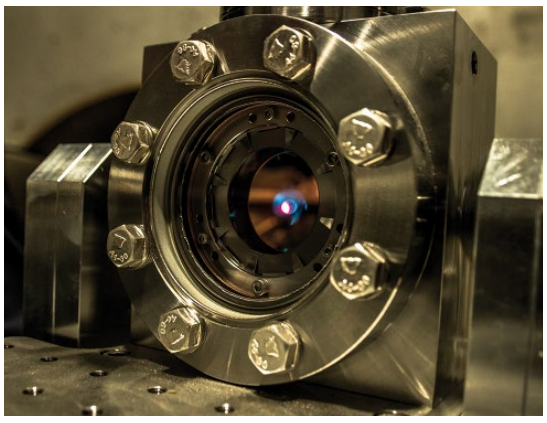
Novel ring laser provides most precise determination of Earth's spin and axis orientation

Munich geophysicists have measured Earth's spin and axis orientation with a novel ring laser, and provided the most precise determination of these parameters yet achieved by a ground-based instrument without the need for stellar range finding.

The acronym ROMY refers to one of its uses – detecting rotational motions in seismology. But in addition to quantifying effects of earthquakes, it can sense minute alterations in the Earth's rotational velocity as well as changes in its axis of orientation. These fluctuations are caused not only by seismic events but by factors such as ocean currents and shifts in the distribution of ice masses, among other factors. Accurate quantification of rotational motions is also important for determining the contribution of seismic noise to the data acquired by the LIGO gravitational wave detectors.

The instrument is made up of a set of four ring lasers that form the faces of an inverted tetrahedron – and each side is twelve meters long. Two laser beams circulate in opposite directions around each face of the instrument. The beam traveling in the direction of rotation takes longer than its counterpart to complete each lap. This in turn causes its wavelength to be stretched, while the other is compressed. The difference in wavelength depends on the precise orientation of each face with respect to the direction and orientation of Earth's rotation. Data from three of the four rings suffice to determine all the parameters of planetary rotation.

"In future and with further improvements, ROMY's high-precision measurements will complement the data obtained by the VLBI strategy, and will serve as standard values for geodesy and seismology. The measurements are also of potential scientific interest in fields such as the physics of earthquakes and seismic tomography", says Igel. "In the context of seismology, we have already obtained very valuable data," he adds.



View into a corner of the ring laser cavity. The red shimmer indicates the laser light that only occurs if the optical path around the triangular structure is closed, allowing the Earth's rotation to be monitored. (Source: LMU, J. Igel)

Reference: *A. Gebauer* et al.: Reconstruction of the Instantaneous Earth Rotation Vector with Sub-Arcsecond Resolution Using a Large Scale Ring Laser Array, Phys. Rev. Lett. **125**, 033605 (2020); DOI: 10.1103/PhysRevLett.125.033605

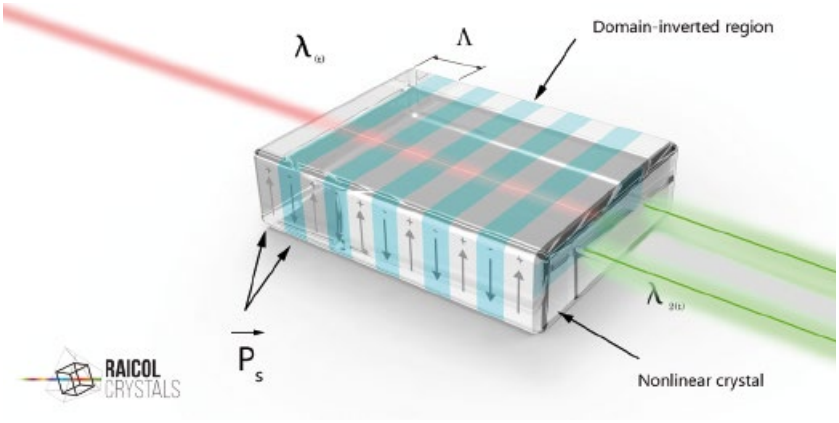
www.geophysik.uni-muenchen.de

Miniaturized Photon Source for Quantum Computing

Promises ultrafast data encryption with significant market potential

Raicol Crystals, a manufacturer of unique non-linear crystals for use in the space, aviation, and pharma industries, collaborates with Qubitekk, which develops and manufactures a variety of products for quantum networks and quantum key distribution. The companies are partnering on a project focusing on quantum communications. As part of the joint project, the companies develop an intangible, minimized photonic source that will serve as an endpoint for sending encrypted messages.

The collaboration between the companies will combine the photon-splitting capabilities of Raicol Crystals with Qubitekk's quantum entanglement source to replace quantum keys with the aim of developing an elaborate endpoint for the transfer of split photons. This development will enable ultrafast data encryption and may be used in a variety of areas including financial, security, medical, and governmental systems. In the long term, the goal of the project is to significantly reduce the size of the quantum photonic source while increasing and refining its capabilities. The companies have been awarded a grant from the Israel – US Binational Industrial Research and Development (BIRD) Foundation. Aner Yarden, CEO of Raicol Crystals, said, "We are proud to receive funding from the BIRD Foundation for our project with Qubitekk. Qubitekk has registered a number of Quantum Key Distribution patents and is a pioneer in quantum communication and networks. Raicol Crystals produces a special crystal that serves as a critical component of quantum communications systems. We will continue to seek collaborations in quantum communications that will allow leading research institutes to leverage our knowledge and experience and lead us to commercial success."



This illustration of the PPKTP crystal shows the polarity of the crystal domains and the doubled laser beam. (Source: Raicol)

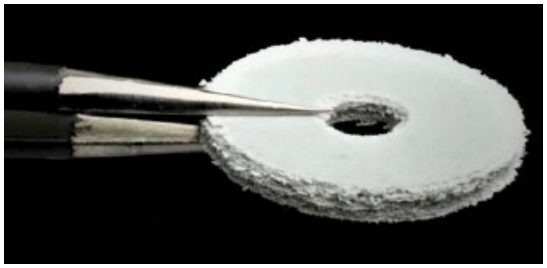
Reference (in press): *Y. Plaut:* "PPKTP Applications: Quantum Encryption", PhotonicsViews **17** (2020) 6, November (accepted for publication); DOI: 10.1002/phvs.202000041

www.raicol.com

Laser Inversion Enables Multimaterials 3D Printing

New technique could transform AM processes for circuit boards and perhaps even robots

Additive manufacturing (AM) has experienced staggering growth at a rate of more than twenty percent per year over the past decade, printing pieces that range from aircraft components and car parts to medical and dental implants out of metals and engineering polymers. One of the most widely used manufacturing processes, selective laser sintering (SLS), prints parts out of micron-scale material powders using a laser.



Sample created by inverted multimaterial laser sintering. (Source: J. Whitehead, Columbia U.)

"AM is key to economic resilience," says Prof. Hod Lipson of Columbia University. But the catch is that SLS technologies have been limited to printing with a single material at a time: the entire part has to be made of just that one powder. "But how many products are made of just one material? This limitation has been haunting the industry and blocking its expansion, preventing it from reaching its full potential."

Wondering how to solve this challenge, Lipson and his PhD student John Whitehead used their expertise in robotics to develop a new approach to overcome these SLS limitations. By letting the laser point upwards, they found a way to use SLS for multiple materials simultaneously.

Selective laser sintering has traditionally involved fusing together material particles using a laser pointing downward into a heated print bed. But using multiple materials in a single print has been very challenging, because once the powder layer is deposited onto the bed, it cannot be unplaced or replaced with a different powder.

The researchers decided to find a way to eliminate the need for a powder bed entirely. They set up multiple transparent glass plates, each coated with a thin layer of a different plastic powder. They lowered a print platform onto the upper surface of one of the powders, and directed a laser beam up from below the plate and through the underside.

This process selectively sinters some powder onto the print platform which is then raised with the fused material, and moved to another plate, coated with a different powder, where the process is repeated. This allows multiple materials to either be incorporated into a single

layer, or stacked. Meanwhile, the used plate is replenished.

The team demonstrated their working prototype by generating a fifty layer thick, 2.18 mm sample out of thermoplastic polyurethane (TPU) powder with an average layer height of 43.6 micrometers and a multimaterial nylon and TPU print with an average layer height of 71 micrometers. These parts demonstrated both the feasibility of the process and the capability to make stronger, denser materials by pressing the plate hard against the hanging part while sintering.

"This technology has the potential to print embedded circuits, electromechanical components, and even robot components. It could make machine parts with graded alloys whose material composition changes gradually from end to end, such as a turbine blade with one material used for the core and another material used for the surface coatings," Lipson notes. "This could be key to moving AM from printing only passive, uniform parts towards printing active integrated systems."

Reference: *J. Whitehead & H. Lipson:* Inverted multi-material laser sintering, Additive Manufac. **36** (2020) 101440; DOI: 10.1016/j.addma.2020.101440

www.creativemachineslab.com

Solar Cells: Picosecond Lasers Save 20,000 Tons of CO_2

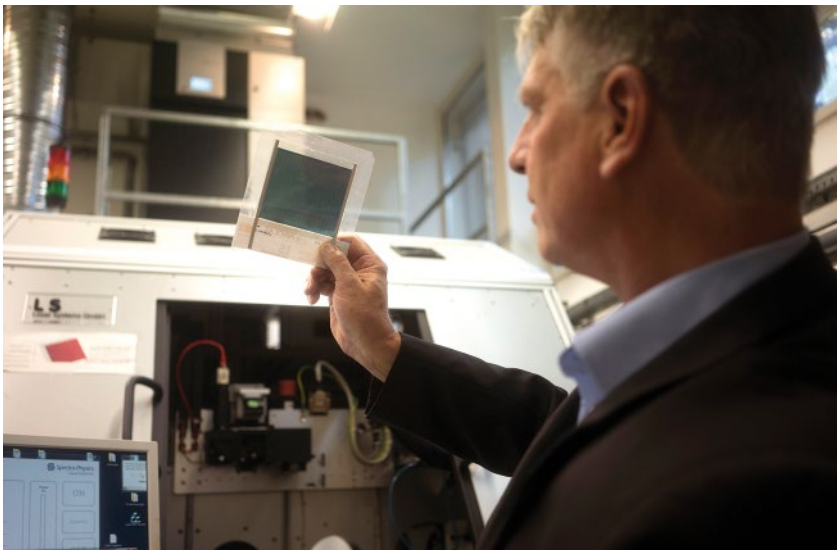
Improved CIGS thin film cells production is 10 to 15 % more efficient

While mass production of currently used silicon cells has made them affordable, their production process is more complex and generally less resource-friendly than that of thin film cells. Furthermore, if these cells are produced using the picosecond laser technique, their efficiency increases even more by another ten to fifteen percent. Although these cells have garnered only a rather modest share of the market so far, they already save 20,000 tons of CO_2 annually, which is equivalent to the amount emitted on average by three thousand people in an industrial nation per year.

CIGS thin film photovoltaic cells are comprised of layers only a few micrometers thick. The wafer-thin layers are composed of a sandwich made from four layers: the glass carrier material at the bottom, a molybdenum layer only one micrometer thick, a three micrometers copper-indium-gallium-diselenid layer and a one-micrometer zinc oxide window layer on top.

To produce energy, the large area of the CIGS cell needs a structure of fine grooves subdividing the large CIGS area into approximately one hundred single cells. This increases the voltage of the single, large cell from around 1 V up to 100 V for the entire module, just like batteries connected in series. It is crucial though that this process does not damage the molybdenum layer.

And this is where the picosecond laser comes into play. The mechanical scratching of the grooves – called scribing – that has been used so far has disadvantages: "The scribing needle produces wide grooves and material of lower conductivity remains at the bottom of those grooves. But if you produce those grooves with a picosecond laser, the grooves are finer and the current flows more evenly. The efficiency of the cell is increased without any noteworthy increase in cost", says Huber.



Heinz Huber is researching methods at the HM Lasercenter for the production of thin film photovoltaic cells with the picosecond laser which save 20 kt of CO_2 emissions annually. (Source: J. Lesser, HM)

By using laser pulses with a duration of picoseconds and a high repetition rate, Huber made industrial production of CIGS thin film cells possible: "A nanosecond laser burns and melts all three layers. Only with an ultra short pulse laser like the picosecond laser it is possible to apply a structure to the upper CIGS layer without damaging the molybdenum layer," states Huber. The connection between the molybdenum and the transparent zinc oxide layer is stronger. This also reduces internal energy losses, which in turn increases efficiency.

Huber thinks that streamlining the production process should improve efficiency and reduce production costs even further. The plan is to consolidate the alternating application of the individual CIGS layers and the structuring of the layer surfaces into one joint application of all layers and their collective laser structuring.

References: *J. Winter* et al.: Ultrafast pump-probe ellipsometry and microscopy reveal the surface dynamics of femtosecond laser ablation of aluminium and stainless steel, Appl. Surface Sci. **511** (2020) 145514; DOI: 10.1016/j.apsusc.2020.145514 • *F. Kessler* et al.: CIGS Thin Film Photovoltaic – Approaches and Challenges, in: "High-Efficient Low-Cost Photovoltaics", January 2020, Springer. Series in Optical Sciences 140; DOI: 10.1007/978-3-030-22864-4_9

www.fb06.fh-muenchen.de/lhm

World Premiere for a Disruptive Streak Camera

SATT Conectus and Optronis signed an exclusive license to market technology from ICube lab

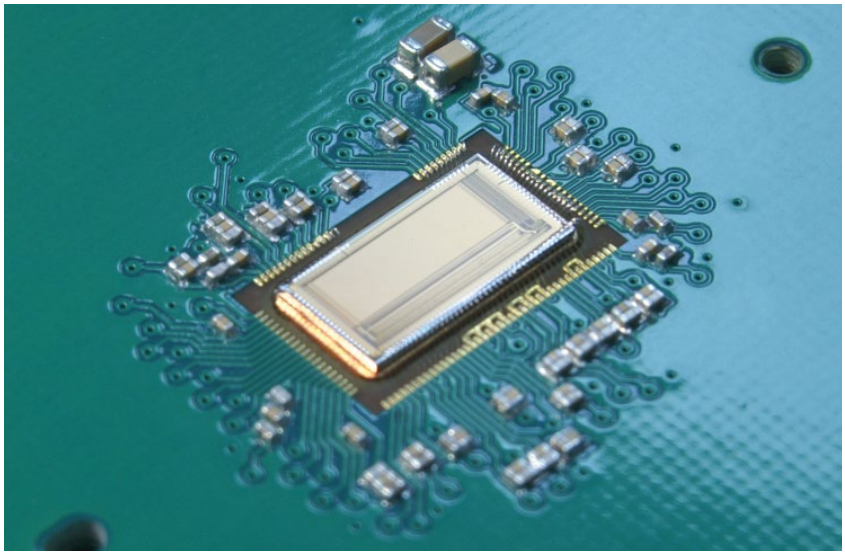
SATT Conectus and the German company Optronis have signed an exclusive license for the worldwide exploitation of the solid-state streak camera technology of the French laboratory ICube. This will result in the launch of a new, unique ultrafast camera for research and industry. The first model is already offered to researchers and engineers since August.

A streak camera is a precision instrument that makes it possible to analyze fast phenomena invisible to the naked eye and, ultimately, to optimize them. This type of high-speed camera can be used in industry, science and applied research. Although the technique of streak imaging is well known in the field of high-speed imaging, the models of this type of camera currently on the market have certain limitations. For many uses, they are still particularly fragile and cumbersome, and require a significant purchase cost (€ 100 k on average). In this context, the new S3C-1 camera is an interesting alternative.

The new S3C-1 camera solves the constraints of current streak cameras. Technically, it is the first fully integrated solid-state streak camera (S3C) architecture realized in CMOS technology: the camera no longer requires either a very high speed rotating mirror nor an image converter vacuum tube. This makes it a much more compact twelve cm cube – current cameras are the size of a small oven. It is lighter – 2 kg instead of more than 20 kg. It is also more robust and resistant to mechanical shocks or intense light, which enable its use in extreme environments.

A 100 % disruptive camera

The performance of the S3C-1 camera is first-rate and the temporal definition is close to the nanosecond , says its data sheet. In addition, it has a novel feature: it can record continuously and this enables the capture of an event after it has occurred. This is very useful for events for which the exact time of triggering is not known, for example in research and test experiments. The instantaneous image acquisition rate exceeds 1 terapixel per second. This camera should benefit all industrial players studying pharmaceutical, chemical, military, nuclear, physical, micromechanical and pulsed laser processes.



The S3C-1 integrates a CMOS sensor with 200 fast photodetectors and a matrix to store 200 time samples for each photodetector. (Source: W. Uhring, U. Strasbourg)

The technology of the S3C-1 camera is the result of the scientific work of the ICube Laboratory and one of its team, led by Wilfried Uhring. This laboratory has been collaborating for many years with the German company Optronis to refine and develop the technology. In 2011, their research results were honored by the INSIS Institute of the CNRS.

Much progress had already been made towards the crucial prototype stage. This is when SATT Conectus came into play. Caroline Dreyer, its president, recalls the challenge: "After studying the economic potential of this nascent technology, Conectus decided in 2017 to provide the missing boost: to invest financially to produce the functional prototype of the sensor, the heart of the S3C-1 camera, and taking a major step towards industrialization. Optronis for its part focused on electronics, software and design developments to conceive the complete camera. Today we have come full circle: we have collectively transformed an invention resulting from academic research into an actual product on the market."

Michel de Mathelin, director of the ICube Laboratory, adds: "Our heterogeneous systems and microsystems team has been designing ultrafast imaging systems for over thirty years, specializing in streak imaging, which is an imaging technique 100 to 1000 times faster than conventional framing imaging. The extreme performance of these systems has been used extensively for medical imaging research in the laboratory. The original idea of transposing this imaging technique into CMOS technology emerged in 1999 in the ICube laboratory. This new approach makes it possible to combine practically all the functions of the ultrafast camera into an integrated circuit chip made in a technology similar to that of smartphone cameras. This makes it a compact, reliable, easy to produce and potentially low-cost camera, while offering additional features such as anti-blooming and post-triggering. It took twenty years of research to come up with an industrial product with such high performance."

Born at the heart of Alsatian research

Patrick Summ, managing director of Optronis, concludes: "We have set ourselves the mission of developing and industrializing S3C technology. Thanks to SATT Conectus, we were able to jointly develop this new camera and acquire an exclusive worldwide operating license. We are building on a solid foundation because the technology has already been established by Conectus. This camera brings an unprecedented innovation that should appeal to all those working on the study of rapid physical phenomena. Our ambition is to be able to offer this at an attractive cost." (Source: Oxygen RP / Alpha-Omega)

https://optronis.com
https://icube.unistra.fr
http://conectlabs.conectus.fr

Quasi-Simultaneous Laser Transmission Welding

KTP develops scale-up rules for the quasi-simultaneous joining of thermoplastics

A key aspect in the production of individual plastic components is the joining of the parts. Plastic welding processes enable media-tight joints combined with low production costs and short cycle times.

One of these processes is laser transmission welding. Here, a laser-transparent part and a laser-absorbing part are in contact with one another while a laser beam passes through the transparent part with a low energy loss. The energy of the laser is converted into heat in the absorbing part. The transparent part is heated by conduction through contact in the joining zone and the weld seam is formed.

Previous scientific studies on the laser transmission welding process have been aimed primarily at small weld seams. The correlation between the individual process parameters of the weld temperature and the mechanical properties of the weld is already well documented. The correct process parameters can be established using the line energy, which is calculated from the laser power used, the radiation time and the date of advance of the laser. Identical weld results can be obtained by adjusting these individual parameters.

Laser and workpiece fixture in the experimental setup at KTP (Source: T. Arndt, UPB)

The scientific studies can, however, only be applied to contour welding. Other parameters come into effect with quasi-simultaneous and simultaneous welding. A squeeze flow occurs in the complete welding zone because of the simultaneous melting process, resulting in an energy loss. This loss is not taken into account in the line energy, which therefore loses its significance. In addition, other influences such as the length and width of the laser path also play an important role and exert a considerable influence on the weld result.

These influences have not yet been adequately studied and so prevent a transfer of the results from small weld seams to complex components. The aim is to make such transfers possible through the development of scale-up rules for the quasi-simultaneous welding of thermoplastics. This will provide an opportunity to transfer optimum process parameters through simple laboratory tests to real parts.

At present, a complicated procedure of determining the process parameters has to be carried out for every new product and to prevent transfer problems this must be done on the actual production systems while halting production, thereby generating high costs. A direct transfer of the optimum process parameters from laboratory tests would therefore have numerous advantages (cost and time savings) and, at the same time, enable the use of the quasi-simultaneous laser transmission welding process in a wider range of applications.

The project has already started and is being supported by eighteen industry representatives. Further interested companies can contact Theresa Arndt, MSc, KTP Paderborn University.

www.ktpweb.de

A Major Leap in Fiber Laser Welding Technology

Enables more advanced welding capabilities for dissimilar materials, such as copper and aluminum

The new Coherent HighLight FL4000CSM-ARM fiber laser builds on the success of the ARM fiber laser series already qualified for automotive applications. This enables more advanced welding capabilities for high thermal conductivity metals, and aligns to welding requirements for e-mobility, energy storage, and general electrical interconnects consisting of dissimilar materials, such as copper and aluminum, and foil stacks that require precise control.

The technology represents a significant improvement in simplicity, and overcomes the limitations of other joining technologies. The latter include unstable welds due to welding head wear and the large heat affected zone caused by ultrasonic or standard fiber laser welding. The ability to move beyond the limitations of traditional fiber laser for welding thin conductive materials is possible because of its unique dual beam output: center beam surrounded by a ring beam. The center beam has extremely high brightness (nominal BPP 0.6) allowing a smaller spot size compared to its multimode counterpart. The small spot size results in very high laser intensity that minimizes heating of the material and, together with the pre-heating effect achieved by the ring beam, significantly improves stability of the melt pool and therefore weld consistency that is a challenge when welding thin conductive materials.

As with other Coherent Adjustable Ring Mode lasers, power in the center and ring beams can be independently varied and modulated.

www.coherent.com

HighLight FL4000CSM-ARM, available with an output power of 4 kW: 1.5 kW center beam plus 2.5 kW ring beam. (Source: Coherent)

Artificial Intelligence Monitoring of Laser Welding

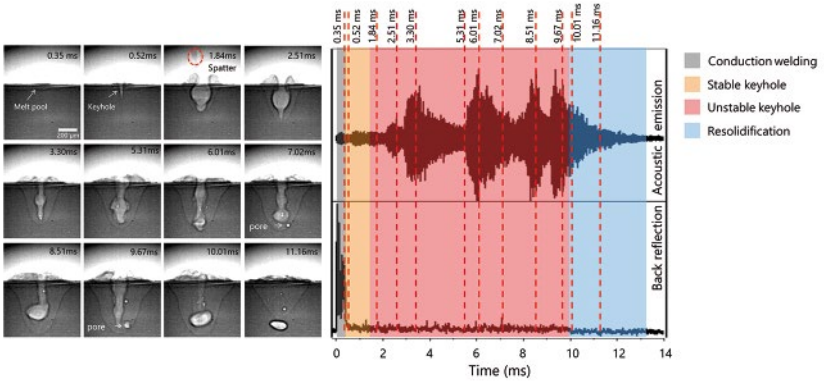
Detecting and documenting the moment of instability in deep penetration laser welding

Until now, the quality of a laser weld seam could only be documented retrospectively, either by means of X-rays, magnetic analysis methods or by dissecting individual samples from production.

While in conduction welding only the surface of the material is molten, in deep penetration welding the laser beam pierces quickly and deeply into the material and produces a thin hole filled with metal vapor and gas. If this keyhole becomes too deep, the pressure of the metal vapor decreases while the surface tension of the molten metal increases. The keyhole becomes unstable and can eventually collapse, leaving a pore in the weld seam – an unwanted fault in the material. To maintain quality, it is therefore important to detect the moment when the keyhole becomes unstable. This has not been possible to a sufficient degree until now, only to look into the keyhole from above using optical methods.

A group of Empa researchers led by Kilian Wasmer has now succeeded in precisely detecting and documenting the moment of instability in deep penetration laser welding. To do this, they are using an inexpensive acoustic sensor on the one hand, and measuring the reflection of the laser beam on the metal surface on the other. The combined data are analyzed within only seventy milliseconds with the help of artificial intelligence – a convolutional neural network, allowing the quality of the laser welding process to be monitored in real time.

The researchers recently demonstrated the accuracy of their monitoring method



X-ray images of a laser beam hitting an aluminium plate, taken at the European Synchrotron ESRF in Grenoble. (Source: Empa)

at the European Synchrotron ESRF in Grenoble. Using their laser, they melted a keyhole into a small aluminium plate. The entire process, which takes less than a hundredth of a second, was recorded with a high-speed X-ray camera. The result: the individual phases of the welding process could be correctly identified with more than ninety percent certainty.

Once the laser beam hits the metal, the first phase of the heat conduction welding process begins – only the surface is being molten. Subsequently, a stable keyhole is formed, which wobbles with longer exposure times. Sometimes the keyhole spits out liquid metal, similar to a volcanic eruption. If it collapses in an uncontrolled manner, a pore is formed. All these phases can now be detected in real-time. In some experiments, the researchers succeeded in creating pores in the weld seam and then closed them again with a second laser pulse. The formation of the pore could be detected with 87 % certainty, successful removal with as much as 73 %.

This method of error correction is extremely promising for laser welding. Until now, the pores in a weld seam could only be detected after completion of the work. Now, the location of a pore is already known during the process. Post-processing with the laser can be started immediately.

The monitoring process can be used not only for laser welding, but also for quality control of 3D-printed metal parts. "One advantage of our monitoring method is that the acoustic and optical sensors we use are inexpensive and robust and can be easily retrofitted to existing industrial plants," says Wasmer.

Reference: *S. Shevchik* et al.: Supervised deep learning for real-time quality monitoring of laser welding with X-ray radiographic guidance, Sci. Rep. **10** (2020) 3389; DOI: 10.1038/s41598-020-60294-x

www.empa.ch

Laser-Assisted Cutting of Human Bone

AOT: 'Carlo' submission at the FDA is expected for early 2021

'Carlo' can ablate bone layer-by-layer by laser and thus avoids microstructural damage to the bone. (Source: AOT)

On June 19, 2020, the Swiss medtech company Advanced Osteotomy Tools (AOT) successfully completed the last surgery required for the first-in-man clinical study of its proprietary Carlo device. The aim of the study was to demonstrate the performance and safety of the system. The cold ablation robot-guided laser osteotome 'Carlo' is a surgical robotic platform, which is used to cut bones using cold laser ablation – i.e. without conventional surgical tools.

To accomplish this, the laser is mounted on a tactile robotic arm that has been designed specifically for medical use. The device allows the surgeon to perform osteotomies with unprecedented precision and arbitrary patient-specific configurations which are not achievable with conventional surgical tools.

Carlo was used for the first time in July 2019 at the University Hospital in Basel, Switzerland. Since then, laser

osteotomies have been used as part of a clinical study during the surgeries of 28 patients at the University Hospital Basel, the Medical University of Vienna (AKH Wien) and the University Hospital Hamburg-Eppendorf. With the successful completion of the clinical study, AOT aims to achieve a CE marking for its device before the end of the year. The submission of the relevant documentation to the US Food and Drug Administration (FDA) is expected for early 2021.

AOT, headquartered in Basel, Switzerland, is the first company worldwide to develop a surgical robotic platform that is able to cut bones using cold laser ablation. The platform named Carlo uses preplanned cutting patterns and a digital workflow to perform osteotomies precisely and completely contactless by laser. The advantages of laser osteotomy over conventional surgical tools such as saws, drills or mills include arbitrary cutting geometry and patient safety: Carlo can be stopped immediately with the speed of light and can be removed effortlessly, as no mechanical components that are utilized can vibrate or even deform under load. Therefore, the device can be safely and universally applied for all types of bone cuts.

Carlo was successfully used for the first time in July 2019 during a transoral midface osteotomy. This surgery also marked the start of the clinical first-in-man study, which had the goal of confirming the performance and safety of the technology in a clinical context.

Reference: First-In-Man Performance and Safety Evaluation of the CARLO® Device in Midface Osteotomies, ClinicalTrials.gov Identifier: NCT03901209

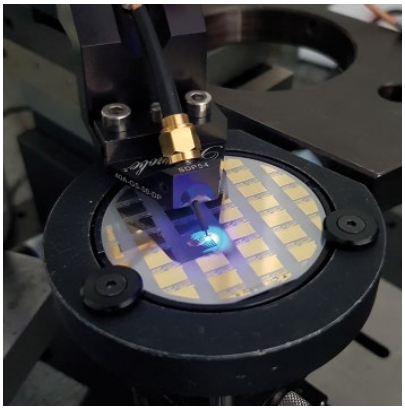
https://aot.swiss

Single GaN Blue Micro-LED Breaks LiFi Throughput Record

Rate of 7.7 Gbps positions LiFi as possible replacement for WiFi

In June, CEA-Leti announced that its researchers have broken the throughput world record of 5.1 Gbps in visible light communications (VLC) using a single GaN blue micro-light-emitting diode (µLED). Their data transmission rate of 7.7 Gbps achieved with a 10-µm microLED marks another step toward commercialization and widespread use of LiFi communication.

VLC, commonly called LiFi (short for "light fidelity"), is an emerging wireless communication system that offers an alternative or a complementary technology to radio frequency (RF) systems such as WiFi and 5G. It is considered to be a promising technology for security-related applications because light propagation can be confined to a room with no information leakage, as opposed to WiFi communication which penetrates walls. LiFi also holds promise for ultrafast data transmission in environments where RF emissions are controlled, like hospitals, schools, and aircraft.



CEA-Leti's expertise in the microLED epitaxial process produces microLEDs as small as 10 µm. (Source: CEA-Leti)

Single microLED communications offer an ultra-high datatransmission rate for a variety of opportunities for new applications. These include industrial wireless high-speed links in demanding environments such as assembly lines and data centers, and contactless connectors, or chip-to-chip communication. But their weak optical power limits their applications to short-range communications. In contrast, matrices of thousands of microLEDs contain higher optical powers than open mid and long-range applications. However, preserving the bandwidth of each microLED within a matrix requires that each signal has to be brought as close as possible to the micro-optical source.

www.leti-cea.com
www.lightcommunications.org

Expanding Online Activities

After the success of the Online Technology Meetings, EPIC is now introducing the 'EPIC Member New Product Launch'

What a crazy year it has been so far. The pandemic has and still is impacting many businesses around the world and travelling restrictions are still ongoing. Our physical events rely on active interactions between all participants and we want to make networking as successful as possible by organizing the world's best events. As a result of this ongoing worldwide health situation, we have decided to postpone all our events until the end of 2020. The health of our members, participants, and employees is our highest priority. We want to ensure business opportunities along the entire value chain and enable a vibrant exchange between top-level and decision-making participants on real industry challenges in a top-class atmosphere at inspiring locations. This is not assured given the current circumstances.

Postponing all our physical events for 2020 was a difficult decision, but we are fortunate that our online activities have been received so positively. Hence, we are continuing our online technology meetings indefinitely, with a great new range of online meetings until the end of the year. Topics we will cover include laser glass processing, 3D sensing, vision and imaging, pharma processes, Photonic Integrated Circuits, dermatology, LiFi and more. And we have established some great partnerships to reach more end-users. We teamed up with the International Ultra-Violet Association (IUVA) for our meetings on surface disinfection and antibacterial surfaces, and our meeting on water quality purification. Our meeting about MicroLED for Automotive is organized in cooperation with Driving Vision News (DVN), and based on two already very successful meetings in cooperation with COBO on beyond 400G and co-packaged optics, we now organize a special meeting on new pluggable transceivers. All our online technology meetings can be viewed LIVE on YouTube and will remain available for anyone interested, so please visit and subscribe to www.youtube.com/c/EPICphotonics

Besides the online technology meetings, we are also looking and even more ways to bring value to our members and the photonics community. For instance, we are launching a whole new service called the EPIC Member New Product Launch. Traditionally, new products are released in conjunction with a major exhibition. However, timing is not always ideal. It is often a bit too early or already a bit too late. Moreover, with so many shows being cancelled, EPIC felt it was time to start a new revolution. Let EPIC maximize your visibility with an online LIVE product launch to achieve the most impact! We will engage relevant journalists, end-users, clients, and the complete EPIC network! Because people can watch the product release online, you can reach out to individuals who are based anywhere in the world, and who would otherwise not attend a photonics related exhibition. The EPIC Member New Product Launch will be a combination of an online meeting with qualified attendees, and a live launch on YouTube for everyone to see. And the online product launch video can also be used for future marketing follow-ups such as inclusion in social media, newsletter, or simply sent to potential clients.

So, if you are planning for a significant new product to be released, please contact us at info@epic-assoc.com

Upcoming EPIC events:

- 05 October 2020, 15:00 CEST
  EPIC Online Technology Meeting on Photonics for Dermatology and Aesthetic Applications
- 12 October 2020, 15:00 CEST
  EPIC Online Technology Meeting on Laser Glass Processing
- 19 October 2020, 15:00 CEST
  EPIC Online Technology Meeting on Additive and Advanced Metal Manufacturing
- 26 October 2020, 15:00 CEST
  EPIC Online Technology Meeting on Free Space Optical Communication and LiFi
- 02 November 2020, 15:00 CET
  EPIC Online Technology Meeting on Photonic Systems for High-end Research
- 09 November 2020, 15:00 CET
  EPIC Online Technology Meeting on Water Quality Monitoring and Purification (in cooperation with IUVA)
- 23 November 2020, 15:00 CET
  EPIC Online Technology Meeting on 3D Sensing
- 30 November 2020, 15:00 CET
  EPIC Online Technology Meeting on Photonics for Improved Pharma Processes
- 14 December 2020, 15:00 CET
  EPIC Online Technology Meeting on Industrial Manufacturing for Naval and Aeronautics

www.epic-assoc.com/epic-events

AIPH and EPIC Sign MoU

Implementing agreements for horticultural producers

AIPH, the International Association of Horticultural Producers, and EPIC, the European Photonics Industry Consortium, signed a collaboration agreement in the first week of July 2020 to strengthen the photonics industry on an international level, bringing together members and knowledge to better serve the industry.

The Memorandum of Understanding (MoU) signature was publicly announced at the EPIC Online Technology Meeting on Precision Horticulture and Agriculture on 10 July 2020. The collaboration between AIPH and EPIC is focused on cooperative activities and supports the development of an efficient and sustainable industry.

The partnership encourages cooperation between the members, including participation at events, collaboration on information exchange and promotion, and advisory mandates to develop an efficient and sustainable industry. Dr. Jose Pozo, CTO of EPIC, said: "Having AIPH on board as a partner brings the opportunity to EPIC members to build potential collaborations and partnerships with the key players in the ornamental horticulture industry. The main goal of this cooperation is to facilitate the communication between different parts of the value chain towards building a common voice for the interests of companies using photonics sensors and lighting in horticultural applications."

"The collaboration with EPIC and its members helps AIPH to further stimulate the development of the horticulture sector" said Tim Briercliffe, secretary general at AIPH. "For this, we need end-users, service providers, equipment vendors, and technology providers to work together using worldwide standards. The huge network of EPIC will support this mission."

"Since 1948, AIPH has united horticultural producers in an international community that thrives to this day. Much has changed in that time. Technologies advanced, cities rose from the ground, and we have become more connected than ever. As a result, our essential bond with nature has been weakened. We support the work of grower associations globally and together we champion a prosperous industry, growing plants that enhance lives, advance societies and sustain our planet, for this generation and the next."

http://aiph.org
www.epic-assoc.com

Tim Briercliffe, secretary general at AIPH (top), and Dr. Jose Pozo, CTO of EPIC (below), during the EPIC Online Technology Meeting on Precision Horticulture and Agriculture on 10 July 2020. (Source: EPIC)

New Team Member to Strengthen Photonics Finland

Photonics Finland welcomes its new team member, Ana Gebejes, PhD. Previously she worked as a project manager in the Epic Challenge education program which was originally launched by NASA. Later on she worked in e-learning software company Valamis Group Ltd as a lead digital learning consultant.

Dr Gebejes is from the city of Senta in northern Serbia where she studied engineering at the University of Novi Sad. She has also studied in the United States and in Spain, and from there she found her way to Joensuu and the University of Eastern Finland (UEF), where she received a doctorate in 2017. In her doctoral thesis, which focused on computer science, she studied the application of spectral video technology in human eye analysis and tracking.

Ana Gebejes (Source: private)

At Photonics Finland she will be working as a head of projects, taking control of the ongoing Miracle project and upcoming Photonics Finland projects. She will also provide valuable support for upcoming Photonics Finland events.

www.photonics.fi

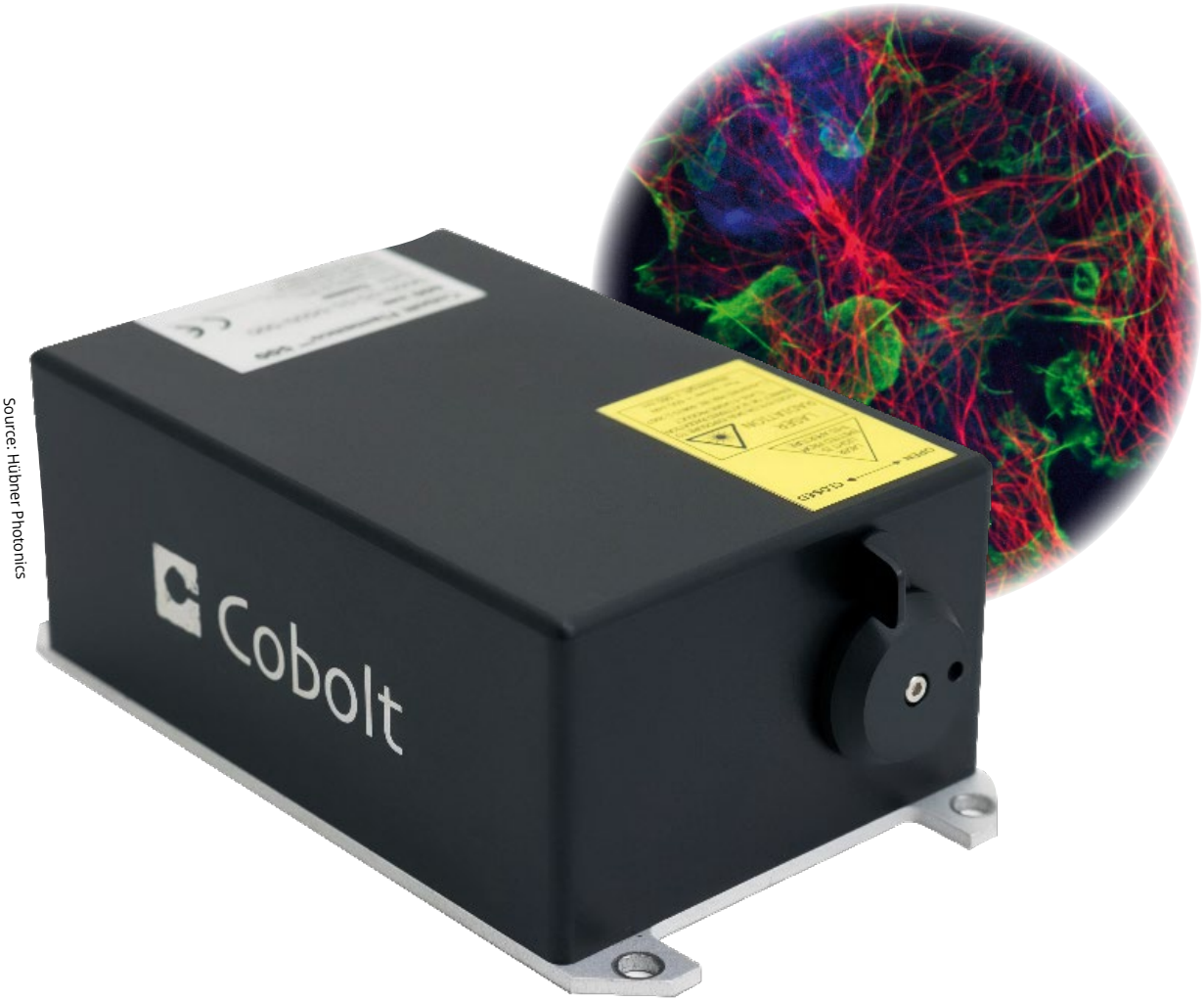
EMVA General Assembly as Virtual Meeting

For the first time ever, the annual general assembly of the European Machine Vision Association will take place in a virtual format in 2020.

EMVA general secretary Thomas Lübkemeier has announced that the General Assembly is scheduled to take place in the afternoon hours of October 15th, 2020. Representatives of the over 130 EMVA members are kindly asked to save the date.

According to the EMVA statutes, the formal written invitation is sent to all member entities in due time before the general assembly.

www.emva.org



Source: Hübner Photonics

Making Light Work
in Superresolution Microscopy

Hübner Photonics proudly introduces the Cobolt Rogue 640 nm laser

The Cobolt Rogue series lasers are continuous-wave diode pumped lasers (DPL) and are multi-mode, high power complements to our Cobolt 05-01 Series of single frequency lasers. The Cobolt Rogue 640 nm is multilongitudinal mode in a perfect TEM00 beam with 1 W output power, ideally suited for super resolution microscopy, especially using Cy5 or Alexa 647 photo-switchable fluorophores for dSTORM imaging.

All Cobolt lasers are manufactured using proprietary HTCure technology and the resulting compact hermetically sealed package which provides a very high level of immunity to varying environmental conditions along with exceptional reliability. With demonstrated lifetime capability and several thousand units installed in the field, Cobolt lasers have proven to deliver unmatched reliability and performance both in laboratory and industrial environments, and are offered with market leading warranty terms.

Through supply of innovative and reliable products, dedicated customer care and a certified quality management system, Hübner Photonics has become a preferred supplier to major instrument manufacturers, leading research groups and public institutions working in the areas of spectroscopy, bioinstrumentation, holography, metrology, particle analysis, quantum technology and public security.

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Website: https://hubner-photonics.com/news/new-cobolt-rogue-640-nm-1w/

"We Had to Build Systems from Scratch"

A portrait of Didier Beghuin, CTO of Belgian manufacturer of proprietary and custom optical systems, Lambda-X

Jose Pozo

Didier Beghuin, chief technical officer of Lambda-X (Source all images: Lambda-X)

After completing a PhD on laser-tissue interactions at the École Polytechnique Fédérale de Lausanne EPFL in 2000, Didier started work for Chevalier Photonics, a small company set up by Philippe Chevalier in 1997. Unfortunately, 18 months later, the company was threatened with bankruptcy and Didier moved to Barco, a Belgian company providing networked display solutions for the entertainment, enterprise, military, and healthcare markets.

His PhD had focused on laser interaction with collagen tissue and, although the idea of going into academia was attractive, he needed to find a secure job to support a young family. In any event, for Didier, his PhD paid off because he gained experience in managing projects, and this experience, properly valued in his next job, did a lot to improve his self-confidence.

At Barco, Didier worked as an optical engineer with a group of electronic engineers, managing various avionics projects. Although that was enjoyable, he decided to accept the offer from Lambda-X in 2003, to work as a project manager on specialty optics projects.

Lambda-X was a small company at that time – Didier was the sixth employee – focused almost exclusively on space applications, building optical systems for applications deployed on the International Space Station. As he says: "The work was fun – we had to build systems from scratch, working with the customer until we got it right. As it was a small company, we had to do almost everything ourselves and seeing the system functioning correctly at the end gave me a real sense of achievement."

Company

LAMBDA-X

Lambda-X creates and manufactures optical systems for space, security, industrial and medical applications. With the successful transfer of a patented optical design for a space experiment in 2008, Lambda-X has since become a world leader in quality control for ophthalmic products with NIMO instruments. Lambda-X is expanding in industry and security markets because custom optical systems are a powerful innovation engine in many different segments.

www.lambda-x.com

ILF is a holographic microscope system that Lambda-X manufactures for Ovizio, a provider of non-invasive, quantitative imaging systems for the life sciences.

In the last 17 years, Lambda-X has grown to 44 employees. Most of the growth has been achieved by expanding initial work on space applications to other businesses and the company now creates and manufactures both proprietary and custom optical systems for space, security, industrial and medical applications.

Ophthalmology: Their first new market was metrology instruments for spectacle lenses, and then more successfully, for intraocular lenses. By transferring a patented optical design for a space experiment in 2008, Lambda-X has become a major supplier in quality control for ophthalmic products, providing NIMO instruments to analyze contact and intraocular lenses.

Didier explains: "We found the best response to our technology in the intraocular market. There was a lot of development in intraocular lenses and we were there with the right technology at the right time. We stayed with the market as it grew and developed a complete suite of software for instruments, and most of the big manufacturers of intraocular lenses are now our customers."

Hyperspectral imaging: Lambda-X has also branched out into spectroscopic systems, including fast 2D Raman, MIR and FIR spectroscopy, and hyperspectral imaging. Interest in hyperspectral imaging has grown in the last couple of years because the technology is able to address the increasing volume of data produced by high throughput cameras. As Didier explains, while they have spectrometers covering nearly all the wavelengths, data storage and data processing are the key elements of many applications, because what the end user needs is a way of making sense of the data.

Custom software: The biggest driver for new software solutions is the ophthalmic business because customers in this sector want very specific solutions with on-line data processing. In fact, software is now the biggest part of the ophthalmic business and Didier believes this will be true for nearly all other applications in future. As a result, software is a growing part of Lambda and they are increasing their knowledge of data processing in general and also the use of artificial intelligence and other processing techniques. To this end, they are collaborating with software development companies both within the Verhaert group, of which Lambda-X is a part, and also external providers, particularly in the field of artificial intelligence.

Light management: Another growing market for Lambda, the company has customers active in lidar applications for the automotive industry and recently helped a tier 1 company develop a light projection system to industrialization, which included fabricating a demonstrator. In cases like these, Lambda's aim is not to become a supplier to the automotive industry; it's more to guide companies to adopt the right technology at an early stage of development and to help them develop their own products.

Optical Surfaces Quality Control: The company has developed techniques to perform optical surface quality controls in parallel with initiatives from European companies such as Bosch and Trumpf, companies that are involved in surface structuring, to produce antibacterial surfaces for example. Among them is the famous phase shifting schlieren deflectometry technique which uses more than one million measurement points to create ultrahigh resolution and is useful for detecting scratches and other cosmetic applications.

Engineering service: One of Lambda's key strengths is the quality of their engineers and the expertise they have acquired in specialty optics. With this versatile in-house capability, they have gained a reputation as a 'go to' company for both start-ups and established companies seeking to develop new optical systems. Engineering ser-

Organization

EPIC – European Photonics Industry Consortium

EPIC is the world-leading photonics industry association representing more than 600 members across 33 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.

www.epic-assoc.com

The NIMO instrument is one of Lambda's products for the ophthalmic market

vices to third parties now account for around twenty-five percent of their business with customers in the automotive, pharmaceutical, industrial and biotech sectors.

Contract manufacturing: Over the years, Lambda-X has built up production capability for its own products and more recently for third party products. To provide these services, they have a 650 m^2 ISO7 clean room facility, high precision tooling for optics alignment and assembly, and expert designers in opto-mechanics, electronics and software development. Manufacturing is based on customer designs, supported by EN9100 certification.

The Future

Didier sees two sectors as important for the future:

New space activities: Lambda are seeing new actors coming into the sector with new requirements that need new responses. Most of the time, it's for specific payloads with specific optics requirements, and this is also true for industry.

Spectrometry: Lasers are becoming more powerful, data is becoming easier to access and, as a result, Lambda are receiving customer demands for new spectrometers from many different sectors. In response they have developed a spectral camera, which will be useful for Raman applications in a wide variety of sectors such as a pharmacology, biotech and materials sciences.

If you could start again, what would you do differently?

"If I started again, there are some things I would learn earlier – the soft skills like communication, people management and understanding behavior in meetings and why people react as they do. These skills are very important in day-to-day working life and the soft skills courses I took late on in my career have proven very useful."

What are your words of wisdom for the next generation of CTOs?

"'Come and join Lambda-X!' But seriously, I would definitely recommend starting a career by working for a small company because you can have much more impact than in a large one. In a large company you are just a small part of a big project, whereas with a small concern you have more opportunities to show what you can do and to make a direct impact on the growth of the company."

Author

Jose Pozo is director of technology and innovation at EPIC, and as such he represents more than five 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

New Trends in Laser Beam Welding

How automotive applications are driving the future of laser technologies

Francesca Moglia and Antonio Raspa

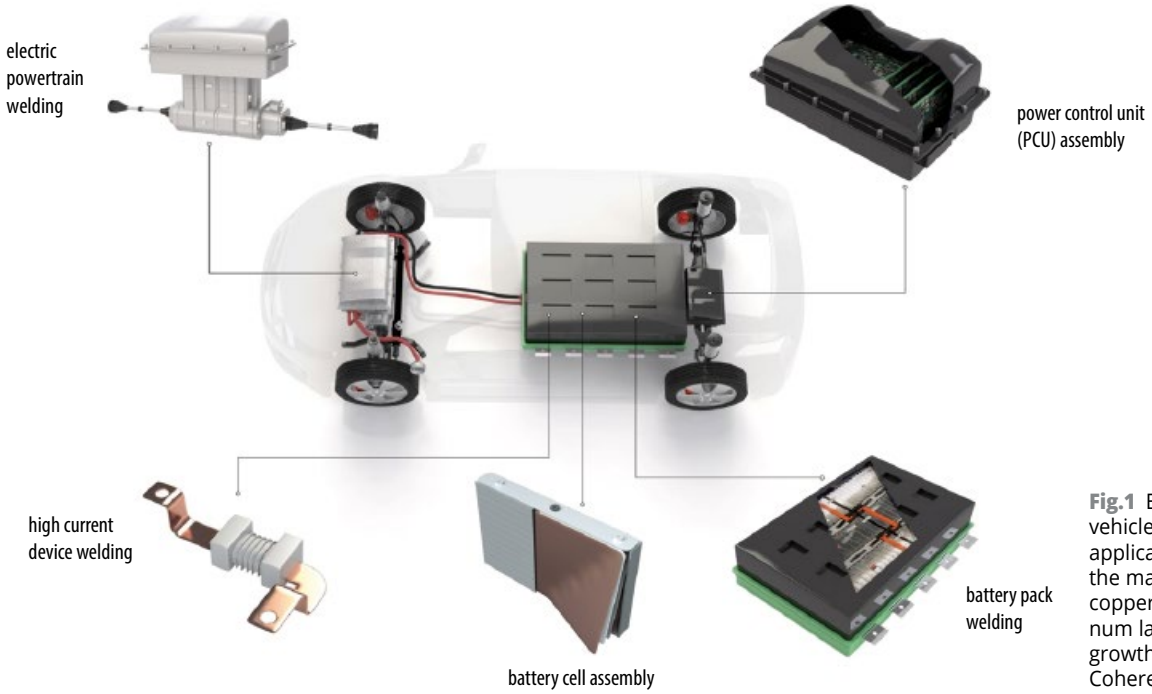


Fig.1 Electric vehicle welding applications are the main drivers in copper and aluminum laser welding growth (Source: Coherent)

Laser beam welding (LBW) is a perfect candidate for accessing Industry 4.0. Many advances are being made in the technology coming from the laser manufacturers and the system integrating companies with the commitment of the photonics community, and one of the applications driving them is automotive and in particular e-mobility. The European Commission's programme is a suitable platform for stimulating the access of laser technology to the world of digitalization.

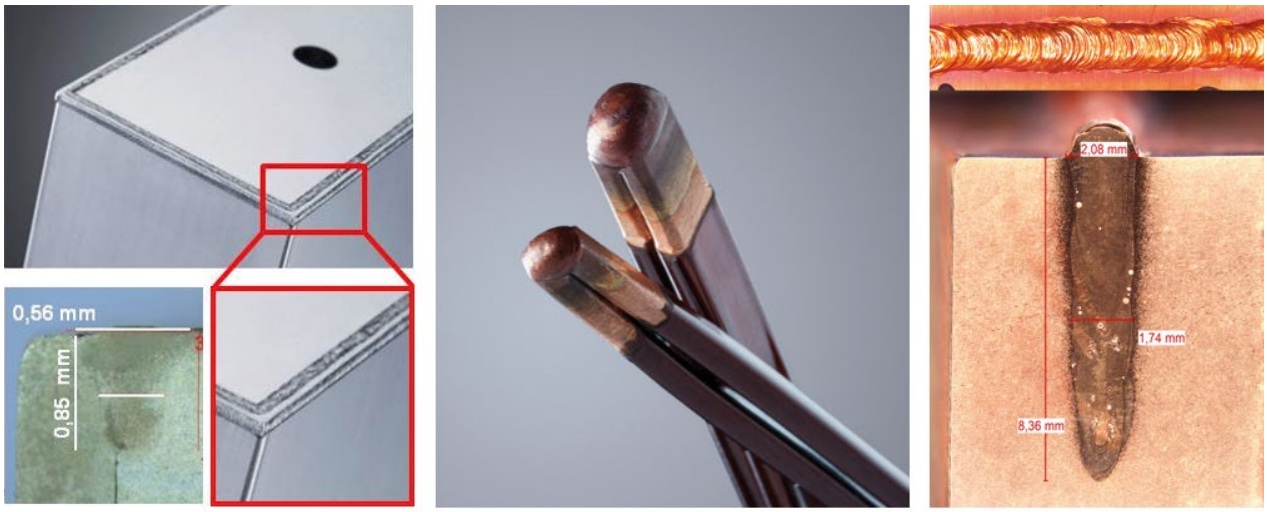
For the whole of the materials processing industry, it was the laser-based technology sector that had the largest revenue in 2019, with over one third of the total. This was despite a general revenue drop in the sector over the previous couple of years. In the subsector of high-power material processing, although welding applications grew faster, cutting still gave the largest contribution. One of the reasons for the acceleration of welding vs cutting was given by the increase of battery welding for the automotive industry.

The industry of car manufacturing: commitments and demands

One of the main challenges in joining materials is the joining of dissimilar ones. The car manufacturing industry has been trying to solve this challenge for over a hundred years. Currently, in this sector, the struggles are joining steel and aluminum as well as the introduction of new materials such as plastics and carbon-fiber reinforced polymers. Furthermore, compliance with the most recent CO_2 emission and safety regulations is fundamental.

When looking at the contributing factors to a vehicle's fuel consumption, 23 % is due to the weight of the vehicle alone. In turn, it is influenced primarily by the weight of the chassis, the body and the mechanisms. This means that this market needs safer and lighter cars to comply with the regulations while still keeping costs competitive. In this regard, laser welding technologies can offer viable and competitive solutions.

The approach of the joining department of the company Gestamp, specialized in body-in-white (BiW), stamping and assemblies for automotive, is fourfold. Remote laser welding of steel and aluminum is a wide-spread technology in their R&D centers. Systems from Trumpf and laser-based machines from IPG, Blackbird, Precitec, Coherent and Lessmüller are the most frequently used devices. Tactile laser welding is also a common method of joining the same materials, and Gestamp has several industrial installations running, also developing new technological innovations in-house. One of their specialties is BiW BKT laser softening or Ges/Soft-



battery cell housing | hairpins for electric drives | PD > 8 mm for busbars

Fig. 2 Application examples of BrightLine Welding for copper, aluminum and steel welding (Source: Trumpf)

bend, a new technology that they have developed themselves that allows them to create new material grades, partially hardening areas through laser heating using a diode laser. These special areas will prevent faults such as spot-welding ruptures and improve the part's performance in a crash. New bending solutions can be obtained for crash situations, starting from fully hardened solutions, creating partially softened areas with more ductile grades, that can offer unparalleled bending properties. The joining of dissimilar hard steels with aluminum is also possible.

Many of their partnerships are focused on developing new technologies for dissimilar material joining. The present main challenges are the mechanical joining of aluminum and press-hardened steel, the thermal joining of new materials such as carbon fibers with steel and the role of adhesives in all these processes. In the case of fiber-to-fiber joining, their BKT system could be a viable solution when combined with the right adhesive. Several potential solutions for steel-to-fiber joining are under investigation. The Gestamp R&D centers also use other laser-based technologies, such as ablation and cladding.

Despite mainly using tactile laser welding, Gestamp is convinced that remote laser welding is going to be an even stronger technology in the future, which will allow lighter vehicles by optimizing the material joining process. This is because remote laser welding can significantly reduce the width of the cover flange, which will lead to lighter parts while maintaining the same performance. The welding process will be accelerated: no filler material is needed for remote laser welding.

Looking to the future, companies such as Gestamp have one request to laser companies: more output power.

The laser manufacturers' approach to LBW for automotive

Coherent dedicates a part of its portfolio to applications in automotive for e-mobility, namely the electric powertrain, the power control modules, the battery cells, the battery packs and various other high-current devices (cf. Fig. 1 and [1]). These applications require the weld seams to withstand thermal expansion and vibrations over the entire lifetime of the car. The typical materials in these applications are aluminum and copper. Coherent's strategy is to employ 1 µm lasers for this and specifically their adjustable ring mode fiber lasers with up to 10 kW of output power. These have two 1 µm laser beams in one process cable: a conventional, high-brightness laser beam coming from the center of the fiber, surrounded coaxially by a ring-shaped beam. Both beams are dynamically independent of each other and can be adjusted, for example in their power, throughout the welding process. As an example, one can preheat the material using the ring laser and launch the center beam when the surface has been adequately conditioned and the absorptivity of the 1 µm beam is particularly high. The independent modulation ranges from cw to 5 kHz. These lasers are back-reflection resistant, which means perpendicular welding is possible without having to tilt the optics. They reduce spattering and porosity and have excellent control of the penetration depth while welding. Furthermore, it is possible to weld dissimilar materials together, such as aluminum and copper, without heating the materials excessively. This ensures comparatively void, spatter and pore-free joints that have improved electrical and mechanical characteristics. Coherent has mastered the welding of dissimilar materials, and is also open to collaboration on titanium, brass and zinc-coated steels welding and any e-mobility related application.

Trumpf is also dedicated to LBW for automotive and e-mobility applications, in particular for power electronics, battery cells, modules and containers, hairpin e-drives and drivetrain components and fuel cells [2]. In this sector, great attention is now given to copper welding in addition to traditional aluminum and steel welding. Trumpf uses green lasers based on frequency-doubled thin-disk lasers belonging to the TruDisk series with an output power up to 2 kW and a very high beam quality. This is their best tool, in combination with remote scanning optics, for fast welding of copper at different and stable welding depths. Green lasers also enable applications such as foil welding and mixed-metal weld joints, specifically aluminum and copper, which need extremely stable welding depths. Furthermore, multispot laser welding is an important trend nowadays that Trumpf sustains with their patented BrightLine weld technology, a 2-in-1 fiber-based system delivering up to 16 kW output power at 1 µm (see application examples in Fig. 2). This special waveguide configuration provides two spot sizes at the same time, with fully

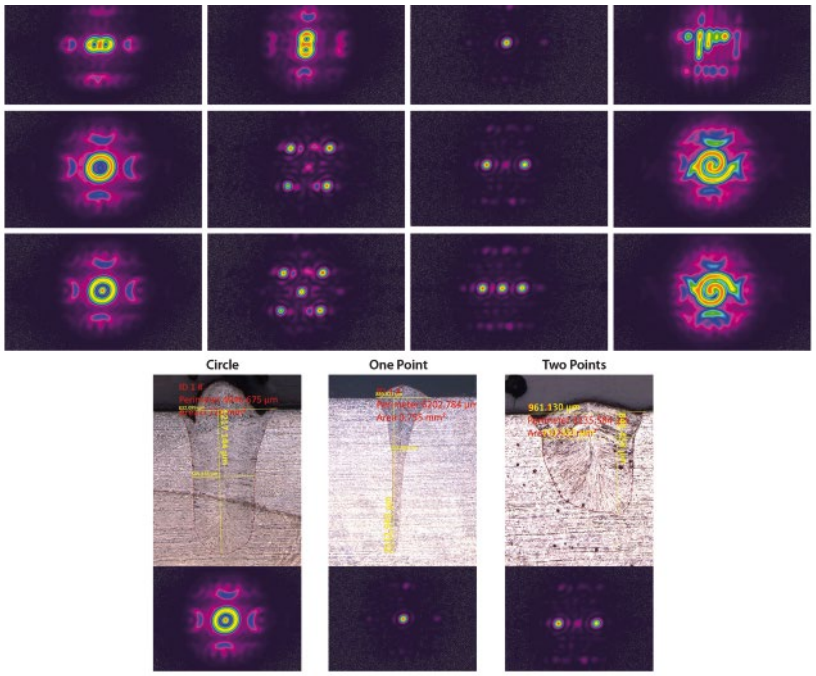


Fig. 3 Possible beam shaping with the dynamic beam of Civan and three examples of correspondent joint profiles (Source: Civan)

adjustable power distribution providing stabilization and spatter reduction of the welding process on all materials. Steel welding can be realized at high speed – exceeding twenty to thirty meters per minute – and efficiently. A particular advantage of copper welding is the ability to run at low or high speed, ensuring smooth weld seams. Trumpf is available to work with the photonics community, especially with experts in monitoring systems, sensoring, data handling, interpretation and process optimization, but also with optics manufacturers able to handle high power, brilliance and brightness in the infrared (>20 kW) for cutting and welding applications and high power at green wavelengths.

Nuburu plays a particular role in LBW with its blue lasers, especially in copper and aluminum welding for electric vehicles and batteries [3]. They also have expertise in brazing and heat treatment. With regard to automotive applications, the idea of using such a short wavelength is motivated by the especially high absorptivity of copper that leads to high-quality, spatter and pore-free welding without the need to apply beam wobbling. This is valid also for dissimilar-material welding, such as steel and copper in batteries, with consistent and controlled penetration depth, causing low heat load because of the use of only a few hundreds of watts of blue laser power. A recent development for large-area battery packs resulted in the integration of a scanner with a 1.5 kW blue laser, while the commercialization of a single-mode blue laser version is expected in 2021.

The experience in e-mobility of laser integrators

Comau, a member of the FCA Group, is a worldwide provider of advanced industrial automation products and systems. Its portfolio includes technology and systems for electric, hybrid and traditional vehicle manufacturing, industrial robots, collaborative and wearable robotics, autonomous logistics, dedicated machining centers and interconnected digital services and products able to transmit, elaborate and analyze machine and process data. They are integrators of laser systems in complex devices such as welding heads, applying hybrid thermography for inline real-time quality monitoring and big data handling. They developed software that uses artificial neural networks on recorded videos which are able to assess the quality of the joint without the need for any disruptive tests. They are also dedicated to improving process stability with tailored software design. Currently, they are open for collaboration in facing the challenge of detecting the amount of power in a joint in real time, with the goal of describing how the joint reacts mechanically and electrically, and certifying the performance in terms of the aging of the joint.

Precitec is a specialist for laser material processing and optical metrology. Their main products are processing heads for cutting and welding with fully integrated sensor technology to monitor and control laser processes in industrial applications [3]. Precitec equipment can be applied to many applications in e-mobility, where the laser tool is an enabler for several processes such as the real-time process control of battery contact welding (copper/aluminum), or the detection of faults such as gaps between sheets, a laser power drop or defocusing due to misalignments of visible light, temperature or back-reflection sensors during busbar welding. The innovative competence of Precitec is demonstrated by the use of OCT technology in laser material processing. This company was the pioneer and driver for the transfer of OCT from medical technology to industrial production and their success proves them right. The use of OCT sensors enables customers to measure the penetration depth and/or topography in real time with µm-resolution without being affected by the welding emissions.

Mature turn-key systems like KeyholeFinder or WeldMaster are tools running, for example, in industrial applications at Audi to weld Aluminum 6xxx series without additional filler wire. The core of this application is the continuous measurement of the seam geometry and, based on this, the adaptation of the oscillation frequency and width as well as the laser power. One application is using WeldMaster to close the battery cell module, which is mounted underneath the Audi e-tron where beam oscillation and power control ensure crack and pore-free weld seams. The absence of filler wire causes a heat reduction of 47 %, as well as significant reductions in running costs and production times, due to the integration of the quality check into the production process through the in-line control.

New technologies and the role of European-funded projects

Many factors play a role in achieving effective and precise welding. One of these is how the laser beam reaches the area to be treated. An innovative technology for this has been brought to the market by the company Civan. They provide single-mode lasers at both 1 µm and 532 nm, delivering output power from 10 to over 30 kW and up to 500 W, respectively. The high power is reached

for both wavelengths via coherent beam combining where many beams can be amplified and then combined into one single-mode output, with control over the beam shape, position and focal distance. They use optical phase array technology to do this whereby multiple lasers create a far-field diffraction pattern, which, controlling the relative phase with different phase modulators, can arbitrarily define the shape and position of the output maxima. The system is driven by specific software able to very dynamically implement a frequency of oscillation from kHz to MHz and on-the-fly changes in beam shape, focal distances or speed, adapting drilling, welding and cutting through different materials in real time (see examples in Fig. 3). In the future, they plan to add an on-the-fly monitoring system which, together with the on-the-fly parameter changing, would allow for real-time closed-loop monitoring.

This technology is a clear precursor of Industry 4.0 and the European Commission has shown great interest in supporting such developments. For this reason, many collective initiatives at European level are also driving LBW under the umbrella of 'advanced manufacturing'. One of them is called PULSATE, a recently granted European project under GA 951998 in the Horizon 2020 and which will kick off in fall 2020. The aim of the project is to connect many digital innovation hubs in Europe with expertise in laser-based manufacturing technologies, including LBW, and to reach all of the SMEs who want to fit in a digital-manufacturing and Industry 4.0 environment and see laser as a key enabling technology but are unable to implement it due to the lack of testing capabilities.

European-funded fast and simple tests of laser equipment will be offered in the first year of the project. There will be two kinds of cases: Technology Transfer Experiments (TTEs) and Adopter User Cases (AUCs). The first are funded with a lump sum of up to € 150,000 in a very quick procedure, plus additional support from top European research centers. The second are economic feasibility studies and mentoring, aimed at reassuring the end-user that the implementation will be effective in their environment. Open calls will be starting in early spring 2021 and the project will provide € 4 M in direct financial support and additionally € 1 M in extra support from the research and testing facilities.

The progress of this project and of the LBW technology will be topics of the annual Executive Laser Meeting, organized by EPIC, the European Photonics Industry Consortium, where executives from laser manufacturer, user, and system integrator businesses – generally the entire supply chain – are warmly invited to discuss present challenges, common interests and future collaborations. In 2021, we will meet at Convergent Photonics in Turin on May, 20 – 21 [5].

*

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[1] *F. Gäbler:* Optimizing Automotive Welding Applications with CleanWeld – A unique approach to fiber laser welding, PhotonicsViews **16** (2019) 4, 52-55; DOI: 10.1002/phvs.201900033

[2] *S. Bisch* and *S. Zaske:* A Green Wave for Electric Cars – Powerful green laser light meets all the requirements of the industry, PhotonivcsViews **17** (2020) 3, 70-73; DOI: 10.1002/phvs.202000019

[3] *J.-M. Pelaprat, M. Finuf, R. Gleeson, & M. Zediker:* Blue Lasers Move Deeper Into Applications – Higher power and brightness enable new capabilities, PhotonicsViews **17**(4), August 2020, pp. 41-45; DOI: 10.1002/phvs.202000032

[4] *M. Schönleber* and *M. Kogel-Hollacher:* When Ideas Serve as Benchmark – The rapid ascent of low coherence interferometry in laser materials processing, Laser Tech. J. **13** (2016) 3, 26-29; DOI: 10.1002/latj.201600019

[5] www.epic-assoc.com/epic-executive-laser-meeting-at-convergent-photonics/

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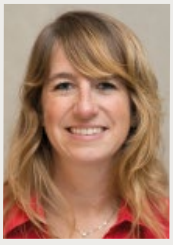

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Efficient Connective Solutions

Automation solutions for the laser welding of plastics

Frank Brunnecker and Christian Ebenhöh

Fig. 1 Typical laser-welded automotive assembly (Source all images: Evosys Laser)

Like other joining processes, systems for the laser welding of plastics must be intuitive and easy to integrate into fully-automated production lines. In particular, the mechanical and control interfaces of the welding stations need to be designed for this purpose.

Laser welding of plastics is widely used in many areas of industrial production, especially because of the typical advantages of the process and its enormous potential. Today, thousands of products are manufactured worldwide using this technology. From micro to macro, every size of assembly is represented, from lens packages for smartphone cameras to 3D structural components for electric vehicles. Another typical application example of a laser-welded automotive component is shown in Fig. 1: this housing for a mechatronic assembly is produced in large quantities and in different variants by laser welding.

Wherever joining technologies, such as bonding, vibration, or ultrasonic welding, reach their limits with regard to strength, speed or the mechanical stress on the components, laser welding offers a cost-effective alternative with enormous process reserves. The contactless technique is characterized not only by a high degree of economic efficiency, but also by a very well controllable, locally limited energy input with very low mechanical stress on the items being joined.

In addition to the continuous development of thermoplastic materials, which can be ever more easily adapted to this process, even more widespread industrial use is also being driven by further progress in systems engineering.

The modular design is the key

A large number of the plastic welding systems employed today are not designed as manually operated workstations, but is often integrated into fully automated facilities. This results in a wide range of requirements for component handling, process control and data exchange with higher-level control systems. In addition, the mechanical design must be suitable for integration into production lines. These days, it is no longer sufficient to offer just compact welding machines. Instead, it should be possible to integrate the systems into a production line without them standing out by their characteristic appearance. Evosys Laser, as an innovator in integrated laser welding units with out-of-the-box (OOTB) modules, is a specialist for interlinked solutions and can rely on many years of experience in this field. The company offers suitable workstations for every process variant.

Fig. 2 shows an OOTB process module of the EVO 0800 series, which can be used for quasi-simultaneous as well as

Fig. 2 EVO 0800 process module for integration into assembly lines

for contour laser welding. It is equipped with a compact standard control cabinet containing all the essential components. The laser source is connected to the galvanometer scanner by means of optical fibers. The unit also incorporates the necessary clamping device, which is mounted underneath the beam guidance, and is equipped with all necessary laser protection devices.

The EVO 0800 can be easily integrated into a conventional workpiece carrier system and, due to its compactness and innovative clamping concept, also into a rotary indexing table. Since the system combined with the workpiece carrier corresponds to laser class 1, only appropriate crushing protection has to be implemented in the area of the welding station.

Another smart solution is the EVO 0700 process module for radial welding, shown in Fig. 3. Laser radiation and process monitoring are directed into the processing zone via a rotatable mirror arm. The module, for example, is used for welding connectors on tube ends in the automotive industry or for radially symmetrical sensors and actuators. In both applications, the assemblies are usually equipped with cables of different lengths prior to the welding operation. The particular advantage of the system design is the high flexibility with regard to existing and future component geometries, such as cable lengths, diameters or even the position of the weld seam. The EVO 0700 is so far the only module on the market that can optionally be equipped with appropriate laser protection. This eliminates the need for complex enclosures that subsequently have to be extensively certified.

While Fig. 3 shows the interior of a manual workstation, the process module in Fig. 4 is being operated at a 4-station rotary indexing table. This customer-specific complete solution – which was developed and manufactured entirely at Evosys Laser – initially consists of an assembly and testing workstation including camera-controlled component scanning. Subsequently, the components are pressed together to the required dimensions in the next station and then transported to station No. 3 for laser welding. The laser welding is temperature controlled and the process data as well as the result are transferred to a central computer via a data interface. Possible bad parts are automatically separated from the good ones at the last station and reliably sorted out.

Evosys OOTB process modules are used worldwide and have been optimized with numerous automation companies and integrators. Both the mechanical and electrical interfaces are optimal for integration through clever standardization. Due to the well thought-out design, the modules can be adapted quickly and easily to almost any application without causing long-term service and maintenance problems.

High availability in series production

After successful integration into a production line, it is only the everyday production routine that influences the economic efficiency of a mass production system. Important for trouble-free series operation – and thus high availability – is a robust design of the welding unit. Here, 'robust' not only refers to the mechanical design of the machine, but also to the beam shaping and laser source.

Evosys Laser relies on the proven calibrated quality concept (CQC) for the optical units of the OOTB process modules. All optical components, including the galvanometer scanners, are measured and calibrated in the in-house laser laboratory. The mechanical design of the beam shaping follows the principle of "simple and robust at maximum effect". This ensures minimum downtime and extremely fast replacement times. A further aspect for the availability of the entire system is the frequently discussed selection of the beam source.

Two laser types are available to the user for laser transmission welding: fiber or diode lasers. Both types are produced today with excellent lifetimes. In addition, the laser output power is continuously monitored and, in case of a drop, it is possible to react in time without downtimes.

Company

Evosys Laser

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

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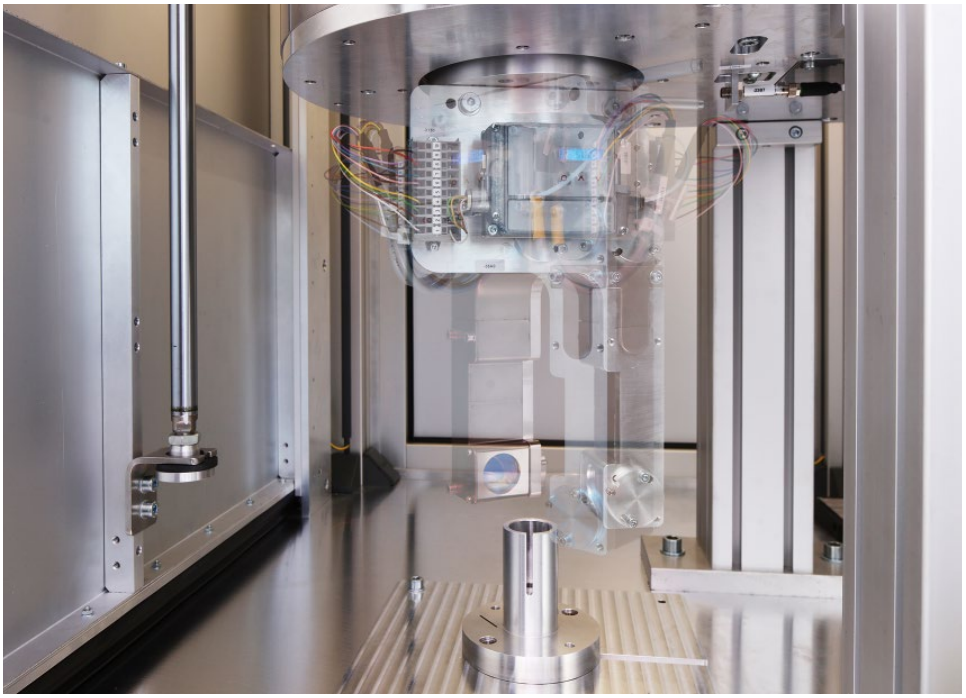

Fig. 3 EVO 0700 module for radial welding

The general electrical and pneumatic components play a mostly subordinate role when considering availability. It is particularly important that regular service and maintenance work is not time consuming as this has a significant effect on availability. In this respect, the OOTB modules are optimized for almost maintenance-free operation.

Ease of use and standard interfaces

In addition to the high availability of a system, intuitive and reliable control is of decisive importance in series production. It ensures continuous monitoring of the welding process and the system components, archives the process data and provides the ability to adapt the process in case of changing conditions.

Evosys Laser employs the PLC technology of the market leaders for the system control of the OOTB process modules. A specially-developed HMI provides a uniform user interface, irrespective of the PLC manufacturer. The operator receives the information relevant to his field of activity on two displays where the current process data is visualized and evaluated. Other processes can also be displayed in addition to the laser welding. The menu-based user interface with password protection for sensitive areas allows simple handling of the controller. The easily adaptable basic control functions cover every aspect – from the administration of several parameter sets for one component to the fully automated, dynamic production of varying assemblies. The EvoLaP in-house process software is also integrated into the HMI. This means that adjustments to existing processes or the setting-up of new ones are a quick matter. Using high quality industrial PCs at the welding station ensures that data archiving or data processing is straightforward.

Another control function that is mandatory today is the complete trace-

Fig. 4 EVO 0700 module with laser protection integrated on a rotary indexing table

ability of each manufactured unit. To ensure this, the information collected during the welding operation must be archived and assigned to the workpiece. The OOTB process modules have various options to achieve this. In its simplest form, data on the industrial PC at the welding station is numbered sequentially. The control system can also be connected to a master computer, or complex data exchange can take place with the central database of a higher level system – anything is possible. The most common interfaces found in industrial production are used for this purpose.

Conclusion

Laser plastic welding machines can nowadays be easily integrated into fully automated production lines, thanks to their compact design. The availability of the systems is guaranteed by the robust component technology, the high reliability of modern lasers and industrial control concepts as well as the low maintenance effort required. Laser plastic welding is challenging conventional joining methods thanks to new, powerful and process-safe system solutions, specially adapted materials as well as the thousands of industrial applications that have already been successfully implemented. Together with the proven process advantages, it also offers a competitive alternative in terms of profitability due to lower total production costs.

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Christian Ebenhöh studied production engineering at the University in Erlangen. Due to his technical education with focus on laser material processing, plastics technology and his stations in applications engineering, he has an excellent knowledge in process technology. He further developed his competence as product and business development manager at a large automotive supplier. At Evosys Laser GmbH, he works as key account manager.

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A Toast to Laser Glass Cutting

Ultrashort-pulse lasers ramp up productivity for manufacturing glasses

The iProtec system is a fully automated machine for performing wine glass cap removal using SmartCleave at rates of up to eighty pieces per minute. (Source all images: iProtec)

Wine glasses have been in use literally for millennia, and most people would hardly consider them a 'high technology' item. But, iProtec (Innovative Process Technology), a company that designs and builds machines for drinking glass production, developed and now offers one of the most sophisticated laser materials processing methods available in their automated systems for removing the moil of drinking glasses. Specifically, they utilize an ultrashort-pulse (USP) laser from Coherent to perform SmartCleave cutting, which delivers superior results, reduced costs, and more environmentally friendly manufacturing.

iProtec was originally founded in 2006, and was subsequently acquired by the owners of Zwiesel Kristallglas AG in 2011. The three sister companies – Zwiesel Kristallglas AG, Ullrich GmbH, and iProtec GmbH – are all at the same location. iProtec now employs over 160 workers. Its primary focus is automated equipment for drinking glass production, and they are the only company offering machines that address every step in the production process for hollow glasses: feeding, pressing, blow molding, fusing, separating, mouth rim polishing, testing, laser marking, packing, etc. Additionally, iProtec services the automotive industry with assembly, gluing, testing, welding, and other systems, and manufactures a variety of other specialized production equipment to specific customer requirements. Having their own design, purchasing, electrical, manufacturing and assembly department ensures high flexibility and perfect customer service.

iProtec employs a holistic approach to machine development, striving to engineer and deliver systems that integrate seamlessly into their customers' existing production setting. A major focus of their efforts is reducing production costs while simultaneously improving quality and yields. Introducing manufacturing processes which protect the environment is also a core value for the organization.

Traditional glass cutting

The drawing shows a highly simplified schematic of wine glass production. A droplet of molten glass is put into a form, and air is blown into the droplet to make it expand and fill the form. The glass cools in the desired hollow bowl shape, but also has a 'cap' (the so-called moil) of material at the top. This cap is useful because it enables the glass to be handled and held during subsequent production stages, such as attachment of the stem and base, but eventually it must be removed.

The edge where this cap is removed from ultimately constitutes the rim of the finished glass; and, since this is where the drinker's lips touch the glass,

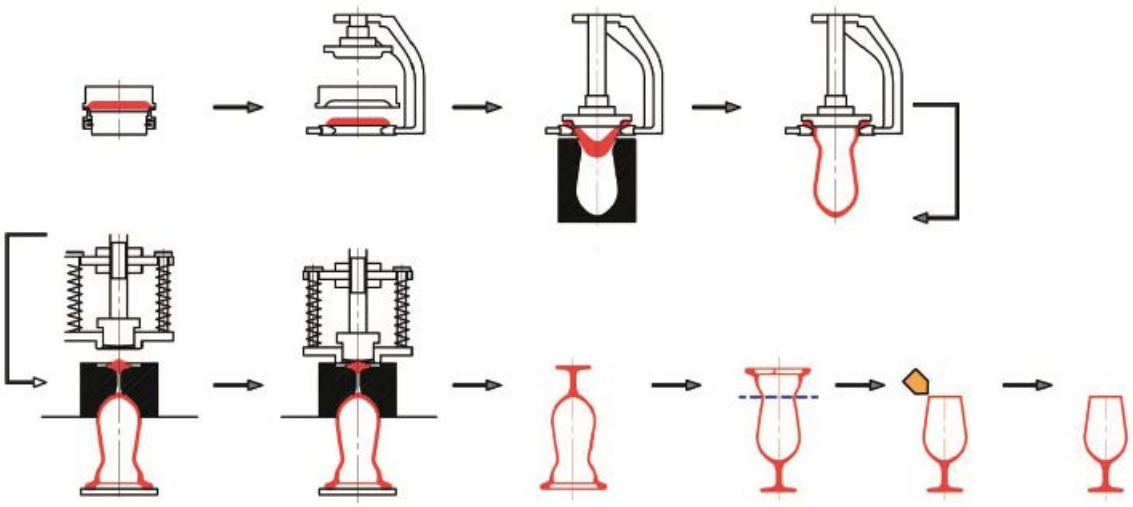

Fig. 1 The main steps of wine glass production: blow molding → preparing and pre-forming the molten glass gob → insertion into the machine → blowing (an air jet expands the glass to fill the mold) → removal of the glass from the machine → pressing→ feeding the molten glass droplet for stem and base plate → pressing the stem and the base plate → removal from the machine → separating → cutting the glass → polishing the mouth rim → finished glass

smoothness of this cut edge is of primary importance.

The technologies conventionally used for removing the cap (moil) can be split into two main groups – that is, cap removal from hot or cold glasses. The cap can be cut off by heating the glass, or by scribing the mouth rim and the use of thermal shock. For the latter, the cap is then subsequently removed by applying mechanical force, either through a blast of air or physical contact.

More recently, the use of a flame for heating has been replaced by heating induced using a CO_2 laser. A step after this to physically remove the cap is also required with this method.

In many cases, cutting methods produce a different quality than required for the finished part. Often, various post processing steps have to be used, such as mechanical grinding and flame polishing, to achieve the desired surface quality. Obviously, this requires additional time and cost. Plus, grinding requires water and creates glass debris, both of which have environmental impacts; the glasses must then be dried, which also requires energy consumption. And: the use of mechanical force on the glass during grinding can cause breakage. Finally, since there are unit-to-unit variations in glass thickness, these cutting processes are not entirely repeatable.

Fig. 2 Wine glass before and after cap removal with the laser system.

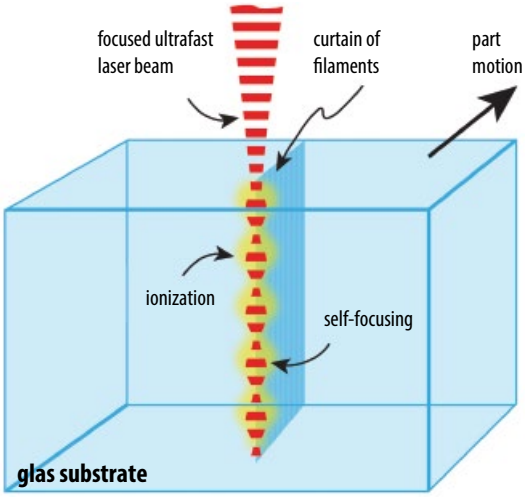

Fig. 3 Schematic of the filamentation process which involves periodic self-focusing of an ultrashort-pulse laser beam. Relative movement between laser beam and work piece creates a line or 'curtain' of these filaments with 3 – 7 µm spacing. The filaments weaken the material and enable a clean separation.

Laser filament cutting provides the solution

'Filamentation' is an alternative glass cutting method to bulk heating (using a flame or CO_2 laser) that exploits the very high-power densities that can be achieved with focused, ultrashort-pulse lasers of even modest overall power. Coherent's tradename for their patented version of this energy-efficient process is SmartCleave. Specifically, it enables high-speed cutting of straight lines, curves, and insets, without taper, into transparent and brittle materials from 50 µm to 10 mm in thickness. SmartCleave also delivers smooth surfaces, with an R_a roughness of less than 1 µm and with edge chip sizes less than 5 µm. Importantly, the process results in a final bend strength that is measurably superior to mechanical processes, which has made it particularly attractive to touchscreen manufacturers.

In the context of wine glass cap removal, SmartCleave addresses virtually all of the drawbacks of flame or CO_2 laser cutting. Specifically, it applies laser energy in such a spatially precise and limited manner that there is no bulk heating of the glass, and therefore, no thermal damage to the material. It creates an extremely smooth edge, with no burrs, cracks or breakouts, which completely eliminates the need for subsequent processing. Thus, all the additional grinding, washing, and drying steps, along with their energy consumption, time, cost, and negative environmental impact, are absent (no dust and precipitation on the glasses). SmartCleave increases yields, improves quality and lowers production costs.

To accomplish filamentation cutting, the output of an ultrashort pulse (<15 ps) laser is focused to a small spot within the substrate. The very high laser intensity achieved produces self-focusing of the beam (due to the Kerr optical effect) within the glass. This self-focusing further increases power density, until, at a certain threshold, a low-density plasma is created in the material. This plasma lowers the material refractive index in the center of the beam path and causes the beam to defocus. If the beam focusing optics are properly configured, this focusing/defocusing effect can be balanced to repeat periodically and self-sustain. This forms a stable filament, that is, a line of tiny voids, which extends over several millimeters in depth into the glass. The typical filament diameter is in the range of 0.5 µm to 1 µm.

In order to make a cut, the substrate is moved relative to the beam to create a series of these closely spaced, laser-generated filaments. Motion speeds of 0.1 – 2 m/s can be utilized, depending on the material thickness and the desired cut geometry. With chemically or thermally strengthened glass, internal stress within the part then causes spontaneous separation, without an additional step. For non-strengthened glasses and other transparent materials such as sapphire, a separation step must follow SmartCleave. This can be accomplished with either a small mechanical or thermal force. For example, the latter is often achieved by heating with a CO_2 or CO laser or flame.

Burst mode – maximizing edge quality and strength

One key factor in the practical implementation of SmartCleave cutting is the use of a USP laser which provides 'burst mode' operation, such as the Coherent HyperRapid NX. In burst mode, the laser provides a series of closely (temporally) spaced pulses. If the timing between subsequent pulses in the burst is shorter than the thermal diffusion time of the material, then heat builds up in the substrate which increases the glass ductility. This produces a more gentle (and therefore lower stress) localized heating profile than a string of pulses with equivalent energy, delivered over a longer period. This gentler heating cycle produces several important benefits. First, it increases cutting speed by as much as a factor of two. Next, it produces holes which are smoother and straighter than achieved with single pulse filamentation cutting. Also, it essentially eliminates the formation of microcracks on the sides of the holes. This is important because microcracks can significantly lower glass strength.

Companies

Coherent

Founded in 1966, Coherent Inc. is one of the world's leading providers of lasers and laser-based technology for scientific, commercial, and industrial customers. With headquarters in the heart of Silicon Valley, California, and offices spanning the globe, Coherent offers a unique and distinct product portfolio and services that touches scientific research, instrumentation, microelectronics, and materials processing.

www.coherent.de
www.coherent.com

IPROTec

IPROTec GmbH is a young, rising company in the industry of special purpose machine building with worldwide operations and projects. IPROTec specialises in the development, construction, planning, manufacture, assembly and commissioning of machines, systems and production lines that are designed optimally under holistic consideration of the customer's specific environment and with the greatest possible expertise.

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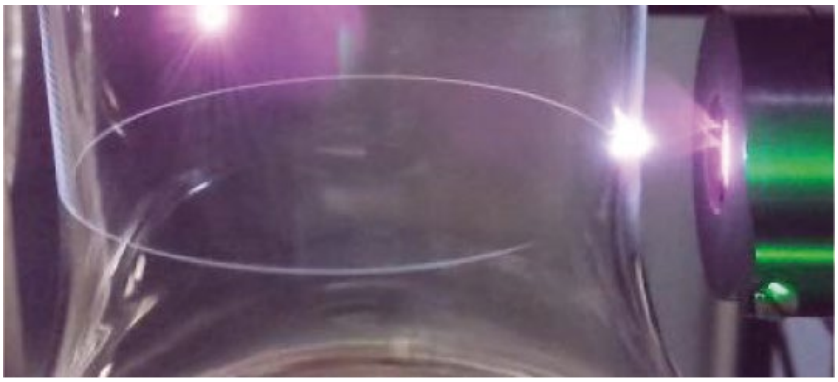

Fig. 4 Coherent HyperRapid NX performing filamentation cutting on a wine glass.

Implementing a SmartCleave subsystem at iProtec

iProtec designed and now supplies a fully automated system which implements SmartCleave cutting for glass cap removal. It utilizes a Coherent PowerLine SmartCleave subsystem, which incorporates a single HyperRapid NX laser with 50 W of average output power at a wavelength of 1064 nm. The subsystem also includes several optical components, beam switches, sensors, and electronics. All managed by Coherent's laser controller, including a laser safety concept that can easily be integrated into the machine safety concept of the iProtec system. Depending upon how the machine is configured and used, it can process up to eighty glasses per minute.

The iProtec system is the first drinking glass cutting equipment available to employ SmartCleave technology, and gives the company an advantage because it enables their customers to lower their energy consumption, while also improving yields and reducing scrap. The system has already proven itself in actual use to deliver the 24/7 reliability required by high volume drinking glass manufacturers.

"Early on in the development of our current systems for glass cap removal, we identified SmartCleave cutting as offering tremendous benefits for our end users," notes Tobias Bredl, project manager at iProtec. "A major reason that we selected Coherent as our laser subsystem supplier was that they were ready and able to partner with us in the development of the process and technology. This is particularly important to us when first implementing a new technology that we're not familiar with. We didn't want to have to become laser experts to take advantage of SmartCleave, so Coherent's willingness to get involved and lend their knowledge and product solutions to reduce our time to market and to lower our overall development costs. Plus, we liked their HyperRapid NX laser for several reasons. It implements burst mode very effectively, and has well-proven reliability. Also, the compact design of the HyperRapid NX makes integration into our machines easy. Plus, Coherent lasers and subsystems are backed by a strong, global service infrastructure. That's important to us, because we send our systems all over the world."

In conclusion, iProtec's ability to provide a superior high-tech solution to a centuries old, low-tech task shows how the unique processing abilities of USP lasers can revolutionize even traditional industries. This serves as an example of how Coherent's 'Industrial Revolution in Ultrafast Science' extends far beyond the laser laboratory to sophisticated processes for making smartphone displays, as well as volume production of the humble wine glass – one of the oldest consumer products used by humankind.

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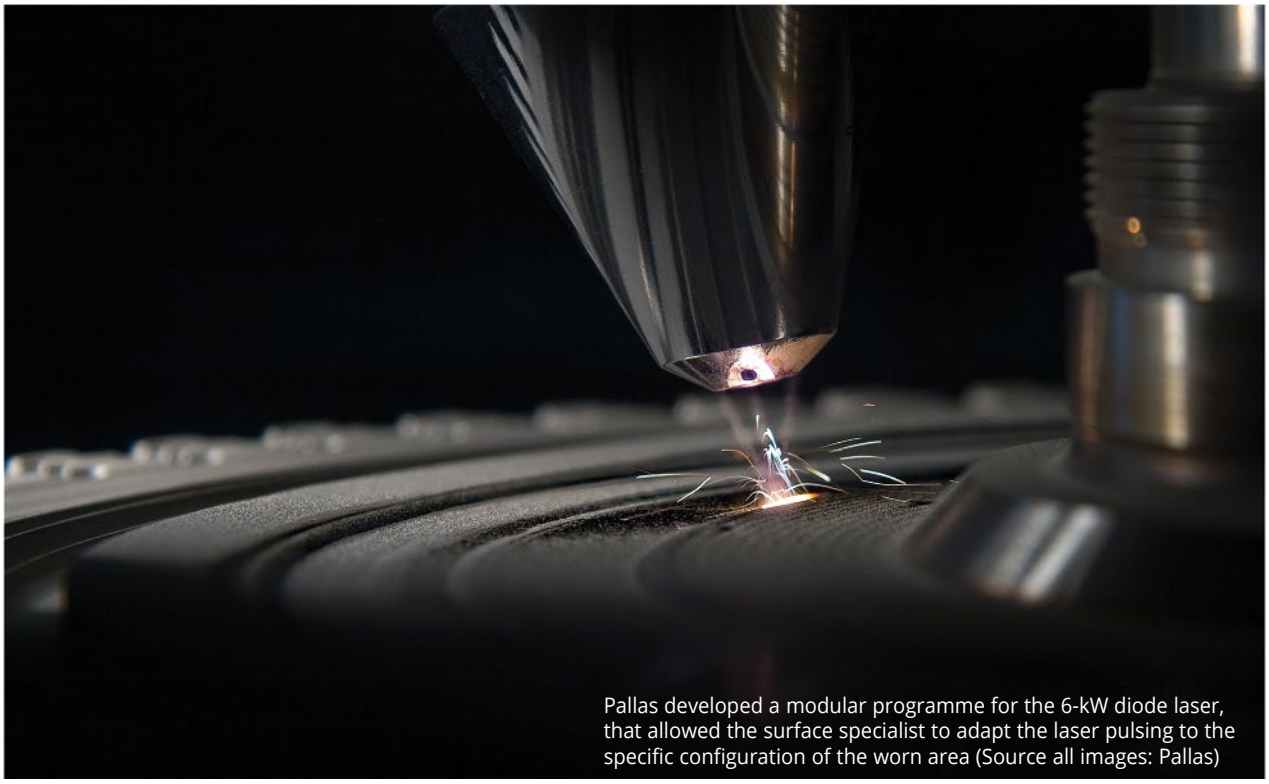
Worn Knife Seatings in the Best of Hands

Laser cladding is the "knight in shining armor" for a sawmill



Pallas developed a modular programme for the 6-kW diode laser, that allowed the surface specialist to adapt the laser pulsing to the specific configuration of the worn area (Source all images: Pallas)

It's all go in the timber processing industry. Every day, in a non-stop process, countless logs of up to 22 meters in length are debarked, measured to the intended format of the final product and processed into lumber. The extreme stress on the equipment and tools in the production line used for this process is something about which the company Gebr. Eigelshoven – a state-of- the-art sawmill in Würselen near Aachen with more than 130 years of tradition in the trade – can tell a thing or two. When it comes to repairing heavily worn circular knife tool-holding fixtures, their go-to solution is laser cladding performed by Pallas, a proven specialist in the repair of highly stressed components.

Founded in 1887 by the clog manufacturer Gottfried Eigelshoven, the factory was enlarged in 1918 to include a sawmill and a cereal mill. In 1940, the first bandsaw was installed. The entire factory burnt to the ground in 2000, but within a year was re-erected and equipped with state-of-the-art technology on a site twenty percent larger than the original site. Even with this enlargement, the new factory's available surface area of 70,000 square meters is still considerably smaller than other timber mills with a comparably high output. Maintaining an annual output of 220,000 cubic meters of trimmed timber – in other words a daily throughput of 1,000 cubic meters on the quadroline bandsaw – calls for a maximum of logistical finesse. Up to 28 trucks per day drop off the raw material – round logs exclusively sourced from sustainably managed forests – and pickup an equivalent amount of finished product and mill residues. Currently, the one hundred- strong staff are processing wood – about eighty percent of it spruce and twenty percent Douglas fir – for structural timberwork. 95 percent of the output is dimensional lumber, i.e. raw material for construction timber, substructures, battens or shuttering formwork. Cut-to-size timber in a variety of formats, packaged according to customer-specific parts lists, and trade items complete the variety of products. The mill's customers range from small, domestic companies to internationally operating bulk buyers. About fifty percent of the customers are located in Germany, thirty percent in the neighbouring Benelux countries, a further ten

The fine machining is done by a circular saw.

percent in France and Great Britain and the rest abroad. Apart from having all the relevant certifications, Eigelshoven has an excellent reputation for the high quality of its processing and treatment, for tightest dimensional tolerances and consistently high surface quality. Its exclusively customer-specific production is the guarantee for made-to-measure, just-in-time deliveries and the required high level of throughput. The management of this family business is firmly in the hands of the fourth and fifth generation of Eigelshovens.

From tree trunk to ready-to-dispatch structural timber

The felled logs are delivered to the log yard, where they are loaded onto the plant, then separated and reduced, i.e. the trumpet shaped end of the log is milled down. They then pass through the debarker and a first metal detector that inspects the logs for metal splinters, nails or munition. Then the logs are first measured per laser to establish their length and diameter as well as any special features like warp or ovality. These measurement data are then assigned to the customer orders in the next stage, the cross-cutting station. This computer-based process determines simultaneously which lengths of which logs are to be cross-cut for which customer orders.

A gantry crane transports the debarked and cross-cut logs to the sawmill, where they pass through a second metal detector. In the sawmill, the complete customer order is loaded into the quadroline mill – four bandsaws with a magnetic guidance system. In an inline process, each log then passes through the 80-meter-long and 15-meter-wide bandsaw line at a feed rate of 28 to 105 meters per minute. First, another two-stage 3D laser measuring system identifies the individual log. On the basis of the optimal cutting plan previously established – also per laser – the log is then automatically rotated into its correct orientation. In the next stage, the chipper canter removes two opposing curved sides of the log. The circular knives used for this process are held in tool-holding fixtures. By means of a computer-aided nesting plan, the bandsaw then cuts the product from the middle of the log according to the customer's order, and also further useful cuts from the rest of the material. In the next stage, the log is rotated through ninety degrees and a second chipper canter removes the other two curved sides. The result: a rectangular block of wood. This is then divided into boards by a variable circular saw with one horizontal and six vertical axes. In the sorting unit, unusable pieces are sorted out and then stacked and banded for delivery to the customer. Finally, the cut-to-size lumber passes through a range of finishing stations like planing, exact truncation with millimeter precision, fully automated six-axis processing (joining), bath impregnation and drying.

Tool-holding fixtures set the pace for speed and quality

A throughput of a thousand cubic meters a day implies extreme stress for the circular knife tool-holding fixtures in the chipper canter. This is where the rough surface of the log – residual bark, irregularities or branches – is

Company

Pallas

Headquartered in Würselen near Aachen, Pallas is a leader in the field of surface engineering that offers a complete range of surface treatment processes from a single source: electroplating, thermal coating, non-stick and plastic coating as well as laser treatment. By combining the advantages of thermal, mechanical and electromagnetic procedures and working materials, Pallas develops application-specifically optimised surfaces for heavy-duty components or tools. For over 50 years now, this owner-managed family business with its three dozen employees has regularly set new standards in the field of technical and decorative surfaces. In key industrial applications like tool- and mould- making, for sealing and bearing seats, rollers or drill pipes, Pallas offers the attractive option of rapid repair as an alternative to time- and cost-intensive replacement with brand new components.

www.pallaskg.de

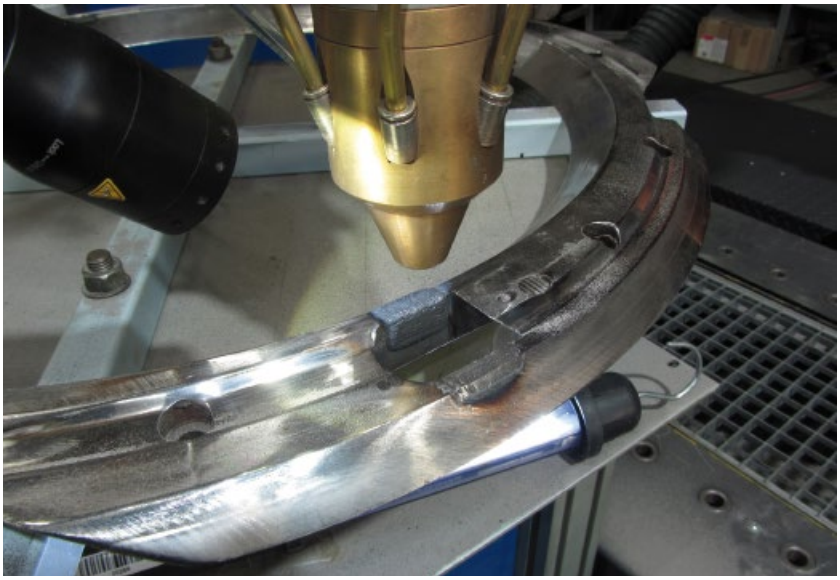
Company

Eigelshoven

The Eigelshoven sawmill produces high-quality structural timber, dimension timber, bulk squared timber, planks and covering timbers. A carefully-selected series of commercial products completes the range.

The production plant, which occupies some 70,000 square meters of floorspace, processes approximately 220,000 cubic meters of coniferous timber every year, of which 80 % is spruce or fir, and 20 % redwood such as pine, larch and Douglas fir.

www.holz-eigelshoven.de

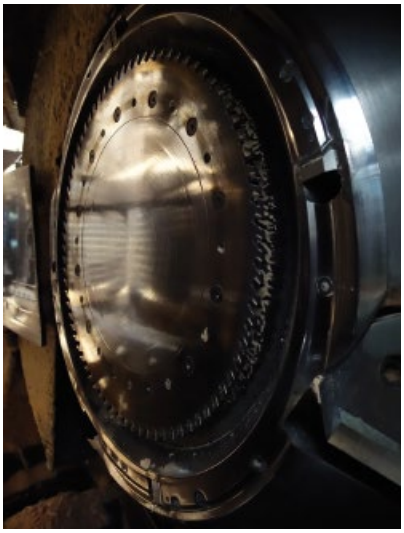


The coating material is applied through concentrically arranged nozzles to the surface area to be treated and melted together with the base material.

milled to an even surface. The roughness is ablated by four 15 × 28-centimeter knives fixed into a cast iron rotor disk which measures 750 millimeters across and is 300 millimeters thick. Another four smaller knives – measuring just 7 × 7 centimeters – are deployed for the smoothing action. These are attached to the rotor disk by means of rectangular tool-holding fixtures. The knives are exchanged every day – just like all the mill's saw blades – and resharpened in Eigelshoven's own grinding shop. When it comes to cut quality and speed, the seatings that hold the small knives in the cutters in the rotor disk are of critical importance. The wear and tear due to the constant friction tends, over time, to create damaged spots on the right and the left of the tool clamping. Wood gets into these recesses and renders the cut unusable due to torn out bits of wood fiber. At the same time, the performance of the machine is diminished, and this puts maintenance of the required daily throughput at risk. In view of the high costs involved in replacing one of these tool holders, Rainer Oprei, technical director at Eigelshoven, has long been on the lookout for a durable repair option. After all, the mill has a total of four of these rotary cutter heads in operation on a daily basis. But he was sceptical – due to bad experiences with initial repair attempts – as to whether such a durable repair option even existed. Then, he witnessed the success Pallas achieved in their treatment of several shafts with bearing damage – and this encouraged him to give the idea another try. When one of the tool holders had to be replaced due to wear and tear, he turned to Pallas and found competent and motivated counterparts in Stephan Kalawrytinos, managing director, and Rodion Honisch, head of the laser division. They suggested a surface reconstruction of the damaged structures by means of laser cladding. Using strictly localised heat input, this generative process facilitates high-precision surface coating with minimal warpage. The coating material is applied through concentrically arranged nozzles to the surface area to be treated and melted together with the base material. In this so-called melt pool, the two materials join metallurgically into a dense coating with low dilution. Moreover, the near-net contour quality of the applied coating means that post-processing costs are kept to a minimum.

Point by point to success

One particular challenge that Pallas faced was that the tool holders had no basis. In addition, the tool clampings were not only worn to different degrees. The hardness in the worn areas also had an extremely inhomogeneous distribution, with differences in hardness of up to 40 HRC. For this reason, Pallas decided to experiment on all four tool-holding fixtures with different working materials that had differing



The four circular knife holders are exposed to extreme conditions: Here, residual bark and irregularities are removed and the roundings are milled to an even surface.

corrosion resistance and material hardness grades ranging from 50 to 63 HRC. However, the heterogeneous surface condition of the worntool-holding fixtures did not permit any continuous coating with high-speed steels, which meant that more manual processing would be needed. Honisch developed a modular programme for the 6 kW diode laser to be used for the task, and this allowed him to adapt the laser pulsing to the specific configuration of the worn area. In this way, he could choose where to begin with the reconstruction: on the flanks, or on the lower edge. In laser pulsing, very short controlled bursts – the laser only flashes for just 200 milliseconds – apply the energy selectively to the material in order to repair complex geometries point by point. Thanks to the near-net contour quality of the process, the coated tool-holding fixtures required only minimal post-processing, which was done with a Dremel. All in all, the repair of each tool clamping took at least eight hours.

No wear after a year of continuous operation

Oprei installed these repaired circular knife tool holders in one of the sawmill's chipper canters in order to test the durability of the laser cladding under the tough conditions of the machine's daily operation. One year later, he examined the wear and tear – and was surprised by what he found. One of the four knife seatings that had been processed by Pallas showed no signs of wear and tear at all; the other three only infinitesimal traces. Normally, after a year in operation, circular knife tool holders are completely worn down. Oprei was delighted, and commissioned Pallas with the repair of a further, much more worn circular knife tool holder – this time using the particular working material that had proved itself best in the first repair. For Pallas, the follow-up order also meant having to find a way to reduce the required manual processing in order to ensure the cost-effectiveness of the repair for both sides. The problem lay in the form of the knife seating, which impeded a suitable positioning of the laser head. In view of the wear pattern, Honisch therefore decided to homogenise the surface to be treated by first milling out the wear points. The milled-out recess – up to seven millimeters deep – had to be designed so that the applied reconstruction coating would meld firmly enough to the base material. The solution was a special processing technique that he developed. Because the knife seating was extremely worn, the coating specialist's first step was to create a slightly raised connecting edge of austenitic stainless steel 1.4404 (316L), on which he then reconstructed the worn basic structure of the tool-holding fixture. On this, he then applied high-speed steel with a hardness grade of 63 HRC as wear protection.

This surface-treated cast iron rotor has now been back in operation at Eigelshoven for a month. Oprei is confident that it will more than fulfil his expectations of a long service life. And he is full of praise for the "enthusiasm with which Pallas took on this task, and their willingness to take risks". The positive result and an 80-percent saving on costs compared to buying a new unit also spoke for the chosen solution. Optimal preconditions for the sawmill to entrust the surface engineering experts with a new – and by no means less challenging – task. The bed knives on the hacker are to be given durable wear protection by means of laser cladding.

*

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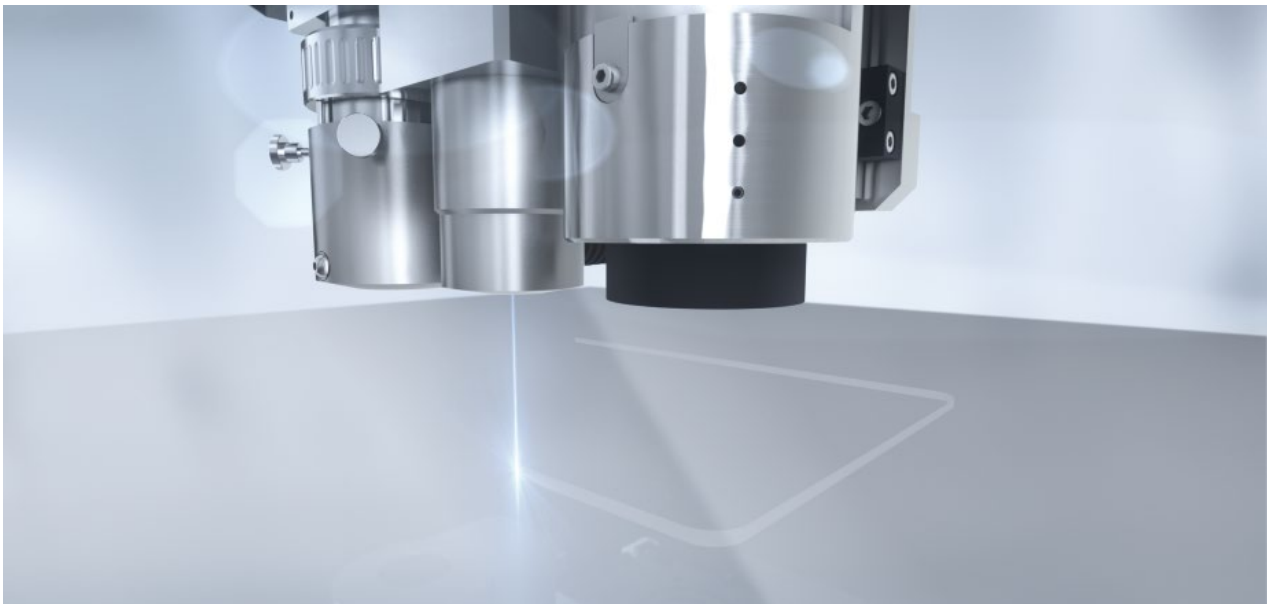
Combining High-Tech Glass Innovations with Advanced Laser Technologies

High-quality glass substrates and supporting laser capabilities for semiconductor and microelectronics applications

Julia Brueckner, Andreas Gaab, and Prakash Gajendran



(Source all images: Corning)

As glass wafer products become more specialized and die sizes get smaller, the demand for high-speed singulation of glass wafers is increasing. Corning Laser Technologies utilizes the advantages of precise laser dicing to process optimized glass types with adapted CTE values, high transmission, and specific refractive indices to enable existing and emerging applications.

Megatrends like multifunctional compact chips, highly accurate miniaturized sensors, faster seamless connections, and engaging immersive experiences are driving the need for glass in semiconductor and microelectronics processes. Corning is well positioned to enable a variety of applications with customizable glass products that can be tailored to meet demanding customer requirements by using their deep technical expertise and applying their manufacturing excellence to ensure an easy scale-up.

Glass can be categorized by its chemical composition and key physical properties. Critical attributes are, for example, transmittance (T_x) at a given wavelength, refractive index (RI), and coefficient of thermal expansion (CTE). Unlike crystalline materials that are used mainly in the semiconductor industry – such as silicon or sapphire that can be doped to achieve minor changes in material properties – glass can be tailored to achieve the required performance through material composition optimization. This article presents a few examples of how tailored glass attributes can enable specific applications in a more efficient way to excel in performance.

In addition to the physical properties of glass, the scalability of production and processing to provide constant quality and high throughput is also required to fulfill today's demands for high volume and low-cost components, especially for consumer electronics products. Glass is utilized in many applications, including carrier wafers for advanced packaging, advanced substrates for RF applications, and covers for micro-opto-electro-mechanical systems (MOEMS), to name just a few. In other applications, glass is part of the final product in the form of lenses, optical filters and waveguides. Independent of the application, all these glasses need to be processed on a large scale to ensure economic production.

Furthermore, there is a clear trend towards miniaturization for many electronic and optical devices to enable mobility, connectivity, and precision sensing for consumer electronic products. Wafer-level processes are essential to achieve the goal of miniaturization

Fig. 1 The customer's journey from development to production where Corning offers support for each phase

of optical devices, and the industry is adopting these processes accordingly to parallelize production and increase yields. A vital advantage of wafer-level processes is that they are well-known from silicon microelectronics fabrication and can be scaled. In fact, many processes on 6" and 8" glass wafers are already established, and the adoption of larger scales will be increasing in the coming years to enhance utilization, throughput, and yields.

The scalability and reliability of these miniaturized, high-volume products largely depends on the quality and specifications of the glass materials. Within Corning, the Precision Glass Solutions (PGS) business unit serves this advanced industry with high quality materials, and Corning Laser Technologies (CLT) focuses on laser-based processing for these applications to solve the toughest technical challenges. This article focuses on these two requisites for glass adoption in the semiconductor industry: key physical properties and key processing solutions.

From development to volume production

Corning offers invaluable engineering support to guide customers from the concept development phase to a product solution. In the first stage, fundamental understanding of glass and its properties is essential to understand material performance and analyze failure root causes. This comes with deep application engineering and fast prototyping to accelerate learning cycles, thus reducing cost and enabling a quick and reliable transition from product development to volume production. Corning provides a stable and scalable supply of glass materials, proven by the long-term supply of glass for the display and consumer electronic industries. Flexible manufacturing platforms allow for customization and stable supply. A proprietary fusion process delivers quality glass with pristine surfaces, low thickness tolerances, and low thickness variation (TTV), allowing further surface finishing and polishing to be omitted for many applications. In addition, this platform can easily be scaled to high volume glass supply, which is crucial for this consumer market [1].

As the volume of glass materials will scale with its adoption in microfabrication processes, glass processing solutions, especially glass cutting, will also need to increase to meet the expectation for speed, quality, and reliability. Processes where the production costs increase with volume adoption, such as polishing or blade dicing, can create limitations to scalability. Laser cutting and dicing technologies provide a solution to move more simply from development to production, also allowing the cost per part to decrease with volume adoption. Another key advantage of this technology for miniaturization and material utilization is the zero-kerf loss property.

Glass properties for specific applications

Tailored glass products that meet specific application requirements are shown in the following section. Table 1 gives a general overview about industry application needs and Corning's solutions [2].

Advanced packaging and glass carriers

There is a wide range of glass compositions tailored for various applications. For example, the fusion-drawn SG 3.4 glass with CTE matched to silicon (Si) is suitable as carrier wafer for semiconductor back-grinding applications. Substrates can also be offered with ultra-low TTV, which is required for high-precision thinning in RF devices as well as in advanced processing applications like nano imprint lithography.

In addition to these fusion formed glasses, specialized glass wafers with customized CTEs are available in order to provide ideal performance for given product designs. This is most relevant in packaging processes to reduce warpage that is induced due to different CTEs of the materials [3].

	Advanced Packaging Carrier	Back-thinning Carrier	Wafer Level Optics	Micro-Fluidics
Why glass?	CTE tunability to reduce in-process warp Transparency for debonding and inspection Scalability with long development cycles	Transparency for laser debonding and inspection CTE tunability to match Si CTE Cost reduction by recycling	Optical materials Constant beam path length and low thermal expansion/high stiffness	Good SNR for optical measurement Low contamination level Bio-compatibility
What Corning offers	Adapted CTE with fine granularity Tailored stiffness Excellent flatness Short lead times	Si-matched CTE Ultra-Low TTV High UV transmittance Alkali-free carrier material	High purity fused silica for front-end processes Broad range of available thickness Low thickness tolerance High transmission and processability	High UV transmission Low auto-fluorescence Chemical durability Compatibility for surface structuring

Tab. 1 Summary of Corning's offerings for the respective market segments

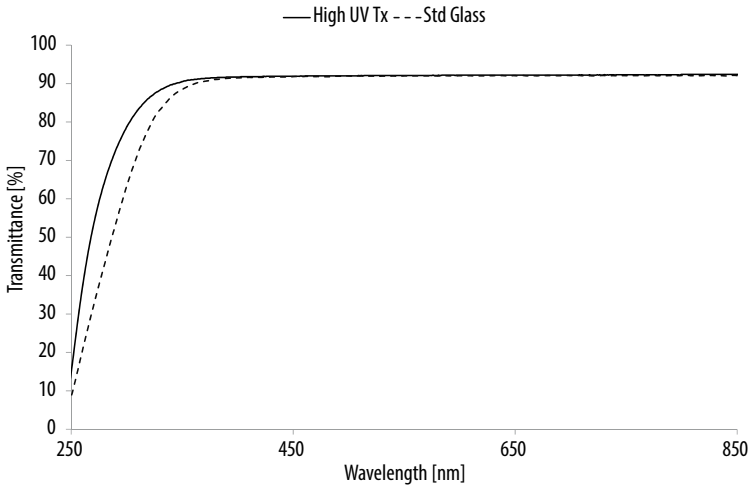


Fig. 2 The transmittance of Corning's standard glass carriers in comparison to a transmission optimized composition at a thickness of 0.7 mm.

A high transmission glass was designed that provides up to twenty percent higher transmission at 280 nm wavelength to meet the requirements for laser debonding in the UV range (Fig. 2). This high UV transmittance enables very efficient laser debonding, bringing with it a longer tool lifetime due to lower input power consumption.

Wafer-level optic solutions

Lens substrates used for lighting applications require a material with good optical transmittance that also allows for robust designs. In addition, it needs to be processable by using photolithography, surface structuring, reactive ion etching, direct laser beam writing, or specific coatings.

Corning HPFS fused silica is often used for these types of applications. Because of its excellent transmittance, low CTE, and processability, this is a material of choice for many optical applications. Surface structuring is also possible using different methods such as wet etching, reactive ion etching, and mechanical machining. Its high purity ensures that it can be introduced seamlessly into the semiconductor front-end lines for high-volume production. It is ideal for precise 3D sensing applications, using diffractive optical elements or meta surfaces, in mobile devices. The close to zero thermal expansion coefficient enables precise optical alignment of the beam path across wide operating temperatures. In other words, HPFS is least susceptible to temperature changes, which enables better imaging accuracy than alternative materials [4].

Back end processes, like chip scale packaging of CMOS image sensors (CIS), are well established in the industry. Here, Corning's SG 3.4 glass may be used for its Si-matched CTE value in combination with excellent optical quality and geometric tolerances such as thickness tolerance, TTV, and warpage.

A range of suitable glass compositions is available for novel back-end applications such as the fabrication of microlens arrays and other optical components for diverse end markets. SG 7.1 and SG 7.8 glasses, for example, have high CTE and good optical transmittance. The key difference between these glasses is mechanical stiffness as shown in Fig. 3. SG 7.1 has a higher Young's modulus that reduces in-process warp and ensures stability during processing and for the final product.

For applications where a rigid and thermally stable glass material is needed, SG 3.7 glass shows excellent performance with a glass transition temperature of 752 °C, roughly 80 °C degrees higher than SG 3.4 and only 150 °C lower than HPFS. With respect to Young's modulus, SG 3.7 shows an even higher Young's modulus of >80

Company

Corning Advanced Optics

We serve the semiconductor and consumer electronic industries by supplying optimized glass compositions with tailored properties in wafer and panel formats. In addition to glass, Corning offers supporting capabilities including laser cutting systems for highly accurate wafer dicing as well as world-class metrology instruments for inspection. Corning enables the fabrication of innovative products by combining unique glass manufacturing and superior processing capabilities to offer total solutions to customers, not only solving various technical challenges from glass supply to inspection and processing, but also reducing design cycle time and cost.

www.corning.com/advanced-optics

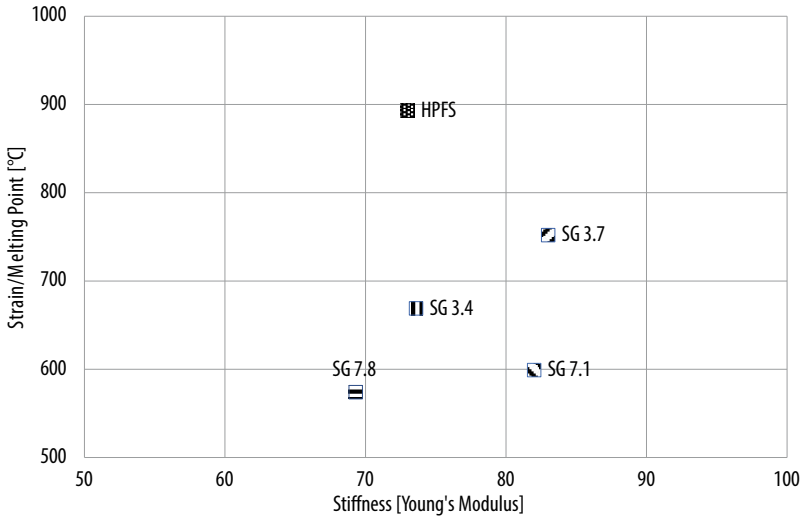


Fig. 3 Differences in strain point temperatures against their Young's modulus to show the range of rheological behaviors the different glass types can cover.

compared to HPFS. This glass also has an outstanding surface quality with respect to TTV and flatness in combination with a high transmission of visible wavelengths.

Microfluidics

Glasses for microfluidic applications need to be etchable and bondable, but also be resistive against acids for functionality. As shown in Fig. 4, SG 7.1 provides a much better acid resistivity than SG 3.4, whereas the best acid resistivity is shown by HPFS. On the other hand, SG 7.1 provides better performance on HF acid structuring in comparison to HPFS and even SG 3.4. Together with its high purity, surface quality, and transmission performance, SG 7.1 can enable new applications for flow cells.

In addition to good processability, the transmittance of SG 7.1 enables outstanding performance in optical metrology for a variety of applications.

Laser singulation for wafer-level processing

While glass wafers are becoming more specialized and end products are becoming smaller, more complex, and more valuable, the requirements for singulation of devices are increasing. Glass wafer substrates are being adopted at a 300 mm diameter whereas die sizes shrink. This is leading to increasing diamond sawing challenges when dicing final products. This is leading to increasing diamond sawing challenges when dicing final products.

Laser glass dicing of different glass compositions, from thick glasses (e.g. 3.5 mm) to very thin glasses (e.g. 0.3 mm), as well as from small die sizes (e.g. 5 mm) to free-formed products (e.g. 30 mm circles) enables many different applications. The key property of laser dicing is zero-kerf cutting performance: the laser process does not remove material in order to singulate the dies, instead it modifies the glass with the desired separation geometry to enable singulation. Compared to a blade dicing approach where the kerf loss is in the range of several hundred microns for a die size of 2 mm, for example, the material utilization could be increased by >10 %. An even greater advantage can be demonstrated in throughput: the typical processing time for laser dicing is in the range of minutes per wafer, depending on the die and wafer size.

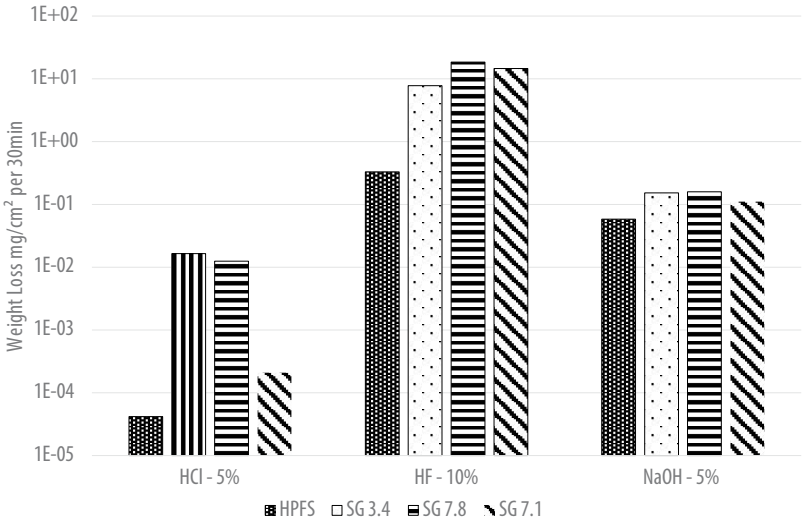


Fig. 4 Weight loss with different reactants (at different temperatures, please refer to specification sheets for details) for glass products covering a wide range of CTE values.

CLT has established a two-step process for dicing glass wafers that first introduces zero-kerf modifications into the glass within a microns-wide zone through the entire glass wafer thickness. The second step, which is to singulate the dies, can be achieved best by thermal laser interaction, which provides fast processing in combination with flexible part geometries. Alternatively, depending on the customer's designs and materials, mechanical breaking along straight dicing lines or wet etching can be the separation method. With the optimal combination of these processes, CLT offers a game-changing solution to increase processing speed, accuracy, cleanliness, and material utilization.

Summary

Corning offers high-quality glass substrates for multiple applications in the semiconductor and microelectronics industries in combination with innovative laser cutting solutions that excel in processing time and material utilization. In addition to these glass offerings and processing solutions, engineering support from development to high-volume production is available. This not only enables customers to find the most suitable solution for their specific application and learn about glass fundamentals, but also allows for continuous improvement during the development and engineering cycles. Solving technical challenges is key for the fabrication of innovative products that involve unique

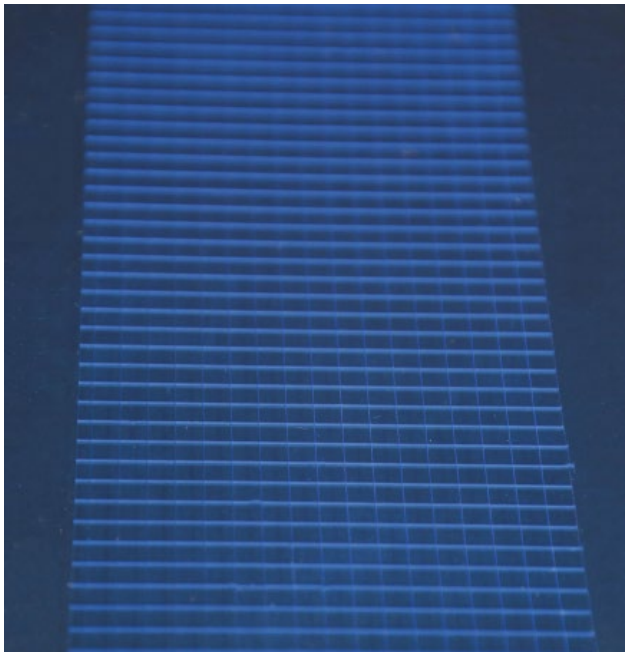


Fig. 5 A fully diced and separated glass panel on stretch tape to ensure mounting for follow up pick'n'place processes. The gap between the dies is >100 µm and has been realized by Corning's zero-kerf laser processing with subsequent stretching.

glass compositions and the processing technologies described above. The company is a valued partner with a proven track record for glass supply in the display and consumer electronics industries: Corning Precision Glass Solutions is focused on glass adoption across the semiconductor and microelectronics industries where the customers rely on the smart processing that can be provided by Corning Laser Technologies.

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[1] www.corning.com/worldwide/en/innovation/the-glass-age/science-of-glass/how-it-works-cornings-fusion-process.html
[2] www.corning.com/precision-glass-solutions
[3] www.3dincites.com/2019/06/good-news-about-glass-substrates/
[4] www.corning.com/worldwide/en/products/advanced-optics/product-materials/PrecisionGlassSolutions/3d-sensing-for-next-gen-mobile-phones.html

Authors

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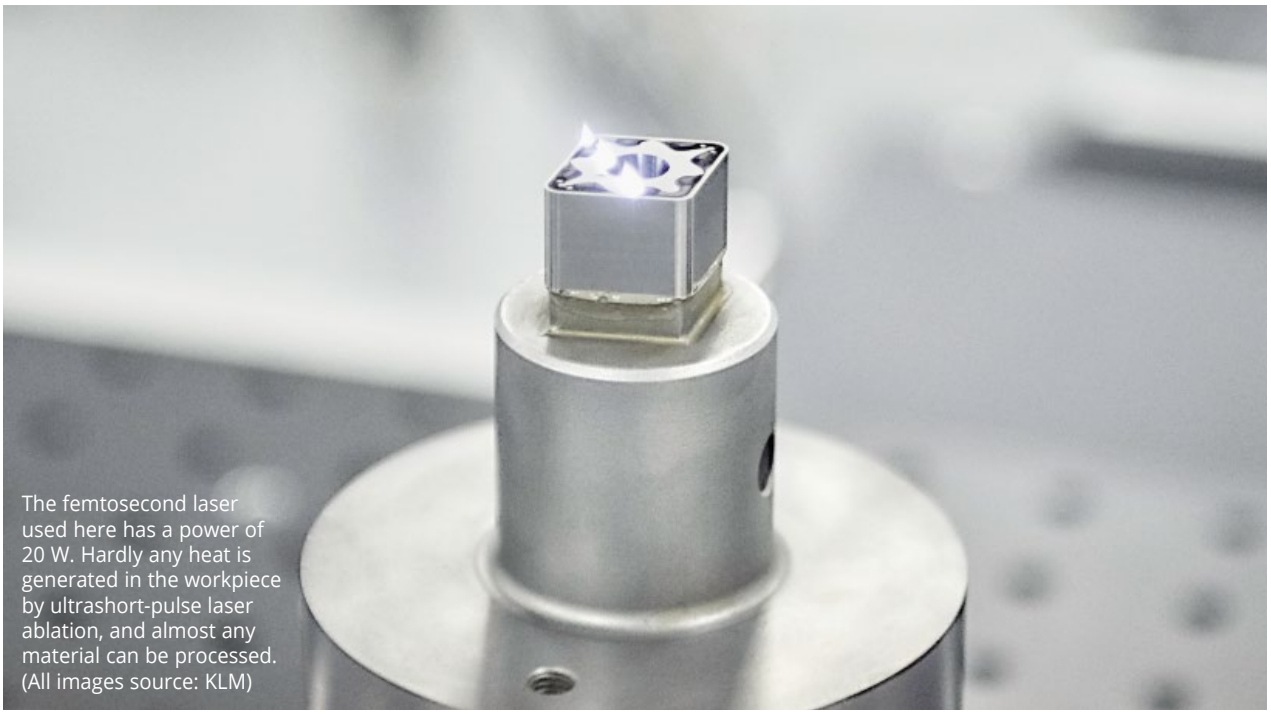
Conceiving the ‘E1’ Laser-Machining Center

The machine with an ultrashort-pulse laser processes hard materials – high-precision, low-energy and without any thermal generation



The femtosecond laser used here has a power of 20 W. Hardly any heat is generated in the workpiece by ultrashort-pulse laser ablation, and almost any material can be processed. (All images source: KLM)

Whether sintered cutting inserts, coins or small parts for watches – the end product must be of high precision and be durable.This challenge has been accepted by the new E1 laser machining center of the startup company KLM Microlaser. It promises extraordinary results, even when working with the hardest materials, as demonstrated by various test customers. For example, the production time of sintered inserts was reduced from eight hours to two hours. Furthermore, the machine is also extremely easy to use.

In 2017, the E1 was still an idea of Ekkehard Alschweig – engineer, co-owner and former head of Kern Microtechnik. Two years later, he bundled his mechanical engineering knowledge with the know-how of the Dutch laser specialists from Lightmotif BV and founded KLM Microlaser GmbH to realize his idea.

The KLM E1 has only been available since the beginning of 2020, a modern high-tech laser machine that is particularly interesting for the mold and tool, watch and coin industries. When it comes to machining small parts, the KLM E1 sets high standards in terms of productivity, long-term precision, freedom from wear, energy efficiency and usability.

According to Alschweig, several key components in the KLM E1 are decisive for this: “We use the basic construction, including the axes and drives of the established KERN-Evo milling machine, use an femtosecond laser source, mirror-based laser beam guidance from Lightmotif and have developed software, which makes operation extremely easy.” To gain an advantage, particularly with regard to manufacturing accuracy, the young company has also developed two unique features: automatic spot + power measurement ‘ASPM’, and ‘adaptive machining’.

High-end mechanical engineering and femtosecond laser

A mineral cast stand in monobloc construction and an x-y cross table, which is manufactured by Kern, are the solid basis of the KLM E1. They ensure the highest precision in the sub-µm range,

The newly developed E1 from the Bavarian start-up KLM of Ekkehard Alschweig is a high-tech laser machine that shows its strengths when it comes to processing small parts. In particular, companies in mold, tool, watch and coin industries can significantly increase their productivity.

which is important for the positioning and measuring of the parts.

The material is removed by a femtosecond laser. Such lasers are already used for eye operations (e.g. cataracts). This already provides an idea of the precision and accuracy that can be achieved with such a laser source.

The KLM engineers use a mirror construction for laser beam guidance. Max Groenendijk, managing director of Lightmotif, explains: "Optical fibers are not suitable for guiding fs lasers. That is why we guide the laser beam with mirrors that are attached to the machine frame, from the laser source to the scanner."

The power of the laser source is twenty watts. This means that the KLM E1 can process a wide variety of materials. Hardly any heat penetrates into the workpiece when layers are removed – heat could cause changes in the material structure.

As with all fs laser systems, the removal depth of the E1 is low and is usually between 0,3 µm and 2 µm per layer, giving an extremely high precision and accuracy. KLM uses all the advantages of this technology, in particular with two features.

Automatic calibration compensates for external influences

ASPM stands for 'automatic spot and power measurement'. It is a system that keeps the machine stable over the long term. Alschweig explains: "Every machine – including ours – is subject to certain thermal and other influences, which do not have an immediate but a creeping effect – that is, over a period of typically a few hours. As a consequence, workpieces are then produced with less precision. We are talking about minimal influences and minimal inaccuracies, but we are preventing them." When working with fs laser machines, two main challenges with an effect on precision over a long term may arise.

First, the zero point of the laser spot can shift from its originally calibrated x-y position, just in the µm range but this is enough to cause inaccuracies. The reason for this is: The light guide mirrors for controlling the laser beam are mechanically attached to the machine frame. If heat is applied to the frame, the frame extends, the spot shifts and inaccuracies occur. As a result, the light guide mirrors have to be re-adjusted.

Second, the power of the laser when it reaches the workpiece can vary. The output power of a laser is never really stable, and in the long term, contamination on mirrors and lenses can also cause small losses. This means that after a certain time, the laser power originally calculated is no longer available. As a result, the removal of material changes.

With ASPM, the KLM E1 has a simple and efficient solution for these two potential challenges. ASPM can be started automatically or just with the push of a button. ASPM then recalibrates the entire system within just two minutes. Alschweig says: "If you rely on accuracy, just do the calibration every time production starts or even just once a day."

Depth accuracy of < ±5 µm

Another highlight of the E1 is 'adaptive machining'. The fs laser removes material in the smallest layers of an average of 1 µm. The exact number is to be defined in individual cases. Adaptive machining optically measures the machined depth and compares the actual, measured values with the target values. The machine then adjusts the laser parameters accordingly and ensures that the target values are achieved.

Without adaptive machining, the depth accuracy depends on the total machining depth and is usually off by up to ±5 % of the machining depth. At a typical depth of 0.5 mm, this results in an expected inaccuracy of around ±25 µm. With adaptive machining, the depth accuracy is simply independent of the machining depth. The E1 achieves accuracies better than ±10 µm. "We even achieved values of less than ±5 µm in many tests," adds Alschweig.

Simple transfer of CAD data and easy program start

Following the requests of numerous customers, KLM has developed the control and operator software of the E1. Neither has anything to do with traditional CNC and the new software is especially user-friendly. The complete CAD / CAM process runs automatically. This means that the data of the CAD program can be transferred directly to the machine control. No additional computers and imports are necessary.

"It is important that the CAD model covers 100 %," Alschweig emphasizes: "If individual points in the model are not connected, of course our machine can-

Company

KLM Microlaser GmbH

was founded by Ekkehard Alschweig in 2019. The company develops and produces a new generation of triaxial laser machining centers called E1. The construction of the Kern Evo serves as the machine base, which has been adapted to the special needs of the new technology. Kern Microtechnik takes over the mechanical engineering and service of the entire system. The complete software for the operation and the machining strategy is developed in-house by KLM, to which Lightmotif BV belongs. An ultrashort-pulse laser is used as a high-tech tool, which is perfectly suited to inserting highly precise and detailed shapes in small-format stamps and pressing tools. The smallest parts for the watch and jewelry industry can also be produced with the KLM E1.

www.klm-microlaser.com

A test customer reduced the production time of sintered inserts (left) from eight hours (with classic EDMing and milling) to two hours (with the KLM E1). Another typical product for the E1: an unpolished stamp (right).

not implement them. We recommend that users always check their customers' CAD programs." If the 3D models fit, the volume to be removed is generated in CAD – this only takes a few minutes – the machine then only has to be set up and the fully automated production can begin just a few steps later. Of course, this setup process only needs to be done once per CAD model. Compared to creating an NC program for milling, the process is simple and very fast.

Test customers: production times reduced by 75 %

Several test customers are already very satisfied with the result. For example, a manufacturer of cutting inserts used to work with an EDMing and a milling process. Now they have converted the traditional process for press punches to produce blanks in green state carbide. With the new KLM E1 they only run one process. The result is clear: the pressing tools were previously produced within an average of eight hours; now only two hours are needed.

KLM Microlaser GmbH

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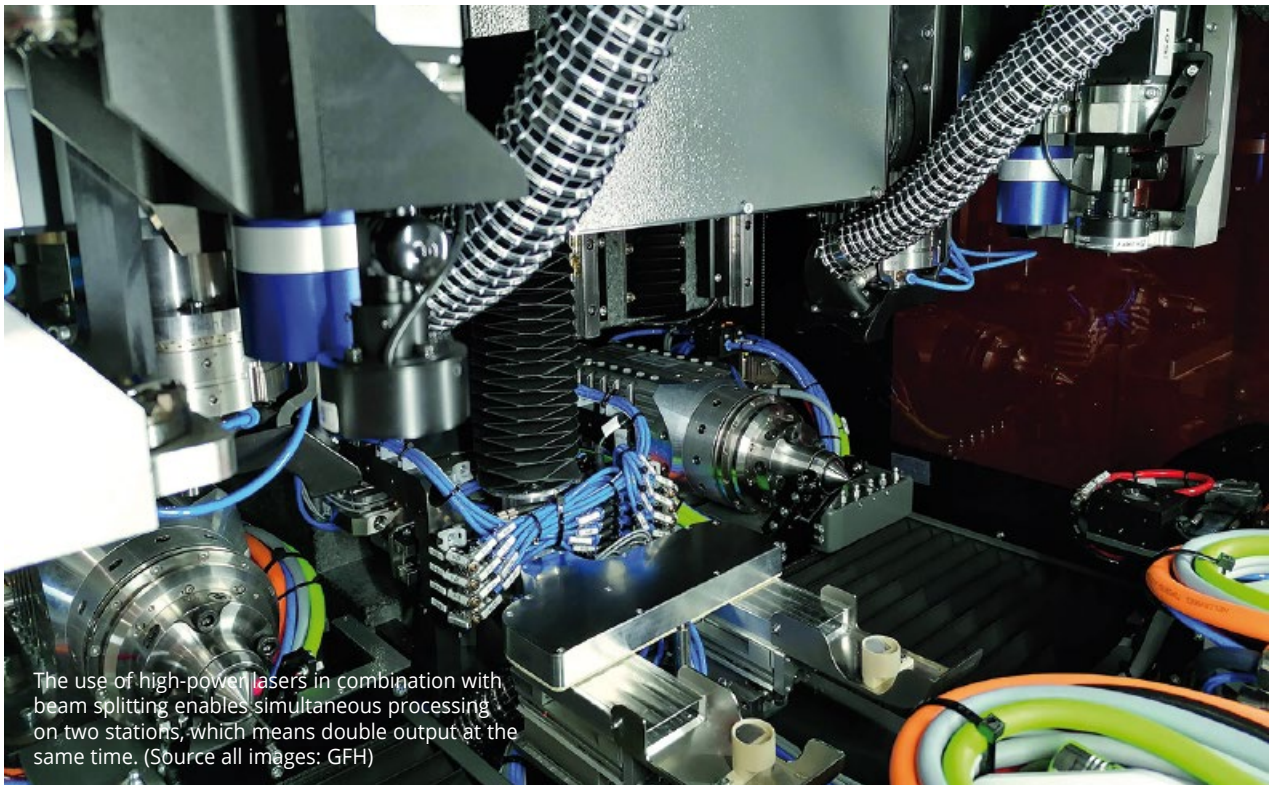
When Things are Running Smoothly

The laser as a turning tool takes cutting technology to a new level



The use of high-power lasers in combination with beam splitting enables simultaneous processing on two stations, which means double output at the same time. (Source all images: GFH)

Turning is one of the oldest and most important manufacturing processes for the production of components in almost every industrial sector. Since the Middle Ages, this process is being continuously developed and adapted to the changing needs. The cutting technology, however, brings the producers to the limits of the technical transability, particularly with regard to small and very small components. Tool wear, tool life, machining forces and heat affected zone became a limiting factor.

Recently, the laser experts from GFH were able to raise this manufacturing method to a new level: The conventional turning tool is replaced by a contactless laser that evaporates the material with ultrashort laser pulses. This technology has been integrated from the GFH into a specially designed production machine. The process-related technology disadvantage of the lower removal volume per unit compared to the cutting process is eliminated by the double-spindle concept. The GL.smart equipped with this technology, in conjunction with the integrated CAD / CAM solutions, represents the next milestone in the history of turning. "Rotosymmetrical components are in the course of miniaturization even smaller and more sophisticated," reports Florian Lendner, CEO of GFH. "This is where conventional manufacturing technologies reach their limits, because the cutting forces, that act on the component and the tool size, make machining more difficult and even make it impossible with particularly sensitive geometries. This is especially true when materials are needed that are considered difficult to machine." Several years ago, GFH therefore demonstrated the possibility of turning and grinding with lasers on its universal laser micromachining systems and delivered the first productive solutions. However, the full potential of the new manufacturing technology could be only partially exploited because the machines were not designed for these applications. There were limitations, for example, in terms of the speed of rotation of the components, the efficient use of laser radiation and generally the complete workflow. These limitations have been eliminated with the new machine: "After several years of intensive development work together with reference customers and supported by European research funding as part of the Horizon 2020 project, we can proudly present our new turning and grinding solution," says Lendner. "It is available as a double spindle in short and/or long turning design,

Thanks to the non-contact removal, the workpiece remains free of force and deformation during the entire machining time. This means that there is no loss of accuracy even with very thin and delicate components.

optionally with a rotating swivel unit as a counter spindle. This means there are no limits to the complexity of the components, and even end machining is possible."

All-round talent for rotationally symmetrical components

In addition to pure turning and grinding processes, the machine is also able to perform drilling, cutting and engraving operations – without any remodeling work. This makes the GL.smart an all-round talent for rotationally symmetrical precision components. A key factor is the combination of high process speed with absolute precision. For this purpose, the air-bearing main spindle is accelerated by a torque drive in a position-controlled manner up to 3,500 rpm within 0.4 seconds. Radial and axial concentricity in the nanometer range enables production with grinding tolerances. A force-controlled tension collet system with wobble correction and automatic bar feed represents the interface to the component.

As the newest machine in the GL series, the GL.smart with dimensions of 2,212 mm × 1,026 mm × 2,320 mm (L × W × H) offers productivity in the smallest of space. In addition to its compact design, the system impresses with an innovative, black glass housing. This granted in addition to full protection against laser radiation, a safe shielding from X-rays that have been proven by test methods. By using high-power lasers in combination with beam splitting, simultaneous processing on two stations is possible, which means double output. "On request, the machine can also be equipped with a bar feeder as a loading unit. In combination with integrated component handling by means of robots we offer a fully automated solution for the 24/7 production of parts without restriction," explains Lendner. In addition, SPC and NOK parts are kept separate and can be taken via robot without interruption of production.

Application fields of medical to watch industry

The applications of the new GL.smart are diverse and range from medical technology for the production of micro tools such as tweezers, micro blades or implants to the watch industry for the manufacture of so-called pivots, which are installed in the clockwork. The advantages of laser processing are, on the one hand, the attractive production times, which can be achieved thanks to the roughing and finishing process using ultrashort-pulse lasers. In a first step, as much material as possible is removed by roughing with a high energy input. For the finishing, the final quality is achieved in the finishing process with less energy. On the other hand, almost any material can be used for non-contact, wear-free machining of even the smallest components.

Laser turning enables unusually high accuracy, particularly in the manufacture and processing of precision parts, so that other, more complex processes such as conventional grinding or roller burnishing can be saved. Thanks to the non-contact removal, the workpiece remains free of force and deformation during the entire machining time. This means that there is no loss of accuracy even with very thin and delicate components. In this way, also parts with a large length can be easily machined.

More than twenty years of process experience

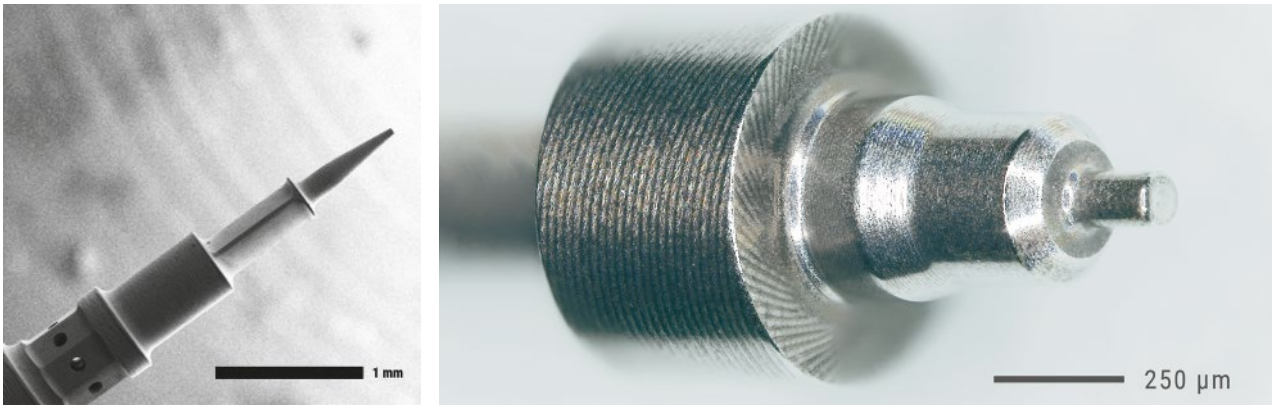
The systems can also be freely programmed and controlled using the GL.control software, also developed by GFH, based on software process know-

Company

GFH

was founded in 1998 and is based in Deggendorf in Lower Bavaria. It is one of the global market leaders and technological pioneers in the design and construction of high-precision laser micromachining systems with ultrashort-pulse lasers (USP). A main focus is on the constant further development of the "tool" laser, with which very different processes from cutting, turning and drilling to structuring can already be covered within the smallest of tolerances and without wear. This means that GFH laser technology not only increases productivity in series production, but also lays the foundation for innovative manufacturing processes and future manufacturing requirements. In addition to series and individual machine construction from a single source, the company also offers professional contract manufacturing according to individual customer requirements and specific requirement profiles on the company's own machining centers. GFH employs around 80 people in the group of companies and is represented internationally.

www.gfh-gmbh.com



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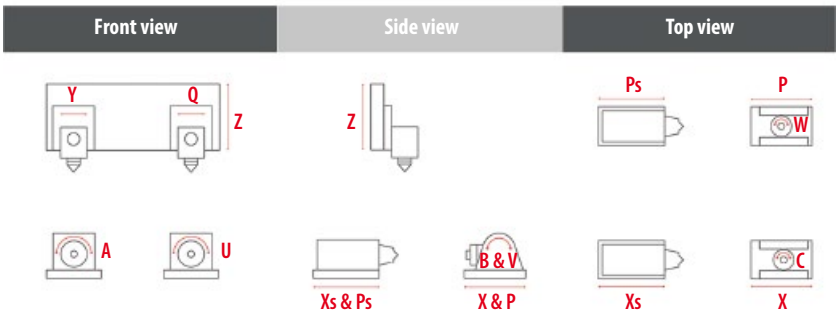

This simplified illustration shows the underlying double processing of the system.

how from more than twenty years. "Thanks to our own software development and daily use in-house, GL.control is in a constant process of improvement and further development," says Lendner. "The intuitive and simple operating concept, the integration of the CAD-CAM functions as well as the complete integration of all subsystems, such as the laser, scanner or drilling optics make it easier for the user to operate the machine true to the motto 'only one software to control everything'."

The PLC of GL.smart, is the fastest CNC control on the market and has been specially designed for laser processing in a development process for more than ten years. This control offers real-time access for the laser control, so that the laser can be switched on with an accuracy of 40 nm at full dynamic of the axes. "Thus, the GL.smart not only convinces with its very compact and innovative design, it also combines precision, flexibility and productivity in an attractively priced laser system that leaves nothing to be desired."

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Efficient Fine Balancing in Two Planes with Laser Ablation

The design characteristics of new impellers require efficient balancing procedures to eliminate noise and increase lifetime

Guenter Hummelt

Fig. 1 During the imbalance measurement, the amount of excess mass and the angle are determined in one or two planes. While the impeller stays on the measurement bridge, an x-y scanner directs the radiation of a CO_2 laser to the respective area and the exact amount is ablated. (Source all images: Nanosystec)

The need for precision balancing of high-speed rotors is continually increasing. This can be attributed to several factors: imbalances generate vibrations, which are a source of noise; the applications must operate quietly; imbalances create additional load on the impeller bearings and therefore shorten their lifetime.

The following article describes dynamic balancing methods, i.e. the workpiece rotates with a certain constant speed, then the imbalance measurement takes place and corrective actions follow.

How to correct for an imbalance

Adding weights

The balancing of car tires is well-known. The imbalance measurement at a constant speed establishes the amount of the imbalance and the angle at which the error is located. A mark serves as reference for this angular value. Weights of the respective mass are then added exactly opposite the imbalance. The measurement and correction are repeated until the imbalance is corrected to the desired degree.

This procedure works well for large rotating parts such as tires where the weights are mounted on the wheel rim.

Firmly fixing added weight at the right position presents a problem for small parts manufactured from plastics. One solution is pockets on the circumference of the rotor: the number of pockets determines the exactness of the correction, limited by the physical dimensions of the rotor and the size of the pockets. It can happen that the imbalance lies between two pockets so that two weights are needed to compensate for the error. This method requires a lot of labor and takes too long for efficient large volume production.

Reducing mass with drilling or breaking

Drilling small holes allows for free selection of the position. The diameter and the depth of the hole determine the volume and therefore the removed mass. However, drilling produces small particles which may negatively impact the bearings. In addition, the force of the drill stresses the rotor bearings.

Another method for reducing the mass is breaking away small pillars located on the circumference of the impeller. This method is faster than adding weight in pockets, but again requires manual labor and works only in discrete steps. Contamination is reduced. Various pillars along the circumference have to be removed to get the desired result for a given impeller.

Non-contact laser ablation

Laser ablation overcomes all of these limitations: the ablation position is freely selectable and the ablated mass is a function of laser power, the time of interaction between laser and object as well as the object-specific characteristics. Because these values are controlled extremely well, even micrograms of mass in the exact location can be removed.

Fig. 2 In previous product generations, this impeller was balanced by manually cutting the pillars that are located on the outer circumference. Such a design limits the balancing result by the number of pillars and their separation. New generations are therefore processed using laser ablation (see Fig. 1).

During the ablation process, the removed material transforms from the solid into the gaseous state, which is extracted and no disturbing particles are generated.

One or two plane balancing

A correction in one plane applies only for a disk-shaped rotor which is oriented exactly perpendicular to its center axis. In most cases however, the rotor has a cylindric shape. The mass which creates the imbalance can be located anywhere on this cylinder. Now, correcting the imbalance in one plane is no longer sufficient. Removing the mass in two planes (usually near both ends of the cylinder) gives the desired result. Any ablation in one plane impacts the other plane so that an intermittent ablation becomes necessary. The measurement system displays the mass and angle in the two predefined planes.

Manufacturing situation for two plane balancing

A fast spinning impeller which is manufactured from plastics requires fine balancing in order to reduce noise and to extend the lifetime. A brushless DC motor drives the impeller. As the impeller rotates at very high speed, it would deform as a function of speed with intolerable values. Higher stability is achieved by adding glass fibers into the plastic before die casting. These fibers give the necessary strength and greatly minimize the deformation, but not to zero.

Two plane balancing is used to achieve an optimal result. A small brass ring on one side of the shaft serves as a sacrificial device as the motor is not accessible and any ablation of the magnetic portion would negatively affect the motor performance. The second plane lies on the plastic area. The glass-reinforced plastic and the brass have completely different characteristics for laser ablation.

Considerations for the ablation laser

In general, the ablation laser in a manufacturing situation requires high power, a good beam profile as well as maximum reliability and robustness. Plastic absorbs laser radiation with a wavelength of 2 µm and more very well. Likewise, glass strongly absorbs infrared wavelengths and is therefore a good match to the characteristics of the plastic material.

A CO_2 laser fulfills the criteria perfectly. The plastic and glass fibers entirely absorb the wavelength of 10.6 µm. CO_2 lasers are proven workhorses that have been used in industrial applications for the last forty years. Operating times exceed 30,000 hours. Their efficiency is high compared to other gas lasers and service requirements are practically zero.

Metals like brass have totally different absorption. Laser radiation with insufficient power density only penetrates the metal for a few nanometers, but without any usable effect. The power density therefore needs to be increased, which is achieved by focusing the laser beam to a small spot of several 10 µm diameter and by using a laser delivering strong pulses.

A Q-switched fiber laser operating at around 1 µm wavelength is a good choice: high reliability, excellent beam profile with an M^2 value of 1.2 to 1.3 in

Fig. 3 The ablation areas on this impeller can be seen on one blade. The position and pattern on the fiber-glass enforced plastic are calculated according to the material removal rate of the laser in order to provide a perfectly balanced result.

Company

nanosystec GmbH

Nanosystec designs and builds high-precision ablation, assembly and test stations. Beside precision ablation using a laser, these systems also use accurate motion control and joining techniques, such as precision laser welding, laser soldering and micro gluing with UV curing. The systems are used worldwide in optoelectronics, medical applications, the automotive industry and aerospace.

www.nanosystec.com

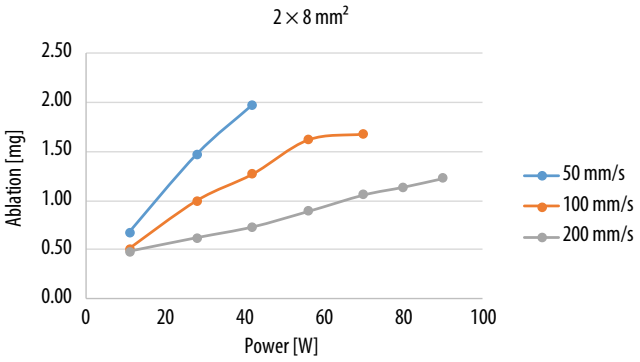

Fig. 4 Ablation rate of ABS plastic material as a function of power. The various graphs show the scanning speeds of a 100 µm diameter CO_2 laser beam focused on the target.

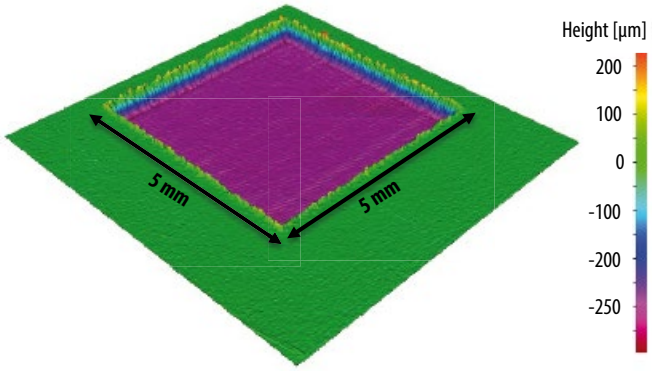

Fig. 5 Material removal on metal requires short laser pulses. The picture shows the ablation of brass by a 100 W pulsed nanosecond-pulsed fiber laser with 500 ns pulse width at a removal rate of 30 mm³/min. (courtesy of Heriot Watt U., Edinburgh).

order to focus the beam down to small spots and pulse powers of several 10 kW. In this way, the power density exceeds 10 MW/cm² and the ablation process works efficiently. The pulse repetition rate and pulse width can be controlled with high accuracy. An ablation of micrograms is easily achieved, which is key to extremely fine balancing.

Imbalance measurement

An industrial measurement system determines the imbalance. The sensitivity is increased by the fact that the weight of the sample is low relative to the load capacity of the measurement bridge. The device assembly consists of the impeller, a bearing, the rotor of the electrical motor (but not the stator) plus the sacrificial disk. It is clamped onto the bridge using a special tool. As the motor is not complete, an air jet drives the impeller to the desired revolutions per minute.

A photosensor detects a reference mark on the impeller. It serves to measure the actual speed and as a reference to determine the angle at which the imbalance is located on the impeller and the rotor. The amount of imbalance and the angle relative to the mark are found for each plane. These values are transferred to the processing software.

Laser ablation procedure

The processing software calculates the necessary energy for the two planes to achieve a corresponding reduction of mass according to the imbalance measurement results. Variables include the size of the ablation area, the depth, the laser power and the time of irradiation.

The laser beams are directed to the ablation areas by x-y scanners. In order to avoid overbalancing, the mass reduction is executed in smaller steps than the measurement values would indicate. As the ablation in one plane has an impact on the second plane, the process has to be sequential and is repeated until the desired balancing quality is achieved.

The process time strongly depends on the imbalance of the assembly before correction. For an efficient process, the imbalance should not be larger than 15 times the tolerated final imbalance.

The device assembly stays on the measurement bridge during the entire process. There is no need for the part to be handled during the core process.

Automation capability

As the part handling is reduced to simply loading and unloading, automation can be implemented at any point. Robots, feeders and conveyor belts can be combined as required for the part presentation and the desired volume.

Summary

Two plane fine balancing requires an advanced correction process, especially if different materials on an impeller need to be processed. Non-contact laser ablation offers several advantages over conventional methods, like drilling: the bearings do not experience any force, the cycle time is shorter, the balancing accuracy is higher and there is no need for manual part handling until the process is finished. This efficient and compact balancing setup can be easily integrated into automated high-volume production lines.

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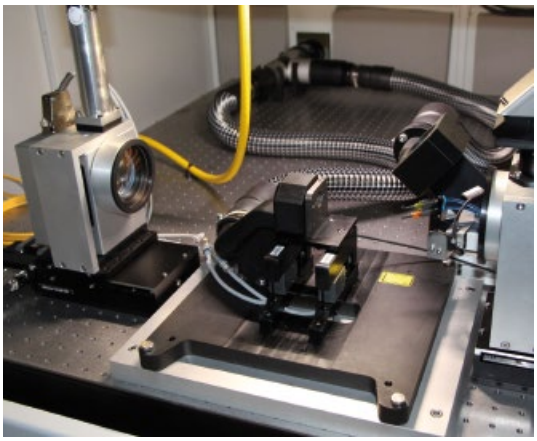

Fig. 6 Nano Balancer configuration with two different lasers for two plane balancing. Each laser beam is directed on the respective area of the impeller by an x-y scanner with axial orientation of the laser beams. The ablation in one plane impacts the imbalance in the other plane so the amount of the ablated mass needs to be carefully calculated.

Author

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The Laboratory at Hand: Plastic Sorting Made Easy

A next-generation mobile near-infrared spectroscopy solution

Felix Schmidt, Nicole Christiansen, and Robert Lovrincic

Fig. 1 The latest generation of handheld NIR spectroscopy devices enables fast, on-the-spot spectral analysis and seamless improvements of chemometric databases. (Source all images: Trinamix)

Sorting plastics according to their chemical composition is a crucial step in the recycling process, turning mixed plastics waste into a high-value resource. Near-infrared spectroscopy (NIRS) is an established method for plastics classification. Evolutionary progress in miniaturization of optical components has enabled the development of hand-held spectrometers. Cloud-based computing and centralized databases provide practically unlimited computing power for classification algorithms and enormous spectral databases. Here we discuss the basics of hand-held NIRS and the essentials of the corresponding data analysis with a focus on plastics sorting.

Closing the material cycle of plastics remains one of the key challenges of modern society. Plastic recycling can help reduce environmental pollution while increasing efficiency when it comes to energy and resource consumption. In order to reuse plastics, however, hundreds of different types need to be differentiated – even though they cannot be distinguished by the human eye. This is one of the reasons why currently less than twenty percent of globally produced plastic is being recycled [1].

Addressing the challenge of distinguishing plastics, other physical properties that go beyond the visible appearance need to be utilized. This is where optical spectroscopy comes into play to identify the material types based on their absorption spectrum. Spectroscopy in the near-infrared (NIR) in particular has been a working horse in high-end analytics for decades. Fairly recently, NIR spectrometers have managed to break out of their well-controlled laboratory environment by becoming smaller, lighter, and more robust. The progress in miniaturizing NIR spectrometers paved the way for

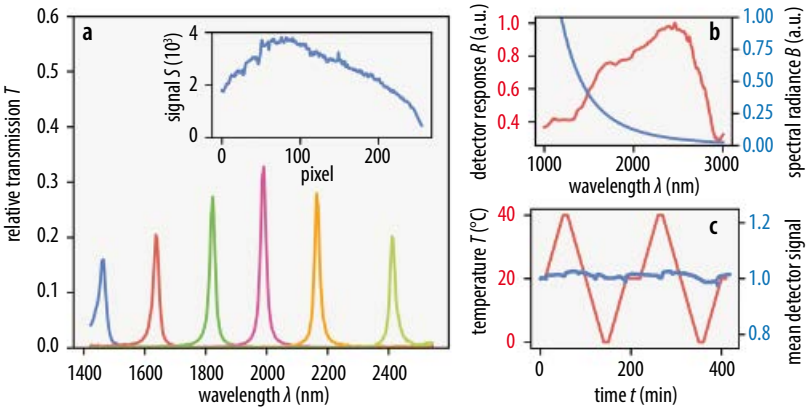

Fig. 2 Performance of a handheld NIR spectrometer based on PbS detectors. Resolution and raw signal: the transmission signal of multiple narrow bandpass filters (bandwidth < 10 nm) across the spectrum is depicted. The inset shows the raw detector signal for a 100 % reflective target (a). Detector response (red) and spectral radiance (blue) of a black body irradiator at 2800 K color temperature (b). Effect of changing ambient temperature (red) on mean of detector signal (blue) over a broad temperature range (c).

handheld spectrometers and their widespread application in the hands of non-specialists.

Applied to the material classification of plastics, such mobile NIR spectrometers will help bring plastics back into the material cycle. Here, we discuss plastics classification using NIR spectroscopy conducted by a new handheld NIR spectrometer, which is based on lead sulfide (PbS) detector technology (see. Fig. 1). The spectrometer is integrated into a proprietary cloud-based solution for recording, retrieving and analyzing NIR data. The spectra are measured, sent to the cloud through a connected mobile app, analyzed in real time in the cloud, and the result is sent back to the user. Thereby, updates in the classification algorithm and material database extend and improve the device's capabilities continuously without the need for firmware updates or new device generations. The technology enables the classifying of plastics samples directly at different manufacturers' and recycling plants instead of collecting, labeling and shipping samples to a lab where the spectroscopic work is carried out.

NIR spectroscopy

Organic molecules absorb light at frequencies specific to their structure. These absorption bands are caused by interactions of the electromagnetic field with vibrational motions of the molecules. The intensity of individual absorption bands (oscillator strength) depends on the change of the dipole moment associated with a particular vibrational mode, while its resonant frequency depends on the mass of the involved atoms and the bond strength between them. These vibrational modes result in a molecular 'fingerprint', located in the mid-infrared spectral region (ca. 3 – 10 µm, or 3,000 – 1,000 cm^{-1} in wavenumbers).

NIR spectroscopy in the wavelength range from 750 – 2,500 nm (13,000 – 4,000 cm^{-1}) covers the regime of vibrational overtone and combination modes. Due to comparably smaller absorption coefficients, the light can penetrate the sample up to several millimeters, far deeper than in the mid-infrared regime. This enables the measurement of a bulk material rather than merely surfaces and lessens the need for sample preparation. One drawback is the higher effort necessary for data analysis. NIR spectra are typically not clear fingerprints of the sample under test. Statistical approaches, sometimes computationally demanding, such as principal component analysis (PCA) or linear regressions, are necessary for predictive models.

Beside the material classification of plastics, prominent applications of NIR spectroscopy include quality control and process monitoring in food, pharma and medical industry, as well as determination of food and feed nutrients, or humidity.

Miniaturization of NIR spectroscopy: detector sensitivity is key

A fast response is essential in many of these applications, which requires real-time feedback about material type or

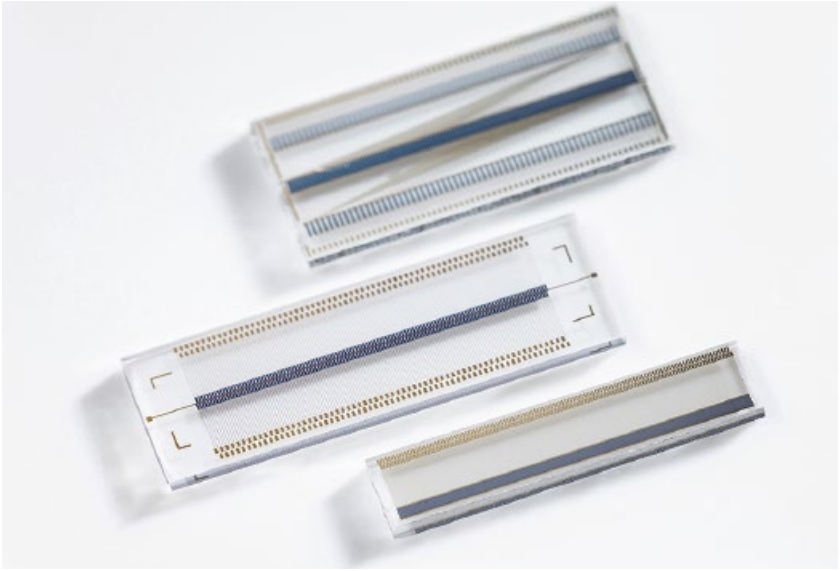

Fig. 3 Lead-sulfide (PbS) detector arrays with high spectral sensitivity in the NIR (1 to 3 µm).

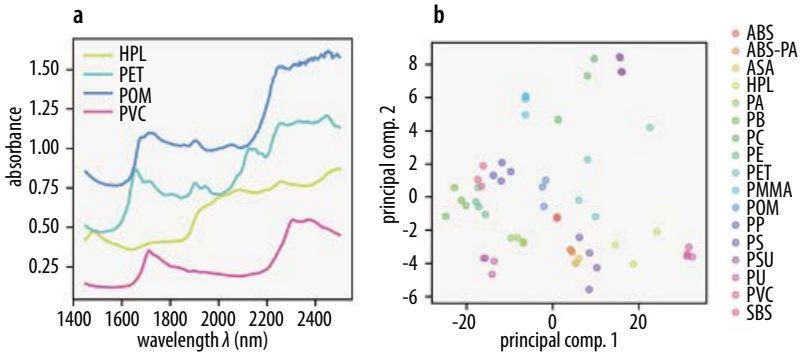

Fig. 4 Absorption spectra for four selected plastics types. For each type, the median of various samples and colors is shown (a). Result of PCA analysis: first and second principal component for NIR spectra of 17 plastic types (b).

quality. So the traditional process of shipping a sample to a distant lab for analysis is not suitable in many usage scenarios. Instead, handheld spectrometers scan the sample on site and yield a measurement result within seconds. The key challenge in building such devices is to obtain a compact, robust and reliable design, while maintaining enough performance in terms of spectral quality.

Handheld spectrometers typically measure in diffuse reflectance mode. Here, the sample is irradiated with an integrated broadband NIR light generated by conventional halogen light bulbs with a color temperature of roughly 2,800 K. In the NIR range, the light enters organic materials and excites overtones of different vibrational modes (mostly C-H, N-H, C-O, and O-H bands). The reflected light is guided onto a dispersive optical element which decomposes the light into its spectral components, resulting in a response function that depends on the wavelength of the light, the spectral radiance $I(\lambda)$.

The Trinamix handheld spectrometer employs a linear variable filter (LVF) as dispersive element, attached to a 256-pixel array of lead sulfide (PbS) detectors (Fig. 3). At each position of the detector array, the spectral radiance $I(\lambda)$ is mapped onto the detector signal $S(\lambda)$, covering the wavelength range from 1,400 nm to 2,500 nm.

Company

trinamiX GmbH

trinamiX is a wholly owned subsidiary of BASF SE, the world's largest chemical company. Founded in 2015, the company has developed a wide-ranging portfolio of technologies and products around both 3D imaging as well as infrared sensing employing a team of more than 120 experts across a wide range of scientific disciplines.

https://trinamixsensing.com

For a reflective measurement, the refection $R(\lambda)$ of a sample is determined in three consecutive measurements. First, the dark signal $S_D(\lambda)$ of the detector is recorded. Second, the signal of a reference target $S_R(\lambda)$, with a known reflectivity – ideally $R_R(\lambda) = 1$ (white reference) – is measured. Third, the signal of an actual, unknown sample $S(\lambda)$ is recorded, yielding the sample's reflectance

$$R(\lambda) = \frac{S(\lambda) - S_D(\lambda)}{S_R(\lambda) - S_D(\lambda)},$$

or, alternatively, the absorbance $A(\lambda) = -\log_{10} R$ (assuming the transmittance is zero). A typical detector signal of a white reference $S_R(\lambda)$ is depicted in Fig. 2a. Low detector noise yields a signal-to-noise (SNR) ratio of above 10^3 across the entire wavelength range and sensitivity up to an absorbance in the order of $A = 2$. The spectral resolution is limited by the LVF properties and corresponds to 1 % of the center wavelength (e.g. 15 nm at a wavelength of 1,500 nm). Fig. 2 shows some performance characteristics of the system described above. Fig. 2a shows spectra of six narrow bandpass filters with different center wavelengths across the full wavelength range. Fig. 2b shows one advantage of PbS based spectrometers: the low radiance of thermal emitters in the long wavelength end of the spectrum is partially offset by the high response of PbS in that wavelength range. Fig. 2c highlights a mandatory requirement specific to robust handheld devices: signal stability over a broad temperature range. To this end, the detector temperature is controlled with an integrated thermoelectric cooler.

The application of PbS detector arrays combined with a linear variable filter allows the construction of a robust spectrometer unit without moving components which is sensitive to molecular vibrations deep into the NIR regime of up to 2,500 nm.

From spectra to actionable results: chemometrics

NIR spectra are complex due to broad and overlapping absorption bands and can therefore not be interpreted directly like other spectroscopic data. NIR data analysis requires specific mathematical techniques – chemometrics – to extract the chemical information, which includes preprocessing methods as well as multivariate calibration methods. The processing of the spectra prior to data analysis is an essential step to remove physical phenomena that are unrelated to the chemical characteristics of the samples. However, the trade-off between information loss and noise reduction has to be considered.

Fig. 4 highlights spectral measurements and data processing for plastics classification. The spectra of four plastics in Fig. 4a show distinct features due to their differences in chemical structure. In total, seventeen plastics classes are currently incorporated in the model. In the first step, a principal component analysis (PCA) is applied to the spectral data (Fig. 4b). PCA, often used for exploratory data analysis, is a technique applied to reduce dimensionality with minimal information loss. The principal components are built in such a way that the first principal component explains the largest variance in the data, the second component explains the next largest variance and so forth. The resulting score plot (Fig. 4b) explains the variance according to possible groups in two dimensions.

The spectra are subsequently processed by applying baseline correction and noise reduction methods. Various machine learning algorithms are applied to the scaled data set.

As shown in Fig. 5, a 13-fold cross-validation was applied in order to estimate the performance of the resulting model. The average accuracy (percentage of correct predicted classes) of this

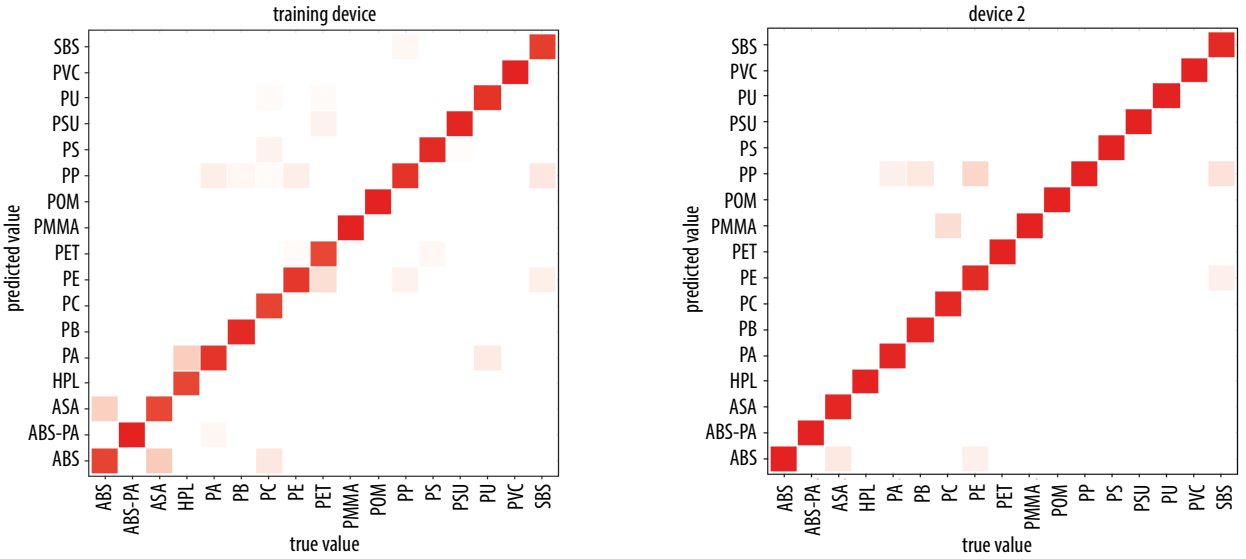

Fig. 5 Contingency plots of predicted classes across different devices. High prediction accuracy is achieved for the training device (left) and maintained after transfer to a different device (right).

model is about 91 %, while individual classes showed different accuracies from 100 to 80 %. To check the transferability of predictions of different handheld devices, we used this model to predict the class of samples measured with a different device. The results showed a mean accuracy across classes and devices of about 97 %, which indicates excellent comparability of spectra between different handheld devices.

The NIR spectroscopy solutions are integrated in a cloud-based environment with appropriate safety techniques to guarantee high-end safety for the data. This comprises authentication (OAuth 2.0), high security API, application firewall and encryption for the data in transit and at rest. The data protection is also enhanced due to stateless microservices. This solution has many advantages, namely the regular update of chemometric models, continuous improvement of the app with new features which can be provided without new installation triggered by the user, and the possibility to work outside a defined working environment like the laboratory.

Summary

NIR Spectroscopy is a powerful tool for the reliable and fast analysis of the chemical composition of materials. Handheld devices can act as a 'lab in the hand' without the need for meticulous sample preparation. The full potential of this approach has only been reached recently through the combination with cloud-based computing, rendering decentralized decision making and deep market penetration possible. Plastics sorting is one early application of this technique – but certainly not the last.

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[1] *R. Geyer, J. Jambeck & K. Law:* Production, use, and fate of all plastics ever made, Science Advances **3** (2017) 7, e1700782, DOI 10.1126/sciadv.1700782

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Robert Lovrincic received his PhD in physics from Heidelberg University in 2009 for work on IR spectroscopy of thin films. He spent two years as postdoctoral researcher at the Weizmann Institute of Science, Israel, where he was a Minerva and Marie Curie fellow. He continued his scientific career as a research group leader at the InnovationLab Heidelberg. Dr. Lovrincic joined trinamiX in early 2019 and currently serves as team leader for customer applications.

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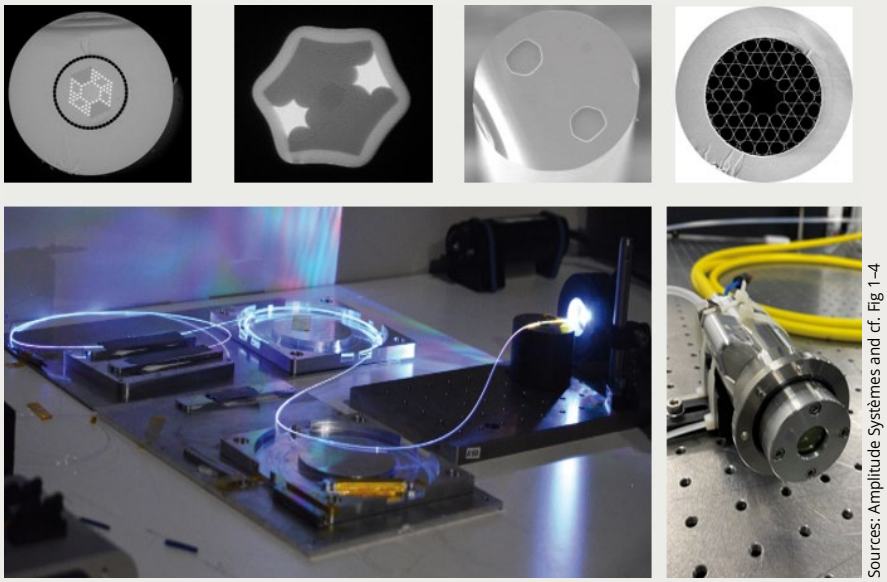
Advanced Fiber Technology for High-Energy Lasers

New microstructured optical fibers manufacturing and design for laser emission and beam transportation

Laurent Bigot, Philippe Roy, Thierry Taunay, Fetah Benabid, and Eric Mottay



Sources: Amplitude Systèmes and cf. Fig 1–4

Upper row: scanning electron image of 4F project microstructured fibers: active fibers obtained with OVD, powders and MCVD and hollow core fiber (from left to right). Lower row: active fiber used for laser beam emission (left) and hollow core fibers for laser beam delivery (right)

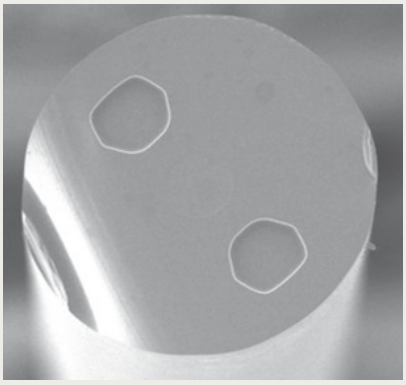
The French 4F consortium has obtained new results on microstructured optical fibers for the development of ytterbium active fibers with a large core and for the transport of intense laser beams via hollow-core photonic crystal fibers. In the case of active fibers, several methods to obtain fiber preforms have been tested (MCVD, OVD, powders, sol-gel), as well as various types of fiber designs.

The development of new lasers with high average power and an excellent spatial quality is a key driver for most new industrial applications. The exceptional development of fiber laser technology over the past decades underlines these two requirements: by spreading the heat dissipation over the fiber length, fiber lasers readily achieve very high average power; by guiding the laser beam in a small diameter core, high spatial beam quality is achieved, thereby enabling high precision applications. Increasing the pulse energy of fiber lasers would further expand the application range, but this requires larger core diameters while maintaining single mode operation.

The French 4F project aims to develop, manufacture and functionalize a new generation of very large mode area (VLMA) optical fibers for future laser applications. The 4F project brings together eleven actors directly or indirectly covering the entire value chain from the fiber component to the laser and combines technological research laboratories (Ecole Polytechnique, Paris and several CNRS laboratories: Xlim, PhLAM and Foton) as well as technology centers (Photonics Bretagne, ALPhANOV) and six manufacturers in the field of components, lasers and subsystems: Amplitude Systèmes, Quantel and Keopsys (Lumibird), Thales, Azur Light Systems, and GLO Photonics.

The project assesses four different approaches to preform manufacturing: MCVD and OVD with vapor-phase doping, sol-gel and the REPUSIL power method. The project will also address different fiber geometries to optimize single mode operation. Key challenges for the 4F projects are the ability to synthesize large volumes of glass, to reach strong absorption at the pump wavelength, to minimize possible photo-darkening and to control the refractive index profile with high precision.

The 4F project's laser partners will use these fibers to develop new lasers for future industrial applications. Finally, the project entails the development and laser-integration of hollow-core photonic crystal fiber for beam transportation.



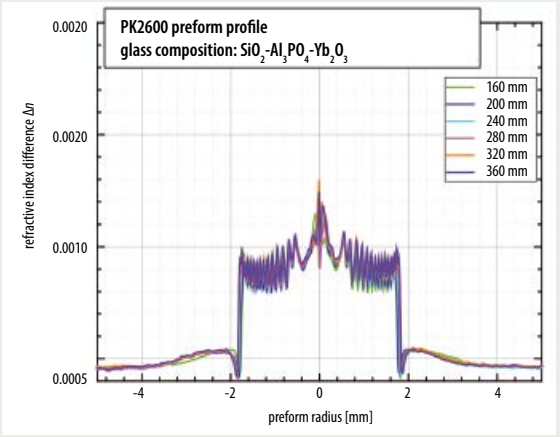


Fig. 1 Low numerical aperture step index fiber (Spurce: Photonics Bretagne). Left: SEM image of the fiber section. Right: refractive index Yb-doped preform profiles.

Three different technologies for the fiber's core

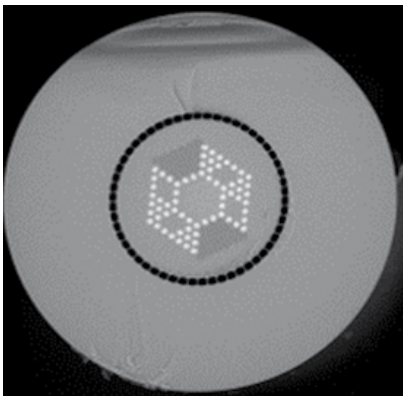
Low numerical aperture step-index fiber

The path first investigated by the 4F project is the fabrication of uniform lengths of large core ytterbium-doped low numerical aperture (NA) step-index silica preforms with the use of a commercial rare earth-based vapor phase delivery system. The ytterbium-doped core glass matrix has been optimized to suffer no photo-darkening and simultaneously be low loss, while maintaining the required low NA necessary to achieve single-mode behavior with good beam quality. Polarization-maintaining (PM), step-index, double-clad Ytterbium fibers were successfully drawn from the fabricated preforms showing minimal variation along the fiber length (1.5 km) and, more importantly, comparison with a perfect step-index fiber with an equivalent core diameter shows a minimal (~10 %) reduction in effective area of the fabricated preform. The major challenge in fabricating low NA-doped preforms for VLMA fibers resides in the ability to obtain a 'defect free' radial refractive index as any imperfection will result in significant degradation of the laser beam quality and reduction of the effective area [1]. The typical refractive index profile along the length of fabricated preforms is shown in Fig.1 right. For this preform, a nearly 1 : 1 molar Al_2O_3 / P_2O_5 ratio was used as the core glass modifier. As can be seen in Fig. 1 right, 250 mm long preforms with a core/clad index difference of ~4.5×10^{-4} showing negligible longitudinal index variation (below 5×10^{-5}) were successfully fabricated. A section of the fiber is shown in Fig. 1 left.

All-solid photonic bandgap fibers

The second route that was investigated concerns all-solid photonic bandgap VLMA fibers. Their main feature is to allow the confinement of the light within a large core surrounded by a microstructured cladding whose effective refractive index is larger than that of the core. This gives rise either to pure photonic bandgap guidance or to an inhibited coupling guiding mechanism, both characterized by the existence of spectral windows for which the core-guided mode cannot couple to any cladding mode either due to very different effective indices or for symmetry reasons. The first consequence is that, for a given geometry of fiber, only well-defined wavelength windows can be guided, which makes it possible to eliminate undesirable spectral components such as those generated by nonlinear phenomena like the Raman effect. As is the case for every optical fiber, an increase in core size – mandatory to increase the nonlinearity threshold when the fiber is used at high power – increases its modal content. In order to maintain single-mode behavior in practice, one option is to increase the confinement losses of the higher order core-guided modes (HOM).

Fig. 2 shows an example of an ytterbium-doped, PM, 2D solid-core photonic bandgap fiber (2D SC-PBGF). Here, the core is made of nineteen ytterbium-doped sol-gel elements, and the cladding is constituted of resonators organized in hexagonal symmetry (see Fig. 2, left). As can be seen, the omission of some resonators in the cladding permits the creation of satellite diamond-shaped waveguides whose fundamental mode is phase-matched with some core-guided HOMs. This concept had been previously applied to demonstrate passive



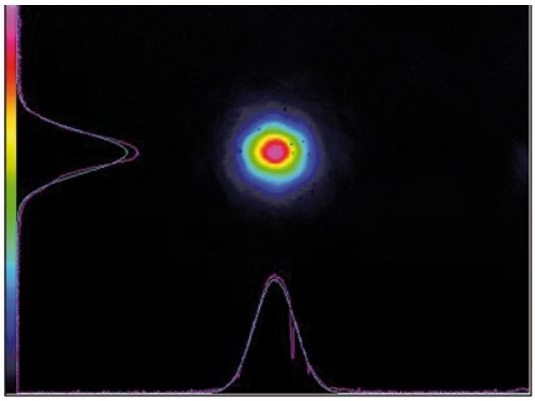


Fig. 2 Left: scanning electron image of 2D SC-PBGF (PhLAM Lab.). Right: output beam profile in amplification regime (Courtesy of Eric Lallier, Thales Research & Technology)

Company

Amplitude

Amplitude is leading the French 4F project and is a manufacturer of ultrafast lasers for industrial, medical, and scientific applications. The group consists of three manufacturing locations in Bordeaux and Paris, France, and San Jose, USA., and an extensive network of support offices in Europe, Asia, and North America. Amplitude offers a unique and distinct product portfolio: diode-pumped ultrafast lasers, ultra-high energy ultrafast lasers and a full line of high energy solid state laser products. From ultrafast industrial fiber lasers to petawatt-class high intensity lasers, Amplitude is focused on helping its customers to bring new solutions.

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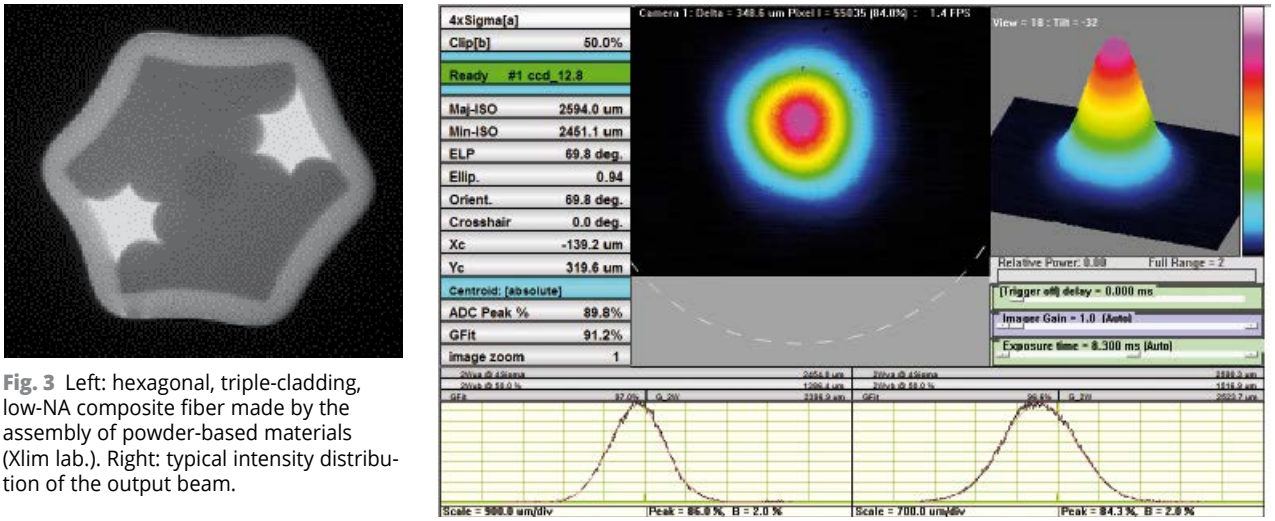


Fig. 3 Left: hexagonal, triple-cladding, low-NA composite fiber made by the assembly of powder-based materials (Xlim lab.). Right: typical intensity distribution of the output beam.

LMA fiber with mode field diameter (MFD) reaching 44 µm [2]. In the proposed design, stress rods are also inserted in the 190 µm diameter inner cladding, itself surrounded by a high numerical aperture air-cladding. This fiber has a core diameter of about 46 µm and has been used as the last amplification stage of a fiber laser system. In this configuration, a view of the mode intensity profile for an output power of about 100 W (limited by the available pump source) is shown in Fig. 2, right. It can be seen that single-mode behavior is observed. An MFD value of 35 µm is obtained when the fiber is conditioned with a radius of curvature of about 10 cm.

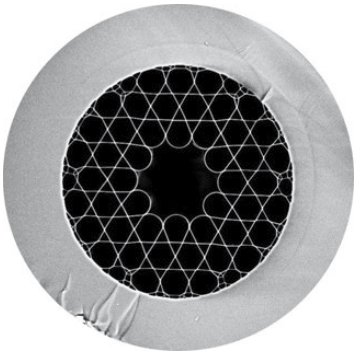
Powder-based, low NA, triple cladding, large-pitch fibers

The third path investigated in the 4F program consists of a simple step-index, low-NA, triple cladding fiber. It was fabricated from an assembly of active and passive, high-index doped silica rods. The rods are synthesized by sintering and vitrifying doped silica powders. An example is shown in Fig. 3.

An aluminum-doped material must be synthesized with extreme precision (typically a few 10^{-5}) so that its refraction index is 6×10^{-4} lower than that of the Yb-doped core: it is at this price that a spread and amplification strictly single-mode can be obtained, even for very large core diameters in the range of 40 to 50 µm. In practice, the doped silica materials are obtained by the sintering of doped silica powders to ensure a homogeneous material with a high level of refractive index control [3]. The relevance of this synthesis method has been demonstrated experimentally, especially with active/amplifying fully aperiodic LFPs with cores of more than 110 µm [4]. The composite preform is made of one Yb-Al-doped rod surrounded by sixteen index-matched Al-doped silica rods to control the modal population. Two B-doped silica rods are finally introduced to provide suitable stress and birefringence. An optional 'thermal pre-compensation' of the index profile can be carried out in anticipation of thermal heating. In this case, the thermal gradient gradually induced during the power ramp-up will compensate the defect induced in the refractive index profile in order to reach single-mode condition only under severe laser conditions.

Hollow fibers for beam transportation

Another aim of the 4F project is to equip ultrashort-pulse (USP) lasers with a safe and flexible beam delivery system. USP lasers with pulse energy larger than 1 µJ require special optical fiber for beam delivery. The fiber must withstand much larger damage threshold fluence than the silica material and must exhibit extremely low optical nonlinearity and low dispersion to preserve the spectral and temporal integrity of the laser pulse. Inhibited-coupling guiding, hollow-core, photonic crystal fibers (IC-HCPCF, see Fig.4 left) are ideal for USP laser beam delivery because they transmit light with very low attenuation, low dispersion and in a spatial mode that has very low optical overlap with the surrounding silica core [5]. This type of fiber is now commercialized by



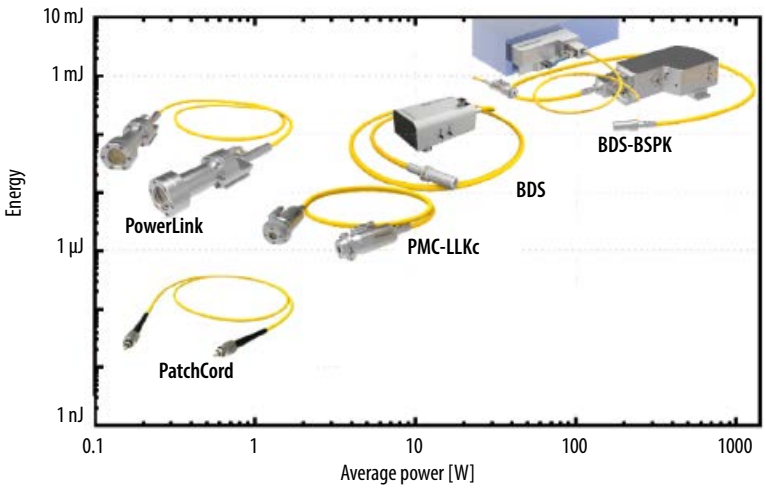


Fig. 4 Cross section of a kagome lattice, hypocycloid core, contour IC-HCPCF (source: Xlim lab, top); USP laser beam delivery modules in the laser energy-average power space (GLO Photonics, right)

GLO Photonics in a variety of laser beam delivery modules. Fig. 4 shows the different IC-HCPCF-based USP laser beam delivery modules. These are developed to address the largest laser parameter space in terms of pulse energy and average power. The patch cord is a fiber module designed for low energy USP lasers and is equipped with an FC connector for standard mechanical mounting. The Powerlink is a module whose fiber tips are attached to a hermetic opto mechanical cell for vacuum and gas handling. The beam delivery system (BDS) and the PMC-LLKc are laser beam delivery modules for industrial applications. In the BDS, the fiber is protected with a semirigid cable for harsh environments. The BDS is equipped with an injection head for easy alignment. It can handle thermal cooling for high average power lasers and can be equipped with active stabilization of beam pointing. Finally, the BDS injection head can be tailored to provide an evacuated environment to minimize the photoionization effect when peak intensities exceed the air breakdown limit, or to have a specific mechanical design to integrate into a USP laser (see BDS-BSPK in the top right corner of the diagram in Fig.4).

Conclusion

Several different synthesis pathways of doped materials have now matured and allow the fabrication of new fibers for high-power laser products. In the same way, the manufacture of hollow fibers and their integration into modules for the transport of high-peak power laser beams has also reached a technical maturity compatible with their industrial deployment. The combination of guidance techniques and material synthesis provides access to active fibers covering a wide range of modal areas adapted to different laser regimes. Other avenues of research to continue the increase of light power include work on the consistent combination of beams from different fibers or cores of the same fiber or the use of higher-order modes with large effective areas.

*

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[1] *J. Boullet:* Regime-dependent photo-darkening-induced modal degradation in high power fiber amplifier, ASSL, paper ATu4A.3, (2016)
[2] *A. Baz, L. Bigot, G. Bouwmans* and *Y. Quiquempois:* Single-Mode, Large Mode Area, Solid-Core Photonic BandGap Fiber With Hetero-Structured Cladding, Journal of Lightwave Technology **31** (2013) 5, 830-835
[3] *K. Schuster* et al.: Adv. Opt. Technol. **3** (2014) 447
[4] *M.-A. Malleville* et al.: Opt. Lett. 42, 52
[5] Couny et al. Science **318** (5853), 1118-1121 (2007)

Authors

Laurent Bigot received his PhD in physics in 2002 from the University of Lyon where he studied rare earth-doped glasses for optical amplification. In 2003, he joined the PhLAM laboratory of the University of Lille where he is now CNRS senior researcher. He currently leads the photonics group and is focusing his research activities on the synthesis of optical materials, and the design and characterization of specialty optical fibers, especially for amplifier/laser and telecommunications applications.

Philippe Roy received his PhD in microwave electronics and optoelectronics (specialty photonics and electronics systems) in 1997 at the University of Limoges. He is now a CNRS senior researcher and head of the fiber photonic group at Xlim. He is involved in the design, fabrication and characterization of specialty and composite fibers, mainly dedicated to advanced fiber sensor systems and to very high-power fiber lasers. He develops rare earth-doped fibers with complex structures based on an aperiodic design to reach higher power levels without modal instabilities and/or non-conventional emitted spectrum.

Thierry Taunay studied physics at the University of Lille, France where he received his PhD in 1997. He then spent twenty years in the US, both in government laboratories and the industry. Since June 2016, he holds the position of technical manager at Photonics Bretagne in Lannion, France. His primary research interests are in the development of specialty fibers for high power fiber lasers as well as new designs of hollow-core fibers.

Fetah Benabid is a CNRS director of research and honorary professor at the University Western Australia. He is the group founder and leader of GPPMM at the CNRS UMR Xlim. He pioneered the development of HC-PCF and their its incorporation into scientific and technological applications. He is the inventor of Kagome HC-PCF and of photonic microcell (PMC). His research interests covers guided photonics and gas-phase photonics. Benabid is the founder and NE-CSTO of GLO Photonics, a a leading manufacturer of hollow-core fibers for industrial applications.

Eric Mottay graduated from École Superieure d'Optique near Paris, a leading institution in France for optical engineering. He is the CEO of Amplitude Systèmes, that he founded in 2001, as a manufacturer of ultrafast lasers for industry and science. He is passionate about laser technology and applications development and believes that sound engineering and collaborations are the key to success in photonics.

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Anniversary at Lasercomb

250th CO_2 Slab laser for die making

Steffen Kirchgeorg, authorized signatory and purchasing manager at Lasercomb, and Dr. Jens von Stamm (sales) of Coherent at the meeting on the occasion of the 250th CO_2 Slab laser shortly before the onset of Covid-19. (Source all images: Coherent)

A very trusting and successful business relationship connects the companies Lasercomb, based in Notzingen, and the laser manufacturer Rofin – now Coherent. For over twenty years, the Swabian company has been using CO_2 lasers produced in the Hamburg facility – and for good reason: the laser's economical operation and low maintenance costs have proven to be perfect for the machine manufacturer's systems.

In addition to mechanical cutting, milling and water jet systems, Lasercomb develops and manufactures laser-based production systems which are used in the packaging industry and in die making. The medium-sized company, which focuses on high-tech solutions, enjoys an excellent international reputation when it comes to complete solutions for demanding customers.

This was not the case in 1973, when the company was founded near Stuttgart. One of their first developments was a system for woodworking using lasers. Subsequently, Lasercomb designed and installed a laser cutting system for die making in the former Yugoslavia in 1975. The system was equipped with one of the first industrially available CO_2 lasers from a British company. However, the lasers soon proved to be too maintenance-intensive and prone to failure. These lasers were also troublesome during transport or cold weather. On top of this, the unfavorable exchange rate to the British pound finally made the use of these lasers uneconomical.

A series of other fast-flow CO_2 lasers followed until 1995, when the starting shot was fired for a success story with systems equipped with diffusion-cooled Slab lasers. From that point on, all Lasercomb laser-based systems – from the compact, low-cost entry-level version through the cross-table laser system to the maximum automated rotation system – were equipped with CO_2 Slab lasers from Coherent. These lasers utilize only a few, extremely durable components and do not require conventional gas circulation, which considerably reduces maintenance and service

Company

Lasercomb

Lasercomb is internationally known as innovative provider and supplier of system solutions for the packaging- and diemaking industry. The company which launched a practical dieboard laser on the market already in the year 1973 – is currently focusing its activities on the development and production of modern, state of the art software and hardware solutions for packaging manufacturers. This system supplier, with headquarter in Notzingen / Germany, specialised in high-tech products, offering complete solutions for the day-to-day tasks facing ambitious customers in the fields of packaging and display production and diemaking.

www.lasercomb.com

MTL system equipped with a 1.5 kW Slab laser prior to delivery to a Spanish customer

work. As in many other applications which processes organic materials, the CO_2 laser is also considered the method of choice in die making and the packaging industry, because the ten micrometer wavelength is strongly absorbed by these materials.

"We have found an extremely professional supplier in Coherent who provides us with efficient, reliable and low-maintenance beam sources with top service. The Slab laser guarantees mature technology, high process reliability and cost-effectiveness. Of course, our customers are also happy about this," explains Lasercomb managing director Ralf Penzkofer.

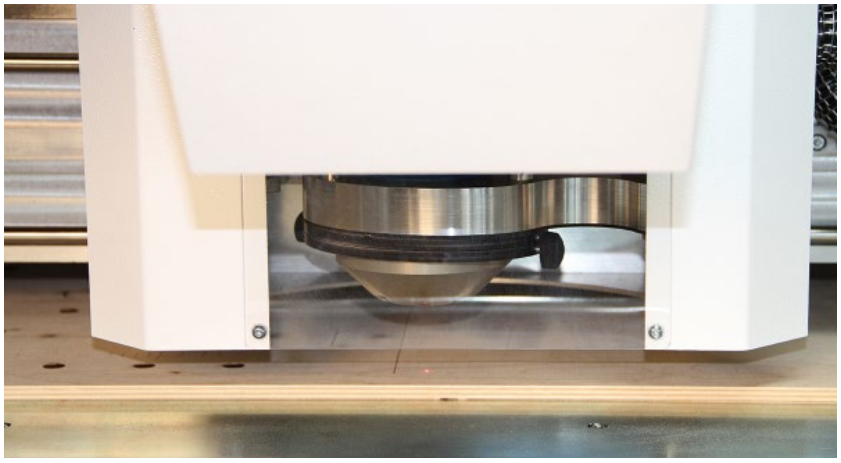
Today, Lasercomb focuses primarily on development, design and sales. Component production is outsourced to partners throughout Europe, so that the company can fully concentrate on in-house solution concepts for customers' new complex tasks. However, the final assembly and test runs take place at the Notzingen plant. Here, the forty employees work in a 2100 m² production area, with another 800 m² of demonstration and administration areas, in order to deliver about fifteen laser-based systems every year to customers all over the world.

Penzkofer attributes the success of the Lasercomb systems to the fact that they offer the best overall technology. The systems combine the basic production processes for die making – cutting, milling and marking – in an intelligent and efficient way. The many years of experience in laser system and special machine construction, and the reliability of the lasers in these systems, ultimately enable the customer to produce efficiently and with minimal downtime.

Over the years, the company provided customers with increasingly effective and easier to operate systems. For example, in laser-based systems, clients can now benefit from a scanner solution for marking that transfers specifications directly from CAD to the machine in the shortest possible time, so that the laser can produce text or logos directly on the die. Of course, new product developments in areas such as networking and remote maintenance contribute to the continuous optimization of the systems.

According to Penzkofer, the advantages and cost-effectiveness of the laser-based systems have also contributed to the fact that the company has been able to record a significant increase in business in the US in recent years. "We are now delivering a much higher volume, as the advantages over local competitors have become clearer. Due to the high local energy costs, more and more US customers are opting for our Slab laser systems. One of our US customers replaced two systems, each with a 2 kW laser of older technology, with a system having a 2.5 kW laser and an integrated scanner solution for marking. This can save 4,000 dollars in electricity per month and 30,000 dollars in gas costs per year."

So, there are many good reasons why an innovative Swabian and an economical laser go so well together. That's why Coherent has also supplied the 250th Slab laser to the Swabian machine manufacturer.



Die cutting with a CO_2 laser

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Source: Messe Munich

Source: W3+ Fair/Convention 2020 Wetzlar/ FLEET

	new / next date
October 13 –17, 2020 → **Fakuma** Friedrichshafen, Germany www.fakuma-messe.de/en	**October 12 – 16, 2021**
October 20 – 23, 2020 → **glasstec** Düsseldorf, Germany www.glasstec.de	**June 15 – 18, 2021**
October 27 – 30, 2020 → **EuroBLECH** Hanover, Germany www.euroblech.com	**March 9 – 12, 2021**
October 28 – 29, 2020 → **chii2020** www.chii2020.com	**online**
November 10 – 12, 2020 → **VISION** Stuttgart, Germany www.messe-stuttgart.de/vision	**October 5 – 7, 2021**
November 10 – 13, 2020 → **electronica** https://electronica.de/en	**online**
November 10 – 13, 2020 → **formnext** www.formnext.com	**online**
November 10 – 13, 2020 → **SEMICON Europa** www.semiconeuropa.org	**online, t.b.d**
November 16 – 19, 2020 **COMPAMED** & **MEDICA** Duesseldorf, Germany www.compamed.de — www.medica.de	
November, 17 – 19, 2020 → **Optatec** www.optatec-messe.de/optatec-virtuell	**online**
November, 24 – 27, 2020 → **sps smart production solutions** https://sps.mesago.com	**online**
November 23 – 25, 2020 → **11th International Laser Symposium** Dresden, Germany https://www.lasersymposium.de	**December 6 – 8, 2021**
November 25 – 26, 2020 **laf 2020** Bremen, Germany www.lafbremen.de	
December 6 – 10, 2020 **European Conference on Optical Communication ECOC 2020** Brussels, Belgium www.ecocexhibition.com — https://ecoco2020.org	

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Resumption of B2B and In-Person Events in China

Review: SIAF and Asiamold, 11 – 13 August, 2020 Guangzhou, China

Held at the China Import and Export Fair Complex in Guangzhou, SPS – Industrial Automation Fair Guangzhou (SIAF) and the concurrent Asiamold – Guangzhou International Mould & Die Exhibition welcomed 655 exhibitors occupying 40,000 square meters of exhibition space and attracted 50,369 visits. They covered a variety of intelligent industrial automation solutions, mold-making, 3D printing, metalworking, foundry, die-casting, laser and bearing technologies. Both fairs presented a one-stop sourcing platform for manufacturing industry players looking to recover and reconnect, following the suspension of numerous global businesses and production lines.

Source: Messe Frankfurt

SIAF Guangzhou and Asiamold were the first Guangzhou fairs to be hosted by Messe Frankfurt since the beginning of the year. The two smart manufacturing fairs served as an important tool for the resumption of business-to-business and in-person interactive events in China. The events were welcomed by the industry which depends on the platform for business exchange, market information and, most importantly, new business opportunities with manufacturers who wish to upgrade their supply chain with the latest and most innovative automated technologies.

"As large scale events are gradually resuming in China, we are excited to be back to facilitating business interactions for the manufacturing industry, particularly within the South China region. The shows marked the first Guangzhou events to be held by Messe Frankfurt since January, when trade fairs were forced to be postponed due to the global pandemic. We are pleased that SIAF Guangzhou and Asiamold were able to go ahead as planned, offering a trusted one-stop platform for manufacturing industries and helping them resume their normal operations," said Mr Hubert Duh, chairman of Guangzhou Guangya Messe Frankfurt after the conclusion of the fairs.

Mr Duh added: "The overall positive response from participants has shown that the manufacturing industry is slowly recovering from the economic impact of the first two quarters of this year. Protective gear and other health equipment continue to be in high demand, and Asiamold's new Mould and 3D Printing Epidemic Prevention Technology Display Zone, among various other thematic zones, proved to be popular. To further support the Chinese government's new infrastructure and manufacturing development initiatives, this new zone along with other smart manufacturing solutions on display have reconfirmed strong business potential for exhibitors at the fairs."

"With SIAF Guangzhou and Asiamold 2020 successfully concluded, we look forward to preparing the 2021 editions on 3 – 5 March to further reactivate and reconnect international exhibitors and visitors once air travel becomes more accessible so they are able to participate," Mr Duh concluded.

www.spsinchina.com
www.asiamold-china.com

Canceled: Fakuma 2020

13 – 17 October 2020, Friedrichshafen, Germany

This year's Fakuma is postponed until next year. "Together with all involved parties, we struggled for a long time to amend the general conditions demanded by the corona pandemic in such a way that Fakuma 2020 could have been promoted successfully," says Bettina Schall, managing director of P. E. Schall. A hygiene and security concept was developed for safe trade fair promotion to this end. "We fulfilled all of the prerequisites. However, in cooperation with the exhibitor advisory board we've now decided to postpone it to October, 2021."

Schall emphasizes: "As trade fair promoters, we see ourselves as service providers for our exhibitors and expert visitors. Current uncertainties among exhibitors and visitors, for example with regard to travel and sending employees to events, are making it necessary to look to the year 2021 with pragmatism and confidence."

Cooperation partners and expert visitors waited for a long time for concrete information, but official regulations and decision-making delays forced them to be patient. The time has now come to focus on the future: "Exhibitors and expert visitors alike should look ahead to building on the success of previous Fakuma trade fairs. This is why we're now all working together on thorough, detailed planning for the upcoming year," she concludes. The mutual decision taken by the exhibitor advisory board and the trade fair promoters underscores their care and foresight, as well as their consideration for the interests of the exhibitors and visitors. The efforts of all involved parties are now being focused on intensive preparations for the upcoming trade fair highlights of the plastics industry.

www.fakuma-messe.de

Canceled: VISION 2020

10 – 12 November 2020, Stuttgart, Germany

Messe Stuttgart will stage the next Vision, the world's leading trade fair for machine vision, from 5 to 7 October 2021. The trade fair organizer is therefore complying with the request by the polled exhibitors and visitors who voted in an extensive survey by a clear majority (75 % of exhibitors and 81 % of visitors) for an attendance event next year. The new date in the odd trade fair year – in parallel with Motek, International Trade Fair for Automation in Production and Assembly – will be retained in the long term.

In addition to the strategic measures initiated in 2020, such as the launch of the Vision Start-up World or an extensive communication campaign on the Chinese market, Messe Stuttgart is planning to further enhance the trade fair experience at Vision 2021 through digital supplements. However, there are no plans for a virtual replacement of the cancelled trade fair date in 2020.

Dr. Klaus-Henning Noffz, director new business development Basler and chairman of the board of VDMA Machine Vision, the promotional supporter, welcomed the approach: "Vision is an essential platform for the machine vision industry. We are looking forward to a strong Vision 2021, and once again with many personal meetings with business contacts and friends from all over the world."

"Important business contacts are forged and cultivated, innovations are presented and developments are discussed here. We are all the more pleased about the date next year in Stuttgart," concurred Gabriele Jansen, managing partner of Vision Ventures and a member of the board of directors of the European Machine Vision Association EMVA, in endorsing the decision.

www.vision-fair.de

Preview: Formnext 2020

10 – 13 November 2020, online only

Due to the recent rise of the Covid-19 infection figures worldwide, and the associated increase in travel restrictions, Mesago Messe Frankfurt has decided to hold Formnext 2020 purely virtually. The digital event will be named 'Formnext Connect'. Formnext 2020 was previously planned as a hybrid trade fair, that is, with the on-site event at the Frankfurt exhibition grounds plus a digital add-on component. This plan was based on the Corona Contact and Operating Restrictions Ordinance valid in the State of Hesse and a health and hygiene concept agreed upon with the City of Frankfurt am Main, the State of Hesse and Messe Frankfurt.

"The current rise of the Covid-19 infection figures in Germany, Europe and around the world have led to increasing uncertainty among exhibitors and visitors. Together with the renewed tightening of restrictions, this will no longer allow the otherwise highly international Formnext to be carried out in the accustomed quality," stated Petra Haarburger, president of Mesago Messe Frankfurt.

Formnext Connect will start as a virtual event from 10 November and will offer a wide range of digital services. These include exhibitor presentations in showrooms (products, information, videos, chat function, lead generation / lead tracking), intelligent matchmaking with all participants supported by AI, live streaming and on-demand content of the supporting program and webinars as well as the scheduling / assignment of appointments for online meetings with exhibitors.

www.formnext.com

Preview: Optatec

17 – 19 November 2020, Frankfurt, Germany

The Optatec international trade fair for optical technologies, components and systems has been officially launched on its new digital trade fair platform, namely Optatec-Virtual. After the originally planned trade fair dates in May 2020 had to be postponed due to the spread of the SARS-CoV-2 virus, trade fair promoters P. E. Schall have set up a virtual meeting place for suppliers and users from the optical industry in the form of a digital marketplace, and are now getting ready for the new trade fair dates in November.

Optatec, which takes place once every two years, is the traditional trade fair meeting place for the most important players in the optics industry. 540 exhibitors from 32 countries and 5,803 expert visitors from 45 nations came to Frankfurt in 2018. Expert visitors are able to gain an impression of current worldwide products, as well as stand-alone and system solutions and applications of optical technologies. These include optical components, materials, coatings, optomechanical components and elements, fiber optics, optical waveguides, laser components, photonics, systems for additive manufacturing, industrial image processing and optical metrology. As a global knowledge platform, Optatec offers a world-class supplementary programme. The exhibitor forum addresses the industry sector's current issues, which are dealt with in expert presentations.

Visitors will also be able to attend a Spectaris workshop covering DIN ISO 10110, in order to explore the current status of and planned amendments to the creation of drawings of optical elements and systems. In this way, Optatec will bridge the gap between scientific findings, new technologies and practical applicability.

www.optatec-messe.de/optatec-virtuell

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