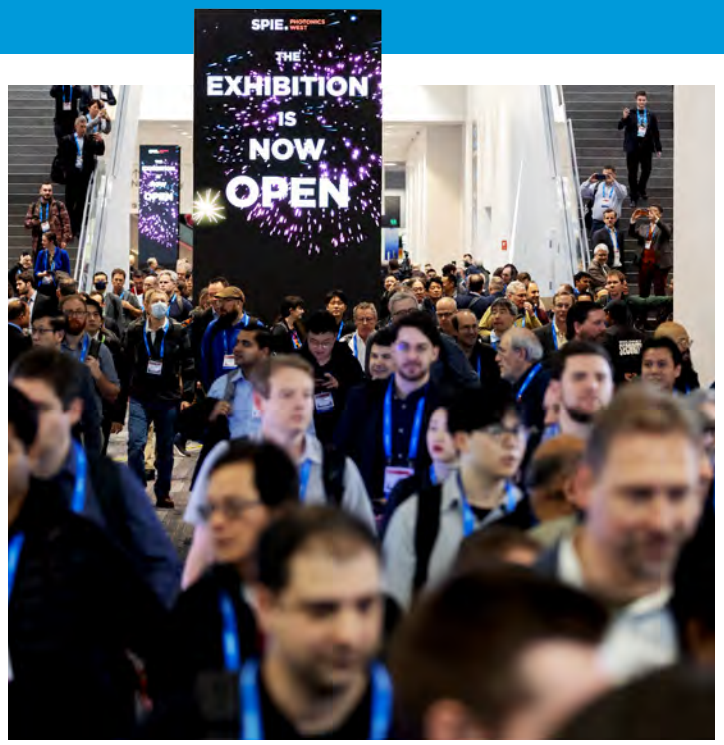
THURSDAY
EDITION

SPIE. | optics.org | THURSDAY, FEBRUARY 1, 2024

PHOTONICS WEST SHOW DAILY

EKSPLA's winning FemtoLux 30

Prism Award winners
p. 28



A surge of attendees as the exhibition opens. Credit: Joey Cobbs.

Pack the halls: More than 24,000 register

The vibrant buzz from the sold-out exhibition floor at this year's SPIE Photonics West was palpable. With more than 24,000 registered attendees filling the halls, exhibitors have been busy talking with customers, forging new potential collaborations, and engaging in business. Even with one day to go, it's clear the week has been a success and that the photonics industry is booming.

"The Global Business Forum made it clear that the optics and photonics industry is in the midst of a remarkable era of growth and innovation," said Stratos Kehayas, PhD, Chief Product & Technology Officer, G&H. "The industry's collective enthusiasm at Photonics West underscores the pivotal role this trade show plays in driving collaboration, fostering innovation, and shaping the future."

"This has been one of the best Photonics Wests we've had in probably the last five years," said nLIGHT Vice President and General Manager, Semiconductor Lasers, Matthew Randall. "It's been

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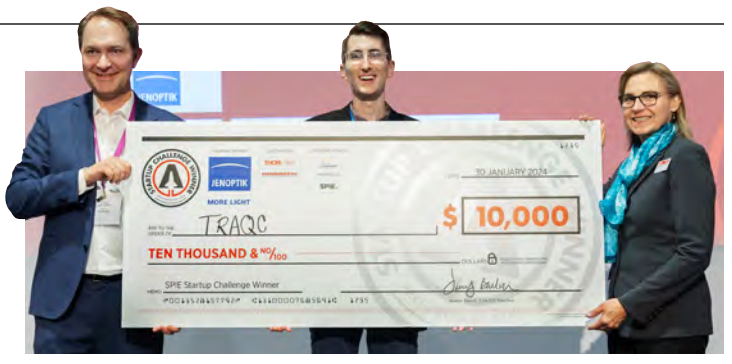
Startup Challenge winner is right on TRAQC

Canadian company pitched inspection system for printed electronics

On Tuesday afternoon, TRAQC was announced the winner of the $10,000 top prize at the 14th annual SPIE Startup Challenge. Their real-time inspection solution for the printed electronics industry utilizes THz radiation and metamaterial technology to ensure quality while reducing waste.

ClearVision, with a non-invasive alternative to permanent vision-correction surgeries based on corneal sculpting with femtosecond laser technology, received $5,000 for second place.



Jenoptik's Ralf Kuschnereit, TRAQC's Benjamin Dringoli, and 2024 SPIE President Jennifer Barton. Credit: Joey Cobbs.

UriMetrics came in third, winning $2,500, with their lens-free imaging solution for reducing the incidence of Catheter-Associated Urinary Tract Infections (CAUTI). All cash prizes are provided by SPIE Startup Challenge Founding Partner Jenoptik.

continued on page 03

DON'T MISS THESE EVENTS.

PHOTONICS WEST EXHIBITION
10 AM - 4 PM
Moscone Center, North-South (Exhibit Level)

INTEGRATED PHOTONICS FOR QUANTUM TECHNOLOGIES: CHALLENGES AND PROSPECTS
10:30 - 11:30 AM
Moscone Center, Expo Stage, Hall DE (Exhibit Level)

QUANTUM COMPUTING, A STRATEGIC TECHNOLOGY ENABLED BY PHOTONICS
11:45 AM - 12:15 PM
Moscone Center, Expo Stage, Hall DE (Exhibit Level)

PRISM AWARDS WINNERS' CIRCLE
1:30 - 3 PM
Moscone Center, Expo Stage, Hall DE (Exhibit Level)

For the full schedule, see the technical program and exhibition guide or download the SPIE Conferences app. Some events require registration.

SAVE THE DATE
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January 25 – 30, 2025

IN THIS ISSUE.

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Industry panelists tout emerging optical interconnect technologies for AI

It's not news that AI seems to be changing everything, but one of the lesser-known impacts is that massive investments into AI infrastructure is pressuring development of new solutions for optical connectivity. A panel discussion at the Photonics West Expo stage gave a glimpse of this fast-moving situation.

"The challenge for supporting large language models developed for generating AI is to scale the size of GPU arrays from hundreds to hundreds of thousands of these GPU arrays," said panel moderator Vladimir Kozlov, founder and CEO of LightCounting. "And you know, a single rack can probably count 32 GPUs, but to get beyond the array, optical conductivity is the only solution."

"AI is driving the bus in a lot of cases," agreed Bijian Nowroozi, CTO of the Open Compute Project Foundation. As the workloads increase, we have to get more speed, more bandwidth. The problem is, as you scale bandwidth, the net power consumed for networking dramatically increases. We've assembled a coalition of entities in the photonics space. We're trying to resolve what the biggest parts of the problem are. What is it that we need to solve?

AI is driving the bus: (L-R) Yosef Ben Ezra, Timour Rakhimi, Uday Poosarla, and Bijian Nowroozi. Credit: William Schulz

Celestial AI Senior Director Uday Poosarla says his company's Photonic Fabric is an EIC and PIC architecture that enables data delivery at the point of consumption. He says it is a full stack solution that is protocol agnostic. "We can also connect the other side of the fiber to either the optical switch, logic memory, or quantum things. We're not leaving you high and dry!"

Timour Rakhimi of startup Alfalume said the company is leveraging quantum dot technology on a gallium arsenide platform. "What makes this technology so bright for AI clusters?" he asked. "First of all, it works up to 120 degrees with high power efficiency. Because it's gallium arsenide, there's much higher resistance to back reflection. When paired with advanced modulation technologies, it makes a pretty robust system."

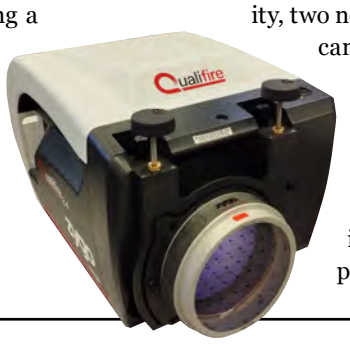
"At New Photonics, we are changing the paradigm and introducing all optical photonic chips which can actually replace this power-hungry digital chip," said CTO Yosef Ben Ezra. We can achieve interoperability for system performance, significantly reducing power consumption and latency. Our technique for all optical equalization can achieve up to 45 gigahertz bandwidth with significantly improved signal quality. With this approach, you can scale up and create complex photonic integrated circuits."

While applauding these and other industry achievements, Kozlov noted that a question remains: Are we finally at the point where optics is going to replace copper?

WILLIAM SCHULZ

Honey I shrank the interferometer (and the supercontinuum laser)

Exhibitors Zygo and Superlight Photonics are two firms showing off efforts to shrink the size of typically more bulky equipment this week. Following a four-year redesign from scratch, Zygo's "Qualifire" interferometer is making its world debut at Photonics West. Intended to enable customers to "bring metrology to the part" with much-improved accessibility, two new versions of the system can be seen at the US firm's booth (#1048), with the smaller one weighing in at just 20 kilos. "This interferometer packs significant enhancements into a small lighter-weight package," Zygo announced.



Zygo's brand new "Qualifire" interferometer features an all-new optical design. Credit: Mike Hatcher

Superlight's supercontinuum source. Credit: Superlight Photonics

Over at the Holland High Tech Pavilion (booth #5211), University of Twente spin-out Superlight is showcasing its battery-powered, ultra-portable supercontinuum laser, which weighs just under a kilo. The SLP-1000 is based around a photonic integrated circuit fabricated by local foundry partners and exploits the firm's patented patterned alternating dispersion technology. That approach is said to "massage" the output over a wide range of wavelengths with lower noise than rival sources — so less power is required, enabling 20 fs pulses to be delivered by battery.

MIKE HATCHER

Startup Challenge

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

"This is great!" said TRAQC COO Benjamin Dringoli about winning the competition. "It's something that allows us to have more eyes on us, which is huge at this stage. In addition, this is a completely focused crowd that we wouldn't have access to anywhere else: it's the opportunity to pitch in front of these industry leaders and get their feedback live, the mentorship session prior to the finals, and having people coming up to me and say, 'Hey, if you need help, let me know.' The networking opportunity of being on the Startup Challenge stage is a huge help. It's wonderful."

"It's a terrific boost," noted ClearVision Founder and Principal Investigator Sinisa Vukelic. "It gives us confidence that we're doing something well, that we are on the right track. It also gives us an opportunity to network and chat with other people, and that's so important and really much appreciated. I'm very grateful to SPIE for organizing this. I think it's a wonderful initiative and I'd be happy to contribute in the future."

"The mentorship that we received as part of the Startup Challenge was particularly useful," added UriMetrics spokesperson Taylor L. Bobrow. "It was really great for refining our pitch and our ask for today. We'll be utilizing this prize money to help with our clinical testing and proof-of-concept studies."

The 2024 SPIE Startup Challenge was supported by Founding Partner Jenoptik; Lead Sponsors Hamamatsu and Thorlabs; and Supporting Sponsor NextCorps Luminate.

DANEET STEFFENS

IN MEMORIAM: BRIAN J. THOMPSON

Brian J. Thompson. Credit: SPIE.

SPIE Fellow and Past President Brian J. Thompson, Professor Emeritus at the University of Rochester (UR), passed away 27 January at the age 91. A leading researcher in coherent optics, holography, phase microscopy, and image processing, he carried out seminal experimental studies on partially coherent light and its effects, which became standard works in literature of this field. Thompson is also credited with developing dynamic particle size analysis — the first direct application of holography.

A native of Preston, England, Thompson earned BSc and PhD degrees from the University of Manchester, where he worked for a time with optical physics pioneer Emil Wolf. Thompson joined UR in 1968 as director of the Institute of Optics and served as dean of the College of Engineering and Applied Science from 1975 to 1984. He continued as provost at UR from 1984 to 1994.

Thompson also excelled as an instructor and mentor to students and others in the optics community. In a 2009 interview with RU's *In Review,* he noted: "If you can create an environment in which people can prosper, that's just as satisfying, and creative, as a new discovery. I find it very stimulating to make things happen — which is not too different than research, if you think about it."

KAREN THOMAS

Schott expands Penang site, eyeing prescription AR

Glass giant Schott has revealed details of additional production capacity at its existing Penang, Malaysia, site, that will be used to manufacture components including waveguides for prescription augmented reality (AR) eyewear developed by partner Lumus.

It comes as the two firms said they would be building on their five-year partnership to meet growing demand for optical AR glasses, with Lumus highlighting its corrective glasses at the SPIE AR|VR|MR exhibition.

Ari Grobman, the CEO of Israel-based Lumus, said: "In early 2019, Lumus and Schott began a strategic partnership with the goal of enabling cost-effective, mass-scale manufacturing of the reflective waveguides featured in our Lumus 2D Maximus architecture.

"Now, Schott is processing waveguides for our next-generation Z-Lens waveguide architecture that enables us to develop even smaller, lighter AR eyeglasses with high-resolution image quality, outdoor-compatible brightness, and seamless Rx [prescription] integration. The success of our partnership is helping to make high-quality optical AR glasses a practical reality for the mass market."

Ruediger Sprengard, Schott's head of AR, added: "This expanded partnership with Lumus represents the logical next step in Schott's history of pioneering innovations in optics and vision technology that turn visions into a reality.

"With this expansion, we are well positioned to meet the growing demand in cutting-edge optics such as AR waveguides based on Lumus' Z-lens architecture."

The Z-lens reflective waveguides are designed to meet "imminent" customer demand for AR glasses, with the Penang expansion able to support all phases of product development in consumer electronics, including proof-of-concept prototype development, engineering samples, and mass production when consumer demand materializes.

Prescription-adaptable AR glasses from Lumus can be seen at the AR/VR/MR exhibition. The startup has just extended its five-year partnership with Schott. Credit: Lumus.

Lumus, which has grown quickly following success in military and medical AR applications, says that the brightness supported by its waveguides allows AR to work well in daylight through a pair of glasses that are very similar to regular spectacles.

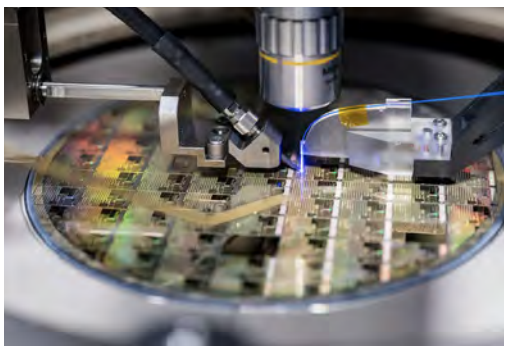
"Lumus' Z-Lens architecture creates several degrees of freedom for glasses manufacturers, including flexibility of the eye-box position and the ability to directly bond Rx prescription lenses," states the firm. "This feature allows consumers to customize their AR eyeglasses to their vision without bulky, heavy inserts, meaning that they can be used as normal eyewear."

MIKE HATCHER

CEA-Leti improves microLEDs' bandwidth and efficiency

CEA-Leti (Booth 5129), a technology research institute based in Grenoble, France, has this week presented two papers on its microLED technology advances, covering the development of matrices of LEDs with increased data-rate density — and strategies to reduce their efficiency loss at small sizes.

How making LEDs directly on a 200 mm silicon substrate opens the way to producing a matrix of LEDs of a few microns that are individually controlled by dedicated CMOS circuits, was described in yesterday's presentation "Parallel Communication with InGaN/GaN Micro-LEDs Using a CMOS Compatible Approach."



Electro-optical characterization of a microLED at wafer level. Credit: CEA-Leti.

CEA Leti says that InGaN/GaN microLEDs "are a strong candidate to enable high data-rate light communication because of their robustness, availability at large scale, and ability to reach GHz scale bandwidth. Using them in an array enables massively parallel transmission and a high data-rate density."

Aside from that, a new CEA-Leti patented process to integrate a GaN LED matrix over a CMOS ASIC has also been developed. In this CMOS-compatible approach, the microLEDs' integration was optimized by bonding them directly on top of a 200 mm silicon wafer using GaN-based devices as both emitters and fast photodetectors.

For this reason, CEA-Leti has focused for many years on improving microLED efficiency, particularly by focusing first on defects passivation and more recently by understanding the impact of carrier diffusion, the subject of the second paper.

Monday's paper, "Influence of quantum well thickness on carrier diffusion length in InGaN quantum wells," detailed the strategy to reduce the InGaN/GaN LEDs' efficiency drop that comes with smaller pixel size, by understanding and controlling carrier diffusion.

"In this presentation, we show experimentally that the diffusion length can be reduced by decreasing the thickness of the InGaN quantum well, as the theory predicts. In addition, we present a power-dependent, unexpected behavior of the diffusion observed in large quantum wells that may help us to understand the physics of the emitters," said Simon Litschgi, lead author of the paper.

MATTHEW PEACH

Attendance

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very engaging, with lots of people coming through, and we're seeing new things at our booth and at others' booths that make this particular show very positive. We are definitely seeing way more innovation now than the last couple of years. So that's been incredibly positive not only for nLIGHT, but for this entire photonic sector."

"It's been pretty overwhelming," said Litilit Sales Manager Martin Rodenbeck. "It's my first time here and the sheer size is just amazing: getting to see so many manufacturers and suppliers and producers all in one place, all on business, all very focused. It's a very enriching perspective, and a very growth-inducing experience, talking with so many people in our industry. I've had some very, very promising leads come up and that's really exciting. It's always great to see that there are people interested in what you sell, and to be be able to bond over that."

"The week has been very good so far," said MKS Instruments Senior Director of Marketing, Photonics Solutions Division, Vincent M. Issier. "The traffic has been very high and the attendance is incredible this year, and we are very happy with the level of engagement from people here. All in all, an excellent show."

"The week has been great," said IPG Photonics Director of Product Management, Beam Delivery, UV, Green & Ultrafast Lasers, Mustafa Coskun. "There was nice traffic coming through and it was really nice to connect with colleagues as well as our customers and other visitors. And this is what we're here for: to listen to our customers and understand what their problems are and how we can help them, focusing on how we can offer a full solution. IPG is focusing more and more on solutions for our customers rather than components. So this Photonics West has been great."

"Photonics West this year has been an excellent experience," added Lumibird Business Development Manager Andrew Larsen. "We've had great customer interaction, excellent booth traffic, and there's a great vibe throughout the whole show. It's been really wonderful."

"This year we were quite busy, even just walking around the show, with so many people we know here and so many companies we are in touch with," said TNO Business Consultant, Optics Manufacturing, Bart Snijders. "It's great to see them all again. We've enjoyed being busy on the floor, busy with meetings. I would always like the show to be six or nine days long, because time is always too short for me here."

DANEET STEFFENS

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Using light to solve growing data demands

Industry session focused on technology trends in optical communication.

This week at Photonics West, there are over 550 presentations where machine learning or artificial intelligence had an impact on, enabled, or was used in the author's research. Photonics is not alone in its desire to take advantage of the increasing power of computing, and in the rapidly evolving landscape of data-intensive technologies, the demand for efficient data processing and transmission has reached unprecedented levels. As traditional electronic systems encounter limitations in terms of speed and energy consumption, there is a compelling opportunity for optics and photonics technologies to help. Silicon photonics not only offers the potential for significantly faster and more energy-efficient data transmission but also opens doors to novel applications across various domains. As industries and research sectors strive to keep pace with the exponential growth in data, the integration of silicon photonics stands poised to revolutionize the way we handle and leverage information in the digital age.

Martin Vallo, Senior Analyst, Photonics for the Yole Group. Credit: Yole.

On Wednesday afternoon, Martin Vallo, Senior Analyst, Photonics for the Yole Group hosted the session "Photonics Technologies for Datacom: Complement or Compete?" The *Show Daily* caught up with Vallo to discuss the technologies poised to help alleviate some of the current bottlenecks in our thirst for data.

Show Daily: What is the current status of photonic technologies in datacom?

Martin Vallo: The typical modules, which may have different form factors, used in data centers comprise optical engines/chiplets, active optical cables (AOC), and high-speed optical transceivers. These modules can integrate various photonic (laser) devices, such as VCSELs, DMLs, EMLs, and CW-DFBs or QD for the silicon photonic integrated circuits (PICs) deployed in optical communication systems such as fiber-optic networks and data center interconnects. The application requirements determine which laser technology will be used.

Vertical-Cavity Surface-Emitting Lasers (VCSELs) continue to play a significant role in data communications, particularly in short-distance optical links and applications. VCSELs are a key technology for data center interconnects, providing the optical links that connect servers, switches, and other networking equipment within data centers. Their low cost, ease of integration, and compatibility with multimode fiber make them suitable for short-distance, high-speed connections where energy efficiency is crucial. VCSELs support a wide range of data rates. They have been used for data rates ranging from 1 Gbps (Gigabit per second) to 100 Gbps and beyond. Advances in VCSEL technology continue to push the achievable data rates, making them suitable for evolving data center requirements.

Directly Modulated Lasers (DMLs) are prevalent in optical communication systems, particularly in short-reach and cost-sensitive applications like data center interconnects. DMLs allow for direct modulation of the laser without an external modulator, simplifying the overall system architecture. DMLs are known for their simplicity and cost-effectiveness. They are suitable for transmitting signals over relatively short distances (up to 2 km) within a data center. DMLs are often employed in applications with lower data rates, typically up to 25 Gbps or 50 Gbps. Advances in DML technology focus on enhancing their performance for higher data rates and optimizing their compatibility with emerging data center architectures.

Electro-absorption Modulated Lasers (EMLs) are widely used in high-speed optical communication systems. They combine a laser with an electro-absorption modulator, allowing for direct modulation of the laser output. This technology is commonly employed in long-haul and metro networks, and intra-DC optical interconnects for transmitting high-speed signals. EMLs are used for data rates ranging from 10 Gbps to 200 Gbps. Ongoing improvement of the performance of EMLs, including increasing the modulation bandwidth and optimizing their characteristics for specific applications, predetermine them to be widely adopted in the market, not only in long-haul and metro networks but also in mid-haul within intra-DC networks where their performance characteristics are beneficial.

> As traditional electronic systems encounter limitations in terms of speed and energy consumption, there is a compelling opportunity for optics and photonics technologies to help.

Continuous-Wave Distributed-Feedback (CW-DFB) lasers are essential components in data communications, especially in silicon photonic integrated circuits (PIC) applications. CW-DFB lasers are compatible with Wavelength Division Multiplexing (WDM) systems, allowing multiple wavelengths to be transmitted simultaneously over a single optical fiber. This capability contributes to increased data capacity in optical communication networks. CW-DFB lasers are utilized across a range of data rates. They are commonly deployed in systems supporting data rates from 10 Gbps (Gigabits per second) to 100 Gbps and beyond, depending on the specific application requirements. The integration of CW-DFB lasers with silicon photonics is envisioned for pluggable optics (AOC, Ethernet) and integrated optics (CPO, Optical I/O), requiring high data rates and improved power efficiency, while reducing the cost of optical transceivers in data centers.

Quantum Dot (QD) lasers have unique properties that make them attractive for use in silicon photonics,

continued on page 09

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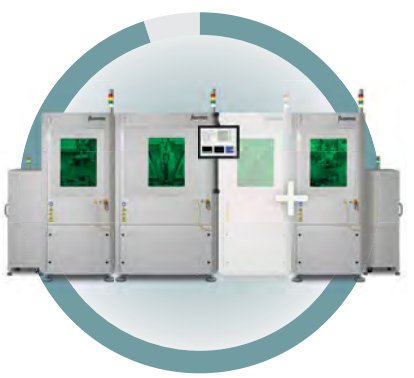

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Martin Vallo continued from page 07

particularly their ability to emit light at specific wavelengths and their enhanced temperature stability. This feature is particularly important for data communication applications where stable laser performance across varying temperatures is crucial. QD lasers can provide wavelength tunability, allowing for precise control of the emitted light's wavelength. This tunability is advantageous for aligning the laser output with specific wavelength channels in optical communication systems. Efforts are being made to ensure compatibility between QD lasers and other silicon photonics components. This includes optimizing coupling efficiency with waveguides, modulators, and detectors on silicon photonic chips. QD lasers for silicon photonics are envisioned for applications requiring advanced optical sources, such as WDM systems, high-speed interconnects in data centers, and long-haul optical communication links.

SD: How close are we to seeing photonics integration?

MV: Photonics integration refers to the incorporation of multiple photonic components and functions onto a single platform or chip; this provides several benefits across various applications. Photonics integration offers numerous advantages, such as miniaturization, power efficiency, improved performance, cost reduction, scalability, high-speed data processing, and a platform for novel functionality.

Integrating multiple active and passive photonic components onto a single chip significantly reduces the size of optical systems. By consolidating functions onto a single chip, energy consumption can be reduced compared to systems that require separate components with additional interconnects. Integration can enhance overall system performance. Having multiple components on the same platform can optimize communication between elements, leading to improved efficiency, lower losses, and better signal integrity. While the initial development of integrated photonic circuits can be complex, the mass production of integrated photonic devices can result in cost savings. Silicon PICs are compatible with CMOS (electronic) fabrication, which allows silicon PICs to be manufactured using established foundry infrastructure. Given the physics of photonics, older CMOS nodes can be perfectly suitable to fabricate photonic devices and circuits. Integrated photonic devices are often scalable, allowing for the easy addition of more components or functions as needed. Enabling high-speed data processing and communication is crucial in applications such as data centers, where the demand for high-speed and high-bandwidth communication continues to grow. Photonic integration can lead to innovative solutions, creating a platform for various fields, including sensing, imaging, and quantum information processing.

While photonics integration offers numerous benefits, several challenges still need to be addressed. Current challenges include material compatibility, manufacturing precision, losses and crosstalk, temperature sensitivity, standardization, testing and characterization, cost of production, and hybrid Integration.

Integrating different photonic components often requires using various materials. Ensuring compatibility between these materials, especially when they have different thermal and optical properties, can be challenging. PIC fabrication demands high precision, particularly at the nanoscale. Achieving uniformity in the manufacturing process is crucial for consistent device performance, and variations can affect the yield and reliability of the devices. Deeply integrated photonic components may introduce losses due to material absorption, scattering, and other factors. Minimizing these losses and managing crosstalk between different components on the same chip are ongoing challenges. Maintaining stable and controlled temperatures across the integrated circuit can be challenging. The lack of standardized design and manufacturing processes for integrated photonics can hinder widespread adoption. Establishing common standards is essential for interoperability and facilitating collaboration across different industry groups. Characterizing integrated photonic devices requires developing reliable and standardized testing methods for various components and circuits, which is an ongoing challenge. While PIC has the potential for cost savings in mass production, the initial development and prototyping stages can be expensive. Reducing the overall cost of production and improving the yield remains a challenge. Integrating different materials and technologies (e.g., silicon photonics with III-V materials) seamlessly and efficiently is a challenge. Hybrid integration techniques need to be optimized for performance and reliability.

Overall, photonics integration plays a crucial role in advancing optical technologies, offering a range of benefits that contribute to improved performance, reduced

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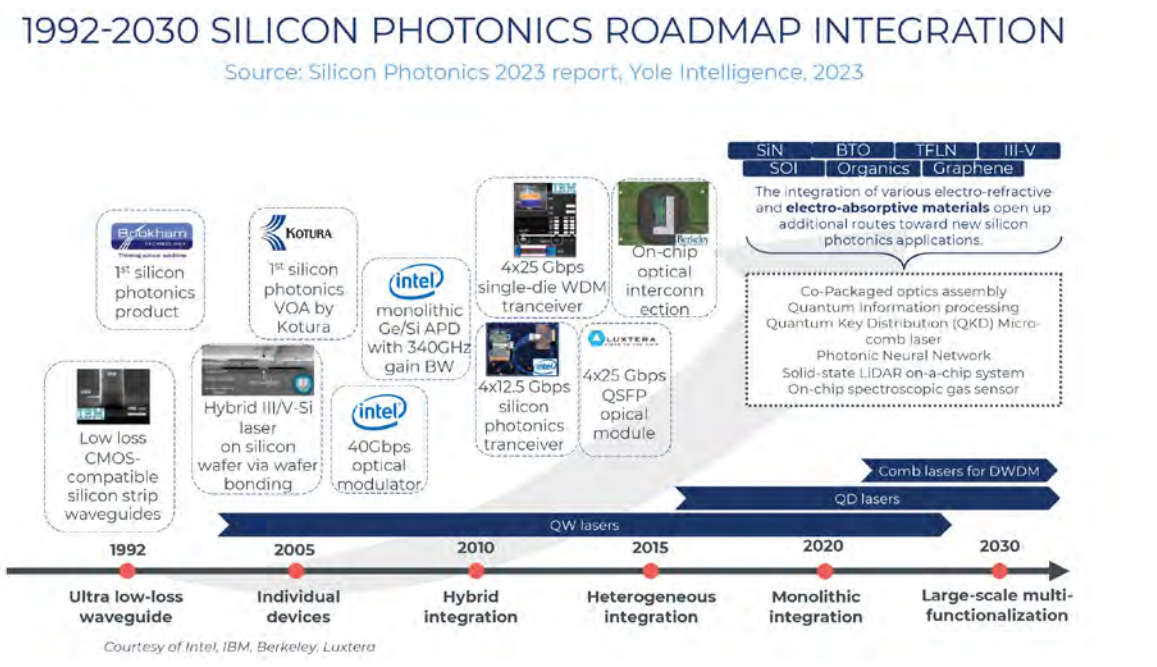

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Martin Vallo continued from page 09

costs, and increased versatility across various applications. Industry and R&D facilities actively address the challenges through ongoing advancements in materials science and fabrication techniques. As the field of integrated photonics continues to evolve, overcoming these challenges will be essential for realizing the full potential of integrated photonic circuits in a wide range of applications.

SD: Which photonic technologies are currently the most integration-ready?

MV: Several photonic technologies have shown notable progress in terms of being integration-ready. The incorporation of silicon photonic integrated circuits (Si PICs) in data communications involves different approaches, including hybrid integration, heterogeneous integration, and monolithic integration. A pragmatic solution for laser integration is hybrid integration, which combines the strengths of silicon photonics (for passive components) with III-V materials (for active components like lasers). Silicon photonics has gained significant attention for its compatibility with existing semiconductor CMOS fabrication processes, enabling the integration of photonic and electronic components (III-V on SOI) on a single silicon chip. It is particularly well-suited for data center, telecommunications, and sensing applications.

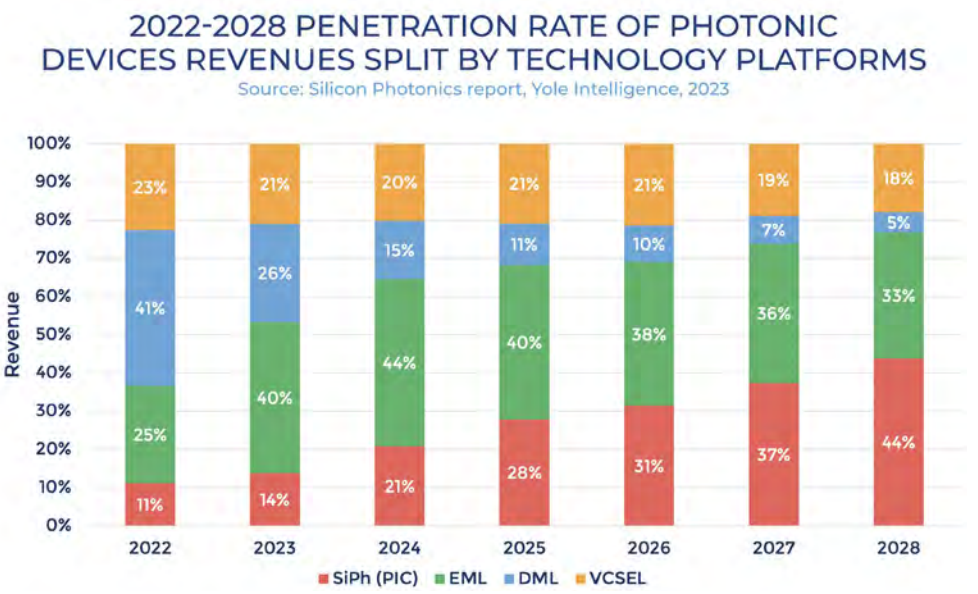
Hybrid integration involves combining silicon photonic devices with components made from different materials, often III-V semiconductors (e.g., indium phosphide). This approach is well-established and widely used, enabling the integration of lasers, modulators, and detectors with silicon photonics circuits. Hybrid integration is crucial for incorporating silicon photonics with other materials with a direct bandgap suitable for laser emission.

Nowadays, hybrid integration is commonly employed in high-speed pluggable optical transceivers. Industry collaborations and standardization efforts are essential for driving the adoption of integrated CW-DFB lasers with silicon photonics. These initiatives can help establish common design principles and ensure interoperability.

Heterogeneous integration combines different materials and technologies on a single platform. In the context of silicon photonics, it often involves integrating silicon photonic devices with non-silicon materials like III-V semiconductors or other 2D materials. Heterogeneous integration enables the incorporation of advanced functionalities and can lead to improved performance in terms of bandwidth, power efficiency, and wavelength range. Research in this area continues to explore novel materials and integration techniques.

Quantum Dot (QD) lasers are the focus of much III-V-on-Si heterogeneous epitaxy research. They are more tolerant to threading dislocations than quantum well lasers due to their high local strain field and decreased carrier diffusion length. Quantum dots have other useful properties that are advantageous for optical networking:

- High density of states — low threshold-current density, low temperature dependence
- Small linewidth enhancement factor — isolator-free operation, narrow linewidth for coherent communication and lidar
- Wide-gain bandwidth and high 3rd-order nonlinearity — mode-locked WDM comb sources



Monolithic integration aims to fabricate all photonic components on a single material platform, typically silicon. Achieving this is challenging due to silicon's indirect bandgap, which limits its ability to emit light efficiently. Researchers are exploring various approaches, including using alternative materials for light-emitting components or engineering the silicon itself to enhance its light-emitting properties. While progress has been made, achieving practical and cost-effective monolithic integration remains a significant area of research.

Achieving monolithic integration of CW-DFB lasers directly on silicon is a challenging but sought-after goal. Researchers are exploring novel materials and fabrication techniques to enable monolithic integration, which could simplify manufacturing and reduce costs. Identifying or developing suitable optical gain materials compatible with silicon photonics is a crucial aspect of the research. The choice of materials for the gain medium in the laser is crucial for achieving efficient light emission.

SD: Which technique has the brightest future?

MV: The pathway for silicon photonics appears to be monolithic integration through quantum dot lasers (QD). Conventional InP PICs require five or six regrowth steps, which are expensive, problematic, and with limited yield. Heterogeneous integration offers the advantage of combining multiple materials, bonding, and processing simultaneously. With this approach, modulators, lasers, and detectors can be bonded side by side and processed together, offering inherent benefits. However, the cost of the substrate is not insignificant, as III–V substrates are considerably smaller than 300 mm, prompting a growing interest in monolithic integration. Therefore, the monolithic integration techniques of on-chip lasers offer a promising approach towards high-density and large-scale silicon photonic integration.

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Siddharth Ramachandran, professor of engineering at Boston University. Credit: Indian Institute of Technology Kanpur.

LASE Hot Topics at Photonics West

Topological confinement and programmable metasurfaces are hot topics in the new year.

The LASE conference at Photonics West is considered by many to be the most comprehensive laser technologies event in the field, showcasing topics such as laser manufacturing, laser materials processing, semiconductor lasers and LEDs, and 3D fabrication technologies. A major highlight of the conference is the LASE Plenary and Hot Topics session on Monday where prominent researchers in the LASE community covered advances in optical fibers, quantum computing, and light projection displays.

The first speaker at the Hot Topics event was Siddharth Ramachandran, distinguished professor of engineering at Boston University. Ramachandran explained how topological confinement can act as a new mechanism for light transport in optical fibers.

As a PhD student, Ramachandran notes, he barely knew what an optical fiber was, seldom used it, and thought it was "simply a wire for light beams." After meeting with technical staff from the fiber research department at Bell Labs at an optics and photonics conference, he came to understand that, far from being an "elementary" light transport mechanism, waveguiding of light was an active field of research with emerging applications in fields as disparate as microscopy, telecommunications, neuroscience, and quantum computing. "This greatly intrigued me and spurred me to apply for my first job at the fiber research department at Bell Labs, which I then joined. [In my current lab] I continue to work on some of the myriad open questions related to the basic science of light transport." At the LASE conference, Ramachandran discussed a recent discovery by his group of a novel light-guiding phenomena, which further underscores how much more remains to be explored in this domain.

Ramachandran began his talk discussing the experiments of Colladon, Babinet, and Tyndall — more than 150 years old — which showed that shining light from an arc lamp into a jet of water streaming in air appeared to "trap" the light within the stream. In other words, instead of the light diffusing out into the entire ambient space as usually happens with any light bulb, the light remained confined to the jet stream. This observed phenomenon led to the principle of "total internal reflection," which states that whenever light in a dense material (i.e., having a high index of refraction) hits an interface that is less dense (i.e., with a lower index of refraction), light with a certain range of incident angles reflects back into the denser medium completely, with no light leaking out whatsoever. This powerful phenomenon is the basis of trapping and transmitting light in every important application that involves light transmission, including optical fibers across the earth or under the sea, and silicon photonics platforms across optical chips.

"Total internal reflection occurs only when the angle at which light hits an interface belongs to a certain range," says Ramachandran. "For a vast range of other (larger) incidence angles, light indeed leaks out substantially, thus restricting the kinds (and angles) of light rays that can be transmitted in waveguides. Topological confinement is a very interesting and conceptually distinctive way of trapping and transmitting light that departs from conventional wisdom."

Ramachandran notes that research has shown that light with large incidence angles beyond the range of total internal reflection can still remain trapped in waveguides due to something called the "topological charge" of the light beam itself. The latter is a measure of how much a light beam rotates around its own axis as it propagates. This "tornado"-like rotation tends to self-trap the beams. The physics of this process is similar to the trapping effect that enables stars to continue orbiting around each other instead of collapsing into each other due to gravity. "Our key finding is that these topologically confined beams are much more robust to bending or twisting fibers, in contrast to beams guided by total internal reflection," says Ramachandran. "So, we envisage this becoming the preferred way to transmit light in many applications that have such a need."

When asked what he would like attendees to learn from his talk, Ramachandran notes that other than the exciting possibilities for light transmission and manipulation revealed by the discovery of the topological confinement effect, "I would most like attendees, especially younger scientists and students, to learn that if they are bold enough to venture into less explored spaces of their fields of expertise they may be rewarded by uncovering surprising new phenomena that are not only scientifically profound and intriguing, but also practically useful in a paradigm-shifting manner."

The other Hot Topics speaker, Laura Na Liu of the University of Stuttgart and the Max Planck Institute for Solid State Research, presented "Electrically controlled metasurfaces at visible frequencies." Liu's research straddles nanophotonics, biology, and chemistry. Her research focuses on developing optical nanosystems to address questions in structural biology and catalytic chemistry.

"Light projection displays play an increasingly important role in our modern

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Building a diverse quantum future

The IBM-SPIE HBCU Faculty Accelerator Award in Quantum Optics and Photonics empowers quantum-focused research as well as hands-on training and experiential education for students.

2022 winner, Dr. Wesley Sims, at work in his Morehouse College lab. Credit: Morehouse College.

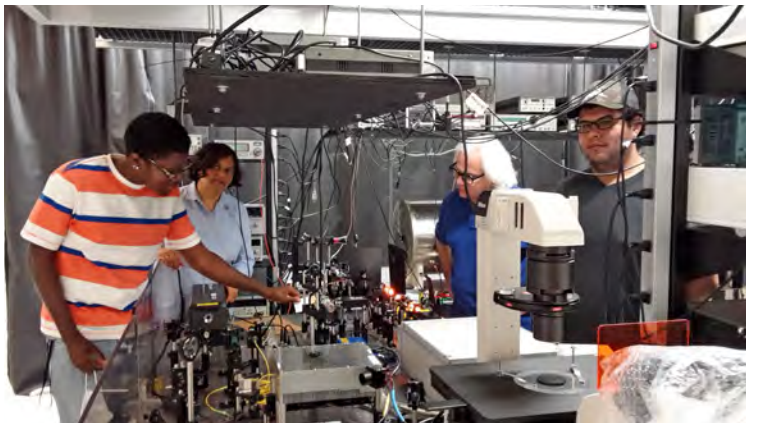
Established in 2021, the IBM-SPIE HBCU Faculty Accelerator Award in Quantum Optics and Photonics honored Renu Tripathi, a professor of physics and engineering at Delaware State University (DSU), as its inaugural recipient. In her proposal, Tripathi sought to demonstrate "a quantum gyroscope with a high rotation sensitivity, suitable for inertial navigation applications." She also outlined plans to develop quantum-science education curricula and teaching practices at DSU, including providing hands-on experience and training to DSU students through summer research programs and workshops. The combination of innovative quantum research and engaging approaches to education was the perfect match to kick off a program aimed at helping to provide a diverse quantum workforce.

The $100,000 annual award, presented jointly by SPIE and the IBM-HBCU Quantum Center, supports and promotes research and education in quantum optics and photonics within IBM-HBCU Quantum Center member institutions — which currently includes 27 historically Black colleges and universities (HBCUs) — and can be used for students or postdoc researcher stipends, travel, conference registration, equipment, materials and supplies, and faculty summer salary. The collaboration arose as a way to ensure that quantum and its related technologies of the future incorporate the skills, experience, and input of a diverse community; SPIE and IBM believe the impact of these technologies will be stronger with the inclusion of the ideas and work of the diverse student-bodies found at America's HBCUs. The IBM-SPIE joint annual award is expected to provide a shared total of $500,000 by 2025.

The winning team from 2023 at Tuskegee University. Credit: Tuskegee University.

"The IBM-HBCU Quantum Center was established to build an ecosystem for traditionally underrepresented students and professionals in the emerging field of quantum computing," said Dr. Kayla Lee — then Academic Alliance Lead, Partner Ecosystem at IBM Quantum and now Global Lead, Ecosystem Growth at IBM Quantum — when the award was first announced. "By extension, this joint award is an investment in the strengthening of research and career opportunities at HBCUs."

Tripathi's quantum gyroscope is progressing nicely: "One of the main constituents of the quantum gyroscope is a comagnetometer," she says. "The award certainly allowed me to start developing an experimental testbed for a $^{87}Rb - {}^{129}Xe$ comagnetometer. We are currently assembling this setup to study the magnetic field response of the comagnetometer operating in the spin-exchange relaxation-free (SERF) regime. This will ultimately allow us to develop a highly sensitive gyroscope." In addition, experiential student teaching and training has been implemented with a new Quantum Science Education Lab — "to enrich student experience in learning, education, and innovation" — as well as a new course, Introduction to Quantum Computing. "Since receiving the award, we have also held three summer quantum-sensing-related research programs," notes Tripathi. "During our eight-week program, students have the opportunity to work alongside senior graduate students, learning about different aspects of the experimental projects and carrying out various measurements and analysis related to the project." At the conclusion of the program, the undergraduates present their research at the university's Summer Research Symposium. "That exposure helps pique their interest in research," says Tripathi. "Actually, most of my students have decided to continue working in my laboratory beyond the summer program."



Experimental setup for a magnetometer using alkali sodium atoms in 2021 winner Renu Tripathi's DSU lab. Credit: Delaware State University.

The 2022 recipient of the award, Wesley Sims, is an assistant professor of physics at Morehouse College and director of its Micro/Nano Optics Research and Engineering Laboratory. The award's multi-faceted impact has had a broad reach, supporting Sims' research as well as several students in his lab, and enhancing Sims' ability to provide transformative mentorship for his students as they build their own careers. Sims is leveraging a collaboration with SPIE Member Sergio Carbajo, who holds faculty and leadership roles at UCLA and Stanford University's SLAC National Accelerator Laboratory; Sims is also a member of the IBM-HBCU Quantum Center. These relationships plug Sims' students into an extensive network of colleagues and peers. "The students are involved in our weekly research meetings with Sergio and his postdoc," says Sims, "so they get real experience on how labs operate. And the IBM-HBCU Quantum Center holds meetings for all the students supported by the involved schools: they get a chance to collaborate and see what their peers are working on at other HBCUs across the country."

Sims' research is focused on quantum sensing, detecting and measuring physical phenomena with high precision. "We're investigating a type of electronic optical dynamics — high harmonic generation — and we're taking a new approach, trying to capture it in real-time," Sims says. "To do this, we're developing a new technology capable of detecting and cross-correlating two different wave packets, or two different photons. We initially called it the hyperspectral attosecond quantum cross-correlator, but as we're getting further and further into the research, we think we might change the name to a time-correlation transducer."

The award provides Sims with the flexibility to modify his research to a gratifying extent, but being able to create career-enhancing opportunities for students remains a major benefit in his mind. Having his own funding at a small liberal arts institution means being able to mentor students into their graduate degrees and providing them with the kind of hands-on experience that will bridge a gap between quantum-workforce needs and available talent. That, he says, "is probably the most rewarding part for me."

Most recently, the 2023 IBM-SPIE HBCU Faculty Accelerator Award in Quantum Optics and Photonics has gone to a group of researchers and educators at Tuskegee University. The team includes the head of the university's physics department Akshaya Kumar; Dimitar Dimitrov, a fellow physicist and committed student mentor; Fan Wu, who facilitates cutting-edge computational tools for this research group's students; and S. Keith Hargrove, a scientist, industry-alliance expert, and the university's provost and senior vice president for academic affairs.

The Tuskegee University group will use the award to implement "Exploring the Optical Properties of Rare Earth-Doped Glasses and Photonic Crystals," a project that will explore and utilize the importance of rare-earth ions doped in glasses which have a significant impact on

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PHOTONICS WEST SHOW DAILY

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Photonics West is the premier photonics and laser event. With more than 1,250 companies, this exhibition continues to be the flagship event to find the latest products, tools, and applications for your research or business needs.

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Welcome to the optics.org Product Focus which we have published specifically for Photonics West 2024 in partnership with SPIE and the Photonics West Show Daily.

Here you will find an effective at-a-glance guide to some of the latest products available on the market with booth numbers if available making it easy for you to check out the products for yourself.

All this information and more can be found on the optics.org website. Simply go to **www.optics.org** for all the latest product and application news.

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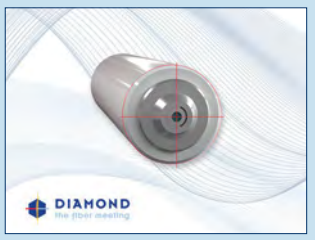

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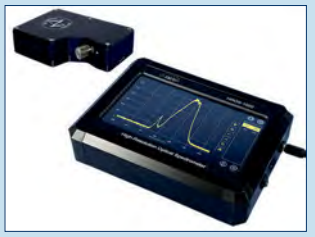

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Omega Optical serves military, industry, and even food testing

Vermont-based firm says it is a global "one stop source" for coatings industry.

An astronomer looking up at the stars these days may well be seeing starlight reflected by gold telescope coatings from Omega Optical. Omega, with facilities across the Northeast United States, has since 1936 been serving researchers, the military, the life sciences, and others in industry.

At Photonics West 2024, visitors will be able to view some major new enhancements of mirrors from the parent, Omega Optical Holdings, which will enable observers to see further than before.

New at PW 2024: Omega's Deep Ultraviolet transmission grating. Credit: Omega Optical Holdings.

Can attendees expect some surprises from Omega at Photonics West? Yes indeed, said Justin Turner, Omega's chief marketing officer. "One development that we are excited about is our robust gold and silver reflective coating. These coatings are designed to stand up to military grade needs, in particular to requirements for acidified salt fog durability, as well as exposure to corrosive fluids used in industrial and military environments."

Typically these coatings will be employed in an imaging application. Consider a telescope that can be positioned on a mountain looking up at the stars, or one that can be fitted on a plane or a drone, high up in the sky, looking down and observing an area of interest.

"By using mirrors, it is more practical to use larger elements, to capture more light," Turner said, "and that allows you to either see further or investigate what you are observing at a higher resolution."

"An additional benefit of reflective imaging is that you can capture a wider range of wavelengths so you can see, of course, what's visible to the human eye. But there are also applications in industry and the military that are interested in going into the infrared, which you and I cannot see, but modern sensors can," Turner said.

"At the same time that you are seeing it in the visible range, a sensor can perceive it in the infrared. That would be either a hyperspectral camera, with a continuous wavelength range, or a multispectral sensor, which detects discrete wavelengths over a broad range."

Typically, in a military setting, such a user would be in charge of reconnaissance and surveillance. If the user is operating in industry, they would, typically, be a quality engineer who is looking at sorting or testing for quality on a range of products, including foods.

"A lot of this hyperspectral and multispectral imaging can be used for testing food quality. An additional element could be for recycling and sorting different items in our communities," Turner said.

Machine vision applications

When those large bins on our community streets with metals and plastics are taken off to a recycling center, you could have somebody standing there at a conveyor belt and manually pushing the metal to the appropriate receptacles and the plastic to other bins — or the process can be automated by a machine vision-led system.

"And in order for the machine to do that separation for you, it has to know which pieces to send where. Based on the light that it's imaged with," Turner said, "it has a chemical signature such that the machine can take a look and say, 'Hey, you go over here. You are a metal.' It's all pretty intelligent."

Omega enables all of those steps by putting the reflective coatings on the mirrors that are part of the imager that collects the light that bounces back from all that recycling.

"Our mirror coatings are like a special set of glasses that enable the recycling system to capture all of the various wavelengths that are necessary to be seen," Turner said.

That is just one example of the products being demonstrated by Omega at Photonics West.

Several other items with Omega's improved reflective coatings will be on display for the first time at Photonics West, where the company has been showing products for a decade.

Another category of Omega's new research output seen at Photonics West in 2024 is its penta-band (offering five colors) dichroic. It provides five discrete wavelength bands, a feature particularly useful in life science and bioscience research.

"It's used with microscopes allowing a search for up to five fluorescent signals at one time from the sample under testing," Turner said.

That is central, he said, for study of diseases, cancer research, for working on next-generation vaccines, and for a wider understanding of drug discovery.

Omega's history

The Omega story reflects its significant expansion over many decades to 185 employees, as one of the largest optical coating companies in the United States.

In 1936, Evaporated Metal Films was launched as the first evaporated coatings company in the United States, and that entity remains the oldest of Omega's constituent companies. That division, known officially by the brand name EMF, has developed corrosion-resistant gold and silver coatings that have become a world leader in applications like sorting materials and military surveillance.

The evaporated metal films — referring to how the coating is applied — silver, gold, and aluminum mirrors were Omega's first industry products, used in markets for astronomical tools.

At Photonics West in 2024, Omega is presenting enhancements to its mirrors. Credit: Omega Optical Holdings.

Justin Turner, Omega's chief marketing officer. Credit: Omega Optical Holdings.

Today, there are four brands owned by the parent company, Omega Optical Holdings, formed in 2020. In addition to EMF, Optometrics, and Omega Optical are part of the platform. The youngest of Omega's constituent companies was formed in 1983 as Spectral Systems.

Omega operates at seven locations across New York, Massachusetts, New Hampshire, and Vermont.

In New York State, the largest site is in Hopewell Junction, near Poughkeepsie; the EMF division is based in Ithaca, near Cornell University; and EMF also has a site in Rochester, which is known as "the central nervous system of optics research in the United States," Turner said.

To the east, Omega also has a gratings factory in Ayer, Massachusetts, which opened in 1965. "The Ayer site is a unique business," said Turner, in that it creates both ruled and holographic masters for original gratings.

Q and A with Justin Turner

Show Daily: What are some new products to look for at Photonics West?

Justin Turner: A notable new industry-related product for Omega at Photonics West this year involves our Deep Ultraviolet (DUV) transmission grating. We are able to mass produce gratings from those masters, using what we call a replication process. You could think of it as embossing or molding for a broader audience.

The Omega Optical brand has also been developing the penta-band (five colors) dichroics for microscope apps used in life sciences. Other new products include corrosion resistant metal coatings and their penta-band dichroic filters.

For anybody involved in spectroscopy, camera systems development, or biological or chemical analysis, these Omega products would be fairly well known components within the industrial space. Ultimately, they are incorporated into

larger industrial or military instrumentation for a wide variety of research and analysis applications.

SD: Which Omega products have special capabilities?

JT: The new Deep Ultraviolet transmission grating uses a unique manufacturing process that is patent-pending. In addition, the corrosion-resistant metal coatings use a proprietary layer formulation.

SD: How do you see the competitive landscape for Omega products?

Omega is unique itself in that with one company we are providing filters, gratings, mirrors, and specialty infrared components. In the competitive landscape, those are usually purchased from discrete companies that do not offer the variety of similar products. So, we are like Amazon. You can buy everything from one source. Everybody else is like a specialty retailer. You have to make four stops.

SD: Does Omega see enhanced market opportunities arising from the U.S. Chips Act, 2022?

JT: Considering the potential impact of the Chips Act of 2022, which provided $52 billion for semiconductor research and development, my short answer is 100 percent yes. Our components are used in semiconductor lithography and in other manufacturing equipment used in the production of chips.

As these new foundries and fabrication facilities come on line in the United States, we will be, through the equipment manufacturers, contributing to the advancement of chip manufacturing in the United States. The deep UV transmission grating that we are releasing this year is central to many semiconductor applications. This grating is very applicable for semiconductor inspection applications.

And going back to the Inflation Reduction Act, our components factor heavily into enabling environmental monitoring. In emissions monitoring for reduction, optical analysis is used to monitor the gas outputs from farms, from factories, and from oil and gas facilities, and our optical components are critical components for the instrumentation that monitors those emissions.

SD: Does Omega have any plans for future acquisitions?

JT: We will continue to grow organically and inorganically. Our near-term focus is to continue to serve our customers with new product developments. We are disciplined in our approach to when and where we acquire and further expand our product offerings.

Optical coatings are central to our strategy, and we will continue to explore ways to complement our current product portfolio based on where our customers are headed, and where we anticipate that their needs will be. If we're unable to develop a capability internally, we would look to the market to see if such a capability could be acquired.

SD: What has been your experience of exhibiting and participating at Photonics West?

JT: I have been attending Photonics West for more than a decade. It is a great gathering that kicks off every year for the optics and photonics industry. It's more than a place to connect with industry folks, and to learn about what's new and exciting. Each year I am fortunate to meet and develop new relationships, new customers, new friends. Overall, the theme for me is that I learn as many new things during the show as time allows.

It enables me to share with people within the business what I've learned. And I can share with our customers and partners what I've seen and observed that can help them. Not all of those things will be from our company. To me, it's a great representation of the continued advancements that the photonics industry makes, and will continue to make.

FORD BURKHART

Photonics West

Sydor Optics: It's a family affair

Celebrating 60 years of cutting-edge optics, industry trends, and community values.

Founded in 1964 by Stefan Sydor, Sydor Optics, a family-run pioneer in optics-component manufacturing, is celebrating its 60th year in business this year. An exhibitor at Photonics West for over 20 years, Sydor has remained a leader in optics technologies by embracing new approaches that meet their clients' requirements. Stefan began his career at Eastman Kodak, grinding and polishing lenses, branching out to work on the 200-inch telescope mirror for the Mt. Palomar Observatory and installing cameras across the globe for the Baker-Nunn satellite tracking network. When his own entrepreneurial spirit called, he founded Sydor Optics, vesting the company's culture with its client-focused, business-growth values from the start: "My father's thought was to make everything better than what it says on the drawing or on the blueprint," notes Stefan's son, Jim. "And that's what we continue to do to this day." Even more impressively, Stefan's grandsons, Matthew and Jonathan, have honed that spirit alongside their father, staying customer-focused and, therefore, continuing to develop processes and technologies that respond directly to the optics and photonics market's trends.

Stefan Sydor and others polishing the 200 inch primary for the Mt. Palomar Observatory. Credit: Sydor Optics.

Jonathan, Jim, and Matthew Sydor (L-R). Credit: Sydor Optics.

If a customer pushes us and there's a good opportunity for enhancing the business — immersing ourselves in a new aspect of the industry — then we invest in the machinery, the tooling, and the people.

"If our customers are pushing us to do something with tighter specifications or with more CNC machining, or going for a flatness or transmitted wavefront that pushes our current capabilities, then we invest in machines that help us do that," says Matthew. "If a customer pushes us and there's a good opportunity for enhancing the business — immersing ourselves in a new aspect of the industry — then we invest in the machinery, the tooling, and the people."

"We don't like saying 'no' to our customers," adds Jonathan. "When they create specs that are tighter and tougher and harder to measure and harder to obtain, we do our best to help them achieve those goals. That's really been the driver for us to continue to get better and have new in-house capabilities." In the industry, he notes, they've seen big increases with infrared and heat sensing — "a lot of that military stuff" — as well as lidar and AI. "These are all driving technology and industry now, and working with new materials and styles of products has helped us continue to grow." Recent boundary-pushing areas for Sydor have included high-precision, CNC machining and non-common materials like zinc selenide, zinc sulfide, chalcogenides, and other IR materials as well as fused silica, Borofloat, silicon, germanium, sapphire: "Those have all been new for us in the last four or five years."

That commitment and readiness to move into new arenas has scaled Sydor Optics up exponentially. When Jim joined Stefan at the company in 1978, it was just the two of them serving around 10 customers, the primary ones being Eastman Kodak, Bausch + Lomb, and the University of Rochester. Sydor's biggest break came in 1990 with a contract for tank windows — primarily to be used in the Gulf War. That high-volume, double-sided project enabled Sydor to buy a pair of large double-sided machines. "That changed Sydor Optics from a job shop making lenses and prisms, to specializing in plano optics, flat optics," says Jim. "*That* was a real milestone. Then we got involved in projection televisions: we did a lot of substrates for wire-grid polarizers for the projection-television market. That was another good growth spurt for the business. Then came the telecom boom, and we produced a lot of substrates for fiber optics." As they grew, their volume production did too. "Our company produces 15,000 to 20,000 components a month with an outgoing quality of 99.6 percent acceptance," notes Jim. "In 1980, that number was closer to 500 a year." The company supports a wide variety of industries, including aerospace, medical, semiconductor, defense, and entertainment: "One of our most productive growth opportunities was working with 3D projection systems for movie theaters," says Jim. "That enabled us to grow substantially because their demand was very high for precision, flat optics."

But the critical piece over the decades, woven into the fabric of the company, was taking on every opportunity that came their way. "My favorite story is about the time my dad took a job, quoted it, received the order, and then had to look up what kind of prism he had to work with," says Jonathan. "That's the mentality that we still have today — we'll will say 'yes' to the customer, and then figure out how to achieve what they want."

The Sydor team, part of the vibrant Rochester optics community, also contributes to building a much-needed technical workforce. Alongside their longstanding education support for employees, Sydor has implemented a new opportunity: their two-year apprenticeship program — which culminates in an optical certificate from Monroe Community College — provides paid work experience, complemented by nine optical courses at Monroe Community College. It's a way to support their employees, as well as a way to address the dearth of optics and photonics technicians across the industry, drawing directly from the skills and programs in their community. As part of another aspect of community support, Sydor has been holding a fundraising clambake for the Monroe Community College's optics program for more than two decades during the SPIE Optifab conference.

"Continuing education has always been a big deal for us in terms of helping our employees grow and learn and investing in them," says Jonathan. "As far as I can remember, we've been doing full tuition reimbursement for college. One employee, we put him through a mechanical-engineering degree, and he's still one of our engineers. Internally, we have probably 15 or more graduates from the MCC program, and probably another 10 to 15 who are either currently or have taken optics classes, Matthew and myself included."

And it's being part of that thriving community that drives the youngest generation of the Sydor family. "First of all, I think it's a really good community," says Matthew. "I always enjoy hanging out with people at trade shows, for example. And being from Rochester, we know the people in optics that have been working in it for 20, 30, 40 years. They're all really good people; everybody helps one another. And then there's the technology: we're a component manufacturer, but what our parts go into, that's really exciting," he says, mentioning a high-volume part produced by Sydor that's currently supporting artificial intelligence. "We've polished windows for the Orion Spacecraft for the NASA space missions, and we're working on medical devices for surgeons using robotic arms for surgical procedures. The technology is fun — it's wonderful, nerdy stuff — and it gets me excited to keep on making, keep on selling, keep on being part of the community."

DANEET STEFFENS

SPIE projects global annual revenues for photonics core components to reach $368B

2024 SPIE Global Industry Report highlights strength of the photonics industry with photonics-enabled products to exceed $2.39 trillion.

Consistent growth, solid financial performance, and a source of good jobs have defined the global photonics core components business over the past ten years, according to the newly released SPIE Optics & Photonics Global Industry Report. The annual report was released Monday at the inaugural Global Business Forum during a presentation from SPIE Senior Director of Global Business Development, Andrew Brown.

Global annual revenues from the production of optics and photonics core components reached $368 billion in 2022, up 26 percent from 2020 and well above global gross domestic product (GDP) growth of 18 percent for the same period. Since 2012, the photonics components industry has grown at a rate more than twice that of global GDP.

Beyond core components, SPIE projects global annual revenues for photonics-enabled products to exceed $2.39 trillion in 2023.

"The report largely confirms what most of us in the optics and photonics industry already know, that light-based technologies underpin a significant portion of the global economy, and its impact continues to grow," notes Brown. "Anecdotally, we can point to some mainstream technology or application and explain how photonics enables or powers the components that make it work. This report puts all of those individual cases together into tangible numbers that policymakers, industry executives, and investors can use to understand the impact of our industry."

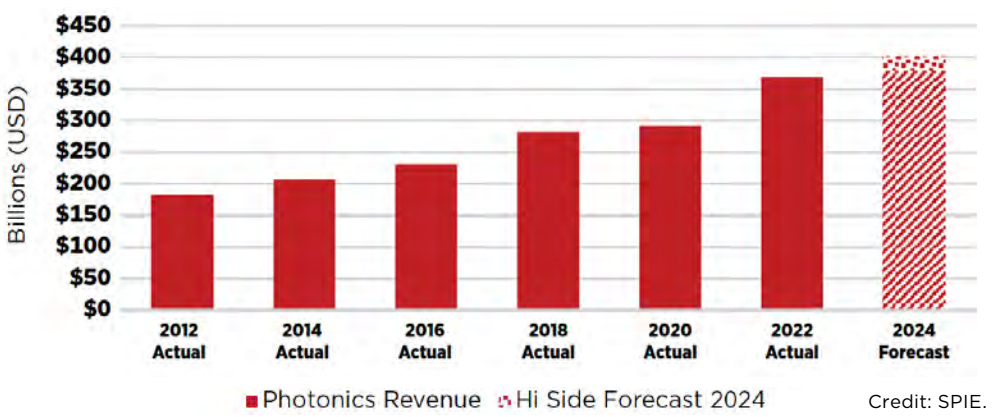
The report draws on the Society's industry expertise, world-class database, and global footprint, which uniquely position SPIE for its analysis and understanding of the photonics industry. For over a decade, the report has tracked metrics like the number of companies, distribution of global revenues and jobs based on company headquarters, and more, painting a solid picture of the photonics industry whose growth outpaces global GDP and other benchmarks.

As defined in this tenth edition of the Industry Report, core photonics components underpin all light-enabled products and services like smartphones, computers, laser-based instruments for industrial and medical applications, cloud computing, streaming content services, and e-commerce. Estimates of the total monetary value of all light-enabled products and related services exceed 15 percent (~ $16 trillion) of worldwide economic output.

Core photonics components range

continued on page 24

Forecast of Core Photonics Components Revenues for 2024



Credit: SPIE.

Global revenues continued from page 23

from raw materials to image sensors and light-emitting diodes (LEDs) to lasers. By focusing on the core components and the companies that produce them, SPIE has leveraged its comprehensive understanding of the photonics business to characterize the global photonics industry.

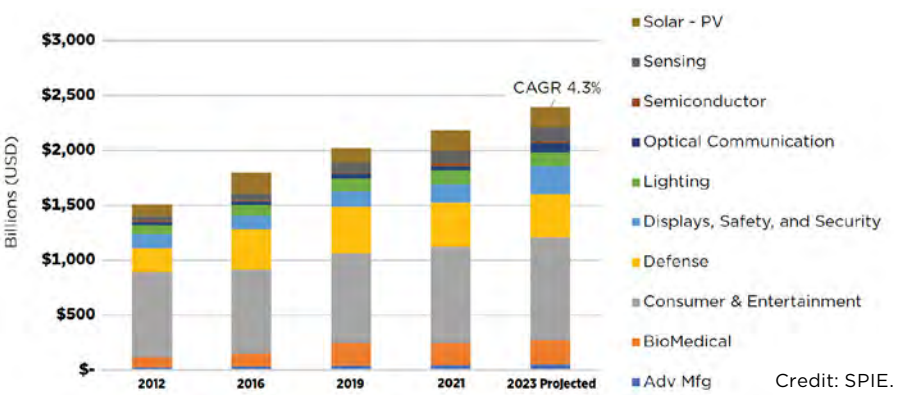
"With ten years of accumulated data, this report delivers a unique perspective on the thriving global ecosystem of photonics components manufacturing, the companies involved, where they are headquartered, their revenues, and the number of jobs created globally by optics and photonics components production," SPIE says. Other key findings of the report include:

- Production of optics and photonics core components is a global enterprise spanning more than 50 countries.
- Core components production employs more than 1.25 million people worldwide.
- Over the past ten years, companies headquartered in China, Korea, and Taiwan have increased their global share of the photonics components business.
- In 2022, photonics components manufacturers headquartered in Japan generated the most revenue and employed the most people.
- Manufacturing of photonics-enabled products generates more than five million jobs worldwide.

SPIE tracked and evaluated 4,706 companies that produced core photonics components in 2022, 84 percent of which are small to medium enterprises (SMEs). "Although most of the companies are SMEs, the larger entities generate the majority of the revenues. In fact, only ~5 percent of all companies, including such household names as Samsung, Corning, Nikon, and Carl Zeiss, generated more than 85 percent of total revenues in 2022," SPIE reports.

To examine the global distribution of photonics revenue, SPIE follows a methodology that captures the company's global revenues in the local currency of the country where it is headquartered and then converts them to USD for global comparison purposes. For 2022, the report reveals that, over the past decade, companies headquartered in Japan have had total revenues higher than other world regions. Those revenues had also been relatively flat until 2022, when they jumped 15 percent over 2020 revenues, with growth also seen in revenues for companies based in Korea and Taiwan that year. Conversely, in China, growth in revenues in 2022 moderated somewhat.

Enabled Markets Segment Trends



Credit: SPIE.

The report notes that the core photonics components industry "has grown to the point that combined demand for lasers and all other photonics components in 2022 underwrote more than 1.2 million jobs worldwide.... As employment has grown, so has the number of countries hosting components manufacturers, making it a truly global industry."

In all, the report notes, the global photonics industry has experienced a decade of consistent growth despite headwinds like chip shortages, regional conflicts, rising costs, and a global pandemic. SPIE forecasts continued but moderate growth in 2024, and more of this data, including challenges ahead, will be explored at SPIE conferences and exhibitions throughout the year.

The size and character of our industry is on display this week at Photonics West," adds Brown. "Being here this week, it is clear photonics is a vibrant and growing community with economic value and scale; this report aims to put numbers and provide a definition to the general sense we in our industry have about our impact. I believe it succeeds in showcasing the industry's continued success."

WILLIAM G. SCHULZ

Quantum panel discusses routes to commercialization

A group of UK-based quantum/photonics innovators told a Photonics West audience how they were successfully monetizing the new technology frontier.

The "Wee-g" is said to be the world's most sensitive MEMS gravimeter. Panel speaker Abhinav Prasad has taken this sensor from the lab to Mount Etna, Italy, where an array of Wee-gs now track volcanic activity. Credit: Courtesy of Abhinav Prasad, University of Glasgow.

Commercialization of quantum technologies was the crowd-pulling theme of another new panel session on Tuesday, entitled Startup Challenge: Commercializing Quantum Technologies in Imaging and Sensing, Quantum Leap. The session, moderated by Ian Tracey, CEO of UK-based high-tech consultancy Anchored In, featured a group of early career researchers from the UK, who are taking their technology from bench to market. The researchers — described in the panel, below — are part of Quantum Leap, a pre-accelerator programme funded as part of the UK National Quantum Technology Programme to commercialize quantum imaging and sensing technologies. The Quantum Leap cohort is now in the USA to connect with international investors and explore new markets. Ahead of the panel session, Tracey told *Show Daily*, "Quantum technology is on the brink of transforming various industries, from healthcare to communications, with innovative imaging and sensing applications. However, moving from the lab to the market presents its own set of difficulties. In this session, our aim is to break down these challenges and uncover the strategies and insights of these emerging leaders." "The panellists are sharing their experiences in securing funding, forming partnerships, and achieving scalability in the quantum technology landscape. They will have explained how programs like Quantum Leap have shaped their entrepreneurial journeys and opened doors to global opportunities," Tracey said.

"Whether you're an investor, entrepreneur, or simply curious about the future of quantum tech, this session presented practical perspectives and a look into the potential quantum-driven solutions that could soon revolutionize various industries."

Quantum Leap program

Quantum Leap is a program designed by Anchored In and QuantIC, the UK's center for quantum enhanced imaging and one of that country's four quantum technology hubs, specializing in quantum imaging.

Prof. Miles Padgett, of the University of Glasgow, UK, is Principal Investigator of QuantIC. He explained, "QuantIC is a £50 million ($63 million) 10-year research program with focus on technology translation. Beyond what we do, and the impact it creates, we have an obligation to our people, especially the early career researchers."

Considering the aims of the panel discussion, Tracey added, "This session featured a group of early career researchers from the UK that are taking their technology from bench to market. It focused on the challenges of commercializing quantum technology, particularly in the field of imaging and sensing. It is a bilateral process.

"Future quantum leaders need to hear from others where the current state-of-the-art in deep science venturing is, at SPIE Photonics West, in the heart of Silicon Valley and the aim was for them to showcase where they are today with their scientific missions," Tracey said.

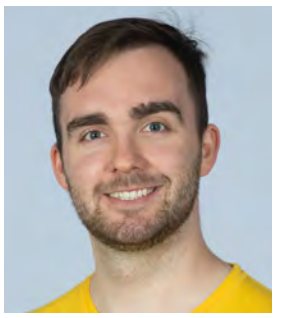
The panelist-researchers are at different stages in their innovation and commercialization journey. A key aspect of Quantum Leap, and a key differentiator from other pre-acceleration programs, is its focus on the development of the individual researcher skill and away from the specific project or technology.

Tracey explained that besides developing understanding of the relevant technologies and pathways to business the Quantum Leap program is intended to open researchers' mindsets towards

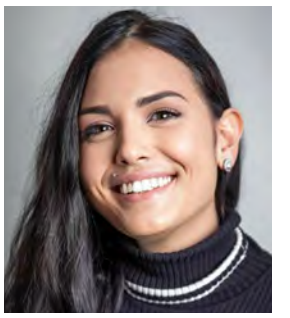
About the panelists

Anke Lohmann. Credit: Anchored In.

Abhinav Prasad. Credit: University of Glasgow



Mark Cunningham. Credit: University of Glasgow.



Eleni Margariti. Credit: University of Strathclyde.

Anke Lohmann has worked at the interface of technology translation for many years, connecting companies and academic groups. She set up a national network for the Knowledge Transfer Network to translate the emerging UK quantum technology into industry and find applications. Lohmann has been involved with the UK quantum technologies community since the UK National Quantum Technologies Programme started.

The panel session included an overview of work undertaken by Dr. Lohmann on behalf of the UK Government where she interviewed more than 25 global quantum investors asking them about barriers to investing in such companies. She shared the highlights of this report during the discussion.

Abhinav Prasad is a Research Fellow at the University of Glasgow. He specializes in developing cost-effective gravity sensing solutions for detecting underground features. His research, including working as a Postdoctoral Research Associate at the University of Southampton, contributes to advancing understanding of subsurface environments.

Prasad commented, "For the past six years I've been developing "Wee-g", the world's most sensitive MEMS gravimeter. I have taken this sensor from the lab to Mount Etna, Italy, where an array of Wee-gs now track volcanic activity. Our team has also used the sensor to monitor the water table and to find buried tunnels. I recently secured a £500,000 grant ($630,000) focused on the commercialization of "Wee-gs", targeting the seismic and gravity markets.

Mark Cunningham is a third-year PhD candidate at the University of Glasgow, specializing in Anisotropic Hyperbolic Natural Crystals, particularly crystal quartz, using Attenuated Total Reflection (ATR) techniques. His research is aiming to pioneer applications in advanced sensing and control of light, bridging the gap between photonics and practical technological solutions. He commented, "Parallel to my academic pursuits, I am honing my entrepreneurial skills through a Level 7 CMI course in Strategic Leadership and Entrepreneurial Practice. This education is sharpening my abilities in leadership, strategic thinking, and innovative problem-solving, essential for my goal of founding a deep-tech venture.

Eleni Margariti is a Research Associate at the University of Strathclyde's Institute of Photonics, UK, where she has been commercializing large-scale integrated devices since 2019. Her PhD was focused on the development of a high-yield micro-assembly technique for wafer-scale opto-electronic systems manufacturing. Her approach involves continuous roller transfer-printing, enabling the parallel integration of semiconductor devices onto functional systems. Her background includes a Master's degree in Microsystems and Nanodevices from National Technical University of Athens and a Bachelor's in Physics from the University of Crete.

commercialization and training the next generation of entrepreneurs.

He said, "Their aims and objectives for commercialization will be different; from learning to pitch their ideas to different audiences, to understand market trends, and engage with potential customers and suppliers. One of the current biggest achievements is the change of mindset to consider more than technical aspects."

Prof. Padgett added, "The panelists' technologies range from endoscopes thinner than human hair to new infrared detection technologies, to scalable manufacturing of quantum devices and portable gravity sensors. The researchers are taking advantage of the opportunity to be at Photonics West to develop personally and professionally and to advance on their commercialization journey, whatever stage they are currently at."

Quantum technology for imaging and sensing

With the promise of game-changing outcomes for many sectors and massive financial returns on investment, quantum computing has captured the imagination of innovators, investors, and governments across the globe. However, most quantum computing companies are still pre-revenue and a more realistic appraisal of the timescales involved in maturing the technology, develop use cases, and achieve return on investment is slowly permeating the industry.

Prof. Padgett said, "Other applications of quantum technology related to imaging, sensing, and timing have not captured the collective imagination in the same way. Partially due to their different applications, quantum imaging and sensing opportunities are less understood by those outside technology development circles. Nevertheless, quantum imaging and sensing hold disruptive power across many sectors and although they have been developing and maturing technologically at a staggering pace, still require continued investment."

So what are the significant market opportunities for quantum technologies? Prof. Padgett believes that quantum technologies encompass a broad range of opportunities. "Sensing and imaging applications, I would describe as displacement opportunities. Industry already has a sensor that can measure that element, and may or not be in the market place due to economic considerations. Quantum imaging and sensors have to cost-effectively displace [conventional] sensors, where the current deployed state of the art sensor might do nothing," he said.

Tracey added, "Based on an Anchored In survey for the UK Government, 85 percent of UK Quantum companies are already importing elements of their supply chain to develop quantum technologies.

"The UK has industrial strengths and leading companies across the supply chain, in areas such as photonics, electronics, and cryogenics, which are essential to quantum technologies. Good examples are Covesion and Oxford Instruments. We have world leading clusters, such as the Compound Semiconductor cluster in South Wales, and a long-established photonics cluster in Scotland."

Photonics-based quantum solutions offer more than conventional systems in terms of performance, price, and

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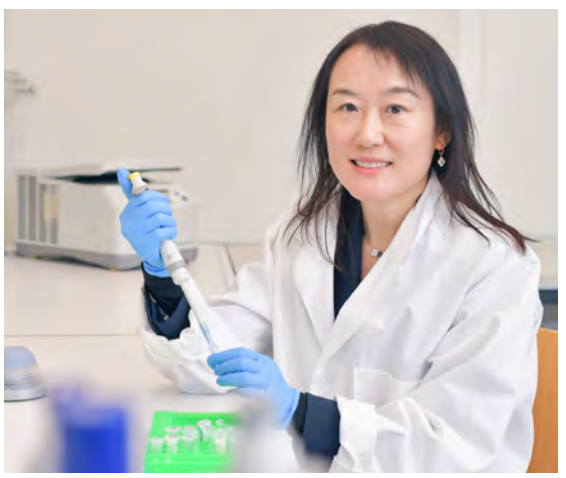
LASE Hot Topics

continued from page 13

life," says Liu. "Core projection systems including liquid crystal displays and digital micromirror devices can impose spatial light modulation and actively shape light waves. Recently, the advent of metasurfaces has revolutionized the design concepts in display technologies, enabling a new family of optical elements with exceptional degrees of freedom." Liu's talk presented examples of electrically controlled metasurfaces for dynamic holographic displays. She also outlined the possibility of achieving programmability and addressability of optical-metasurface devices at the single pixel level.

KAREN THOMAS



Laura Na Liu, University of Stuttgart and the Max Planck Institute for Solid State Research. Credit: University of Stuttgart

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Starlink fixes its space lasers to achieve 99 percent uptime

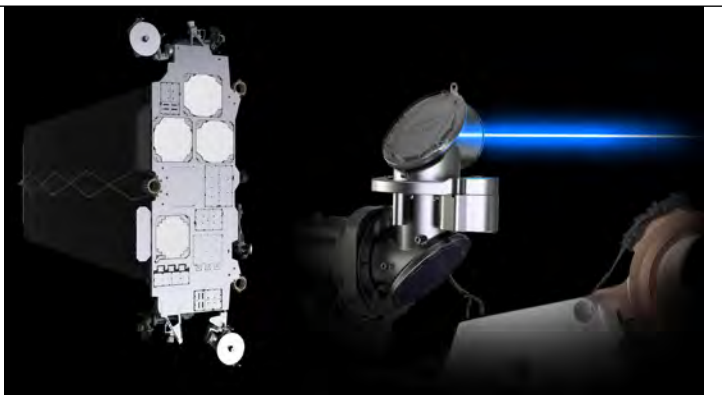
Starlink engineer Travis Brashears presented an invited paper that opened the *Free-Space Laser Communications XXXVI* conference Tuesday, under the bold title "Achieving 99 percent link uptime on a fleet of 100G space laser inter-satellite links in low Earth orbit."

His presentation gave an overview of the design, mass manufacturing, and operational challenges confronted in the development of SpaceX's global satellite laser mesh network, which now comprises more than 5,000 free-space optical communication terminals, each achieving data transmission rates of 100Gbps and link uptime over 99 percent.

Brashears also revealed a table of headline figures from Starlink's recent market progress and technical achievements: delivering over 42 petabytes of data for customers per day — "We are transferring terabits per second every day across 9,000 lasers," Brashears said.

To applause from the audience, Brashears announced, "Starlink is now accessible in more than 70 countries, across all seven continents, including Antarctica. We have successfully connected more than 2.3 million active customers and are continuing to expand our reach."

Without revealing details of component brands or specifications — "physicists can probably guess some of what we're doing" — Brashears outlined the key components of a lasercom terminal.



Each Starlink V1.5 satellite has several laser link terminals that allow the constellation to create a mesh network in space and reach even the most remote users. Credit: SpaceX.

"We utilize off-the-shelf components and qualify them for operation in space, including transceivers, sensors, and drivers," he said. "We have unlocked rapid software development with microcontrollers rather than FPGAs, we handle jitter and thermal variation with actuators, and we cover a large field of regard and high tangential velocities using coarse pointing and look-ahead actuators."

Looking to the future Brashears concluded that Starlink's laser systems would need "smaller form factors to connect to third party systems; configurable capacity rising to 400G; and even the capabilities to connect to the Moon and Mars!"

MATTHEW PEACH

Furukawa and Nichia raise blue laser power

A collaboration with Nichia has enabled Furukawa Electric to double the power of the blue laser output from its hybrid blue-infrared industrial lasers. The two Japanese heavyweights outlined the latest developments in a pair of presentations during Sunday's *High-Power Diode Laser Technology XXII* conference sessions.

First up, Taisuke Atsumi from Furukawa detailed the firm's expanded line-up of "BRACE-X" hybrid lasers that have resulted from the collaboration so far. Nichia's new chip designs and beam combinations have increased the output power of the blue laser diode modules used by Furukawa from 250W to 500W, enabling new hybrid systems featuring the "BR2200," which offers up to 2.2kW of blue power at 465nm, and the "BR1030," with a higher power density.

Atsumi told the conference that those improvements meant that, when combined with a 6kW near-infrared laser in the hybrid arrangement, the BR2200 was able to weld 5mm-thick copper plate — nearly double the thickness possible with its earlier hybrid system, while maintaining high quality.

Following Atsumi, Nichia's Kazuya Hatakeyama detailed what had changed inside the water-cooled blue laser diode modules. Those improvements include a new laser chip design with a longer cavity and better thermal resistance enabling a higher drive current, meaning that each individual diode now delivers 16W power — up from 13W previously.

Nichia has also reduced the package width, and alongside other upgrades it means that the module can now host 36 emitters — up from 24. With the new design implemented, Nichia is currently able to mass produce 500W modules, but Hatakeyama said that the company had already made a prototype module delivering more than 800W. Visit booth #132 to find out more.

MIKE HATCHER

Quantum panel continued from page 27

new capabilities, believes Padgett. "For example, in medical imaging, quantum technologies will allow endoscopes the thickness of a single human hair, or brain scanners the size of a cycle helmet."

UK National Quantum Technologies Program

Since 2014 the UK has invested in the National Quantum Technologies Program. The NQTP is a £1 billion ($1.27 billion) dynamic collaboration between industry, academia, and government.

It also acts as a cornerstone for the underpinning scientific research, skills training, and international collaboration with the aim of building a resilient UK quantum-enabled economy.

Padgett commented, "The UK is also unique in the way it has explored quantum imaging explicitly in the NQTP and maintained a balance between computing, communication, sensing, and imaging, exploring a variety of applications for the new quantum enabled markets."

Quantum technologies panel moderator Ian Tracey, CEO, Anchored In. Credit: Anchored In.

While there has already been significant progress in the development of market-ready quantum technologies, the research hubs and wider quantum-photonics community are working on a range of problems yet to be solved.

In March 2023, the UK Government published the National Quantum Strategy, where it committed to publishing long-term quantum missions to galvanize technology development towards ambitious outcomes.

Padgett concluded: "With the biggest impacts for quantum technologies expected in the long-term, time-bound missions can crystallize where we want to get to as a country, focusing the activity and investment needed in the public and private sectors.

"Since the publication of the strategy, the government has worked with industry, quantum experts, and investors to develop missions that will bring significant benefits to the economy and society such as increased compute power, new navigation and timing systems, more precise sensors, and improved outcomes for patients across areas such as dementia, epilepsy, and cancer through earlier diagnosis and ultra-precise surgery."

MATTHEW PEACH

Diverse quantum future continued from page 15

quantum optics, photonics, and quantum-stage storage. One application in particular involves the integration of solid-state laser materials, crucial for transmitting quantum information via light.

"Our team is very grateful to receive the IBM-SPIE HBCU Faculty Accelerator Award in Quantum Optics and Photonics," said Kumar. "We are excited to be introducing Tuskegee University students to the frontier area of quantum optics and photonics research. This grant will be particularly helpful to the university's faculty and students researching glass materials doped with rare earth ions and photonic crystals for quantum upconversion, quantum cutting, and light quantum control applications. At the same time, a tandem approach for understanding the photonic crystals via theoretical simulation and experimental research is planned by university researchers."

"In supporting quantum research programs and education at HBCUs through this collaboration with the IBM-HBCU Quantum Center, we hope to empower a truly diverse scientific and engineering community," said SPIE CEO Kent Rochford. "Quantum is critical to technological innovation, and we want to ensure that the field is open, accessible, and inclusive for current and future generations of optics and photonics students. Three years in, this program is already contributing to delivering that objective."

DANEET STEFFENS

Wasatch announces X Series for Raman spectroscopy

Wasatch Photonics (Booth 3341) is presenting its new flagship line of compact Raman spectrometers and systems. The WP Raman X series, according to CEO David Creasey, "is the most powerful, comprehensive compact Raman product line ever created, with superior sensitivity and flexibility to serve the needs of researchers and OEM instrument developers alike."

X marks the spot: Wasatch Photonics CEO David Creasey and VP of Marketing Cicely Rathmell with their X Series Raman spectrometers. Credit: Joey Cobbs.

The X series product family includes modular spectrometers, integrated lasers, complete Raman spectroscopy systems, and OEM modules from 532-1064 nm, configurable to the needs of each application. It has been designed with a singular goal — to accelerate the development of new applications of Raman and bring them to life.

The X series replaces the company's line of WP Raman spectrometers used widely in medical diagnostics, materials research, food quality, security, authentication, and the environment. The new line leverages Wasatch's patented VPH gratings, signature sensitivity, and robust and reproducible optical bench — now refined for ease of manufacture with a configurable, unified optomechanical design. This allows for a high degree of customization for research and/or prototyping, backed by scalability to high volumes in the company's recently expanded US manufacturing facility.

The X series includes Raman spectrometers and systems for use at 532, 638, 785, 830, and 1064 nm excitation, covering the fingerprint and functional range of Raman peaks with 10 cm^{-1} resolution or better.

Configuration options include a choice of f/1.3 or f/1.8 input aperture, detector cooling level, slit size, and sample coupling. Models available include: 1) standalone spectrometers for modular Raman spectroscopy, 2) spectrometers with integrated excitation laser to reduce size, cabling and cost, 3) fully integrated Raman systems for maximum signal in the smallest footprint, and 4) OEM versions of each to reduce size, weight, and cost in volume.

Dr. Creasey added, "The X series started with a question — what does the future of Raman look like? Raman is well established in hazmat detection and pharma, and now it's starting to take off in medical diagnostics and similar bioanalysis, pioneered by innovators who see its potential to provide very specific answers to complex questions.

"We created the X series to give them the sensitivity, reproducibility, and configurability they need to answer these questions with confidence, and to bring their solutions to market more rapidly."

MATTHEW PEACH

Hübner debuts expanded laser range and terahertz systems

Hübner Photonics has launched a range of new sources from its Banksy-themed booth (3567). You may be familiar with the *Girl With Balloon* (originally sprayed on a bridge in London) and fans of the mysterious graffiti artist might spot spray-paint-style tributes at various points around the Moscone.

New sources from Hübner include the VALO Tidal Femtosecond Fiber Lasers. These passively cooled compact systems delivers pulse durations of typically 40 fs at 2 W of output power.

Elizabeth Illy, head of marketing told *Show Daily*, "Due to its exceptional peak power and integrated dispersion pre-compensation unit, the Tidal is suitable for nonlinear applications like high harmonic imaging and wafer inspection."

There are new wavelengths and powers for Hübner's Cobolt 06-01 Series. The Cobolt 06-DPL 594 nm laser, which gives a CW power output up to 100 mW with direct modulation capabilities, can be integrated into laser combiners such as the C-FLEX or simply for stand-alone use in the laboratory. Furthermore, there is a higher power for the Cobolt 06-MLD 488nm, now with 300 mW.

The new Cobolt Disco 785 nm single-frequency laser delivers up to 500 mW in a perfect TEM00 beam. This wavelength is an extension of the Cobolt 05-01 Series platform, and with an innovative design delivers excellent wavelength stability, a linewidth of less than 100 kHz, and spectral purity better than 70 dB, providing the performance needed for high-resolution Raman spectroscopy measurements.

Girl With Balloon: Hübner Photonics marketing head Elizabeth Illy and the new Cobalt laser. Credit: Joey Cobbs.

Hübner is also showcasing a range of lasers for applications in quantum technology. The Cobolt Qu-T Series is a family of compact, single frequency, tunable lasers operating at wavelengths of 707 nm, 780 nm and 813 nm. The Cobolt Qu-T Series is suited to quantum experiments based on atomic transitions and generation of entangled photon pairs through spontaneous parametric down-conversion.

Rounding off the Sweden-Germany-based company's 2024 package is an invited talk at the Photonics West conference: "Single-mode radiation-balanced Yb-doped silica fiber laser and amplifier," taking place on Thursday.

Illy commented, "We are excited to share the findings of a research project developed in collaboration with Prof. Digonnet's research group at Stanford University. Dr. Enkeleda Balliu's presentation will describe the latest breakthroughs in second-generation radiation-balanced fiber lasers and amplifiers."

MATTHEW PEACH

Jenoptik launches diode laser and presents photonic solutions

Jenoptik (Booths 1341, 1441) has this week presented its broad product portfolio of high-performance optical components and systems, for diverse applications in medicine, laser and optoelectronics developments, semiconductor equipment, data transmission, and imaging.

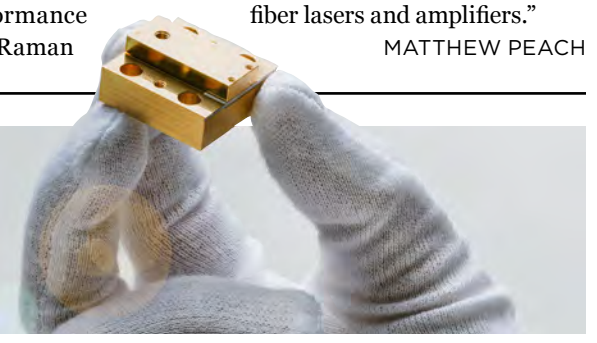
Novel open heat sink diode laser package "LS" is designed for optical pumping of next-generation solid-state-lasers, which significantly increases output power levels compared to the industry-standard CS.

While only slightly deviating from the CS form factor, the LS form features improved conductive cooling of the laser bar thanks to a double-side cooled open heat sink design. As a result, the LS offers superior performance compared to the CS with cw-output power levels exceeding 150 W at 9xx nm.

Featuring an almost identical form factor as the CS-package, Jenoptik's LS package offers upgrade capability of already existing assemblies based on the CS with the benefit of boosting optical power.

To further support future image-guided surgical procedures as well as diagnostic imaging applications, Jenoptik has developed a solid-state-based color-gamut tunable (white) light source which allows for high-brightness illumination at virtually any chromaticity setting.

Color-gamut tuning via mixing of three or more independent color-channels allows for imaging under different multi-spectral illumination conditions and thus enables improved visual discrimination for the surgeon and/or future AI-based image-processing-algorithms for minimally invasive endo-illumination.



Open heat sink diode laser package "LS" for optical pumping of solid-state-lasers. Credit: Jenoptik.

Also at their booth is the opto-electronic UFO Probe Card; with this, Jenoptik offers wafer manufacturers and wafer test equipment suppliers a solution for the synchronized testing of electronic and photonic components.

MATTHEW PEACH

BOOTH 3273

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