WEDNESDAY
EDITION

SPIE. | optics.org | WEDNESDAY, FEBRUARY 1, 2023

PHOTONICS WEST SHOW DAILY

'I spy... busy booths at Moscone'

Credit: Joey Cobbs.

LASE 'hot' topics: how about 130 million degrees?

Hot stuff: The target chamber of Lawrence Livermore National Laboratory's National Ignition Facility, where 192 laser beams delivered more than 2 million joules of ultraviolet energy to a tiny fuel pellet to create fusion ignition on Dec. 5, 2022. Credit: LLNL.

Photonics West attendees have a critical role to play, ensuring that some of the biggest challenges facing humanity can be met. That was a recurring theme heard from speakers during the LASE Hot Topics session held Monday afternoon, where fusion energy, quantum computing, and a step-change in road safety were all up for discussion.

Luminar Technologies CTO Jason Eichenholz — a Photonics West stalwart who has been attending since he was a graduate student — had some stark figures on road fatalities to share. "There were 1.3 million [vehicle-related] fatalities last year," he told the packed event. "We've become accustomed to — and nonchalant about — that. I think that we can do better."

Ultimately, the goal for Luminar is to save millions of lives. That means making sensor systems that are able to handle every kind of road situation, and to work reliably in all scenarios. The step-change is possible, but requires an industry shift to adopt autonomy, he argued, with lidar at 1,550 nm the key to making that happen. Getting there is no easy task: Eichenholz outlined the enormous technical challenges and trade-offs involved

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International quantum councils to collaborate

(L-R) Vlad Gheorghiu, Celia Merzbacher, Taro Shimada, and Thierry Botter. Credit: Joey Cobbs.

Tuesday morning at Photonics West, Quantum Industry Canada (QIC), Quantum Economic Development Consortium (QED-C), Quantum Strategic Industry Alliance for Revolution (Q-STAR) and European Quantum Industry Consortium (QuIC) signed a memorandum of understanding (MoU) to formally establish the International Council of Quantum Industry Associations. The council aims to strengthen communication and collaboration among the participating consortia on goals and approaches to the development of quantum technologies.

Emerging quantum technologies leverage fundamental properties of quantum physics to surpass the capabilities of traditional 'classical' systems. "Quantum technologies are expected to revolutionize the health, mobility, logistics, finance, climate science, environmental sustainability, energy, and

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DON'T MISS THESE EVENTS.

QUANTUM WEST: FUNDING COMMERCIAL ADVANCES IN QUANTUM TECHNOLOGIES
9 – 10:45 AM Moscone Center, Quantum Stage, Hall A Lobby (Exhibit Level South)

PHOTONICS WEST EXHIBITION
10 AM – 5 PM Moscone Center, North-South (Exhibit Level)

JOB FAIR
10 AM – 5 PM Moscone West, Level 1

LUNCH AND LEARN: EQUITY IN THE OPTICS AND PHOTONICS INDUSTRY
12 – 1 PM Moscone West, Community Lounge (Level 2)

MICROLEDS FOR CONSUMER APPLICATIONS
1:30 – 2:30 PM Moscone Center, Expo Stage, Hall DE (Exhibit Level)

AMERICOM PANEL: WHERE HAVE ALL THE TECHNICIANS GONE? HOW OPTICS ECOSYSTEMS ARE BRINGING THEM BACK
2:45 – 3:45 PM Moscone Center, Expo Stage, Hall DE (Exhibit Level)

3D SENSING FOR CONSUMER APPLICATIONS
4 – 5 PM Moscone Center, Expo Stage, Hall DE (Exhibit Level)

OPTO AND SELECT BIOS POSTER SESSION
6 – 8 PM Moscone West (Level 2)

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

IN THIS ISSUE.

CEA-Leti details progress on AR building blocks, retinal projection, and holography

Reflecting CEA-Leti's pursuit of developing silicon photonics and integrated optics for AR glasses, the France-based research institute (booth 959) is giving a tranche of updates on its progress on several technological building blocks, such as retinal projection and holography. CEA-Leti representatives are highlighting no fewer than 15 papers and poster presentations at Photonics West.

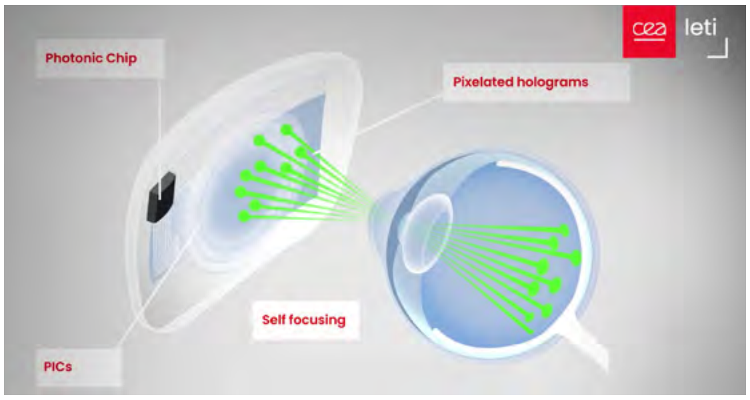
The global market for AR glasses should grow from $12BN in 2022 to more than $74BN by 2032, a CAGR of 20.3 percent, according to Future Market Insights.

CEA-Leti says silicon photonics now allows scientists to precisely manage the positioning of light on the surface of a device. It offers the ability to densify these light positions with extreme rates, allowing the concentration of complex optical functions on small surfaces. Its application on glass substrates, with silicon nitride as a guiding material, opens the way to applications related to the visual field and augmented reality.

CEA-Leti's research on retinal projection has been structured around a breakthrough in adapting silicon photonics technologies in the visible spectral range, instead of the infrared spectral range where they historically have been implemented.

"Implementation of photonic integrated circuits in the visible spectral range is a breakthrough because of the very strong dimensioning constraints associated with short wavelengths," said Christophe Martinez, a lead and contributing author on several papers. "Our challenges are both technical, to establish the right manufacturing processes, and theoretical, for example, to know the physical effects related to these technology evolutions," he said.

While all vision-related applications use optical systems to project images on the retina, retinal projection uses only the eye to form the image provided by a device. Instead of transporting an image towards the eye, the device provides the information that allows the eye itself to generate the image.



CEA-Leti's retinal projection devices use the eye as the unique optical system to form an image. Credit: CEA/Vendredi4

Following its 2018 introduction of a disruptive concept for an integrated smartglass display for augmented reality glasses based on hologram pixelization for image formation, CEA-Leti will validate this holographic technology in its paper, "Evaluation of a Pixelated Holographic Display Concept for a Near Eye Display, Recent Results and Technological Developments."

The paper presents first convincing results on this imaging part by pixelated holograms and evaluates the transparency of these holographic components that must be integrated on glasses. In a near-eye display configuration, the paper also will show how a periodic distribution of holographic pixels of about 25µm allows the projection of an angularly coded image without an optical system between the eye and the display.

MATTHEW PEACH

Fraunhofer FEP's organic silicon platform suits imagers, microdisplays, and sensors

For more than a decade, researchers at Fraunhofer Institute for Organic Electronics, Electron Beam and Plasma Technology (FEP) in Dresden, Germany (booth 4515) have been working on OLED-on-Si technology — in which OLED layers are integrated monolithically on CMOS.

This design enables the development of optoelectronic components such as light-emitting microdisplays for applications, such as in smart AR, VR, or MR systems or other wearables and data glasses, as well as detection components such as organic photodiodes.

This week, FEP researchers are presenting a universal organic-on-Si photonics platform that can be used to develop and realize devices for such different applications in a standardized, thus cost-effective way. They are presenting their latest results of the various backplanes, OPD image sensors, and OLED-on-Si microdisplays for an oxygen sensor.

Bernd Richter, deputy division manager for microdisplays and sensors at Fraunhofer FEP, explains: "Our new photonics platform consists of an organic frontplane on an integrated Si-CMOS backplane. It enables a wide range of applications and the cost-effective implementation of variations from microdisplays to image sensors and optical sensors.

Miniaturized optoelectronic systems with emitter and sensor functions on a chip are realized with OLED-on-silicon technology. Credit: Fraunhofer FEP.

"For example, low- and high-brightness microdisplays can be manufactured with various color schemes ranging from monochrome to selected color schemes, to full color RGB/RGBW."

The technical capabilities of the platform have been demonstrated in three application scenarios:

The first is an image sensor using a stacked approach of an OPD frontplane on a CMOS backplane for an extended spectral range. The integrated image sensor uses an OPD frontplane that is vacuum processed and achieves higher sensitivity than conventional CMOS image sensors in the near-infrared range.

Secondly, an application-specific microdisplay modification was realized using different OLED frontplanes with a universal 720p CMOS backplane. The RGBW version uses the full performance of the backplane. A white OLED with color filters is employed. This development shows the possibilities of the technology platform by integrating multiple filters.

A two-color RGRG version yields a significant increase in luminance, which can be further optimized in efficiency and brightness.

A third version dealt with the implementation of a monochrome stack for particularly high brightness as well as the possibility to double the resolution.

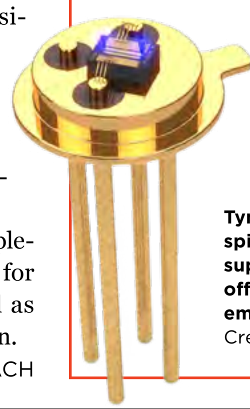
MATTHEW PEACH

ISLIGHT MAKES DEBUT WITH SPECKLE-FREE SLEDS

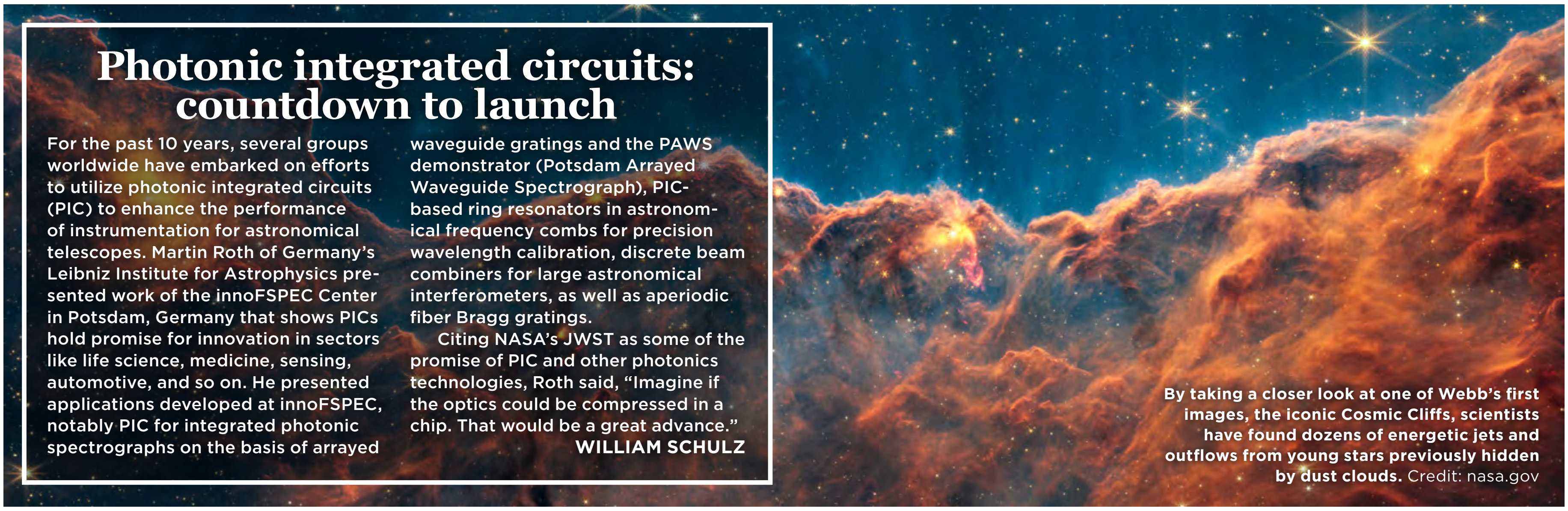
Recent Tyndall National Institute spin-out iSLight, which has developed speckle-free, high-power blue superluminescent LEDs (SLEDs), is making its world debut on the Moscone Center exhibition floor this week (booth 4645).

The startup says that its novel devices currently offer a peak power of up to 2W at wavelengths across the blue spectrum, while technical lead Juan Salvador Dominguez Morales told *Show Daily* that the patented device architecture is applicable to other material systems — and so could also be fabricated to emit in the green, red, and infrared. iSLight is currently using Tyndall's own wafer fabrication facilities in Cork, Ireland, but plans to engage with commercial foundries to scale up production in the future.

MIKE HATCHER



Tyndall National Institute spin-out iSLight's superluminescent LEDs offer speckle-free emission at 2 W. Credit: iSLight.



Photonic integrated circuits: countdown to launch

For the past 10 years, several groups worldwide have embarked on efforts to utilize photonic integrated circuits (PIC) to enhance the performance of instrumentation for astronomical telescopes. Martin Roth of Germany's Leibniz Institute for Astrophysics presented work of the innoFSPEC Center in Potsdam, Germany that shows PICs hold promise for innovation in sectors like life science, medicine, sensing, automotive, and so on. He presented applications developed at innoFSPEC, notably PIC for integrated photonic spectrographs on the basis of arrayed waveguide gratings and the PAWS demonstrator (Potsdam Arrayed Waveguide Spectrograph), PIC-based ring resonators in astronomical frequency combs for precision wavelength calibration, discrete beam combiners for large astronomical interferometers, as well as aperiodic fiber Bragg gratings.

Citing NASA's JWST as some of the promise of PIC and other photonics technologies, Roth said, "Imagine if the optics could be compressed in a chip. That would be a great advance."

WILLIAM SCHULZ

By taking a closer look at one of Webb's first images, the iconic Cosmic Cliffs, scientists have found dozens of energetic jets and outflows from young stars previously hidden by dust clouds. Credit: nasa.gov

IPG digs deep with its latest UV lasers

Fiber laser specialist IPG Photonics is launching three new deep-ultraviolet (deep-UV) lasers at this year's Photonics West, pointing to its expertise in nonlinear crystal material as the key to their development.

The new laser architectures are said to provide an easy-to-integrate, compact, and lightweight optical head tethered to a compact laser source — with the resulting tools reportedly ideal for micromachining and materials processing workstation integration.

Included in the range are 3W continuous-wave and 5W nanosecond-pulsed sources, both of which operate at 266 nm. The single-frequency CW laser is aimed at applications in photolithography, inspection, and spectroscopy, while the pulsed laser is designed for micromachining tough materials like diamond, glass, and Teflon.

The third of the new deep-UV lasers is a picosecond source delivering 5W at the shorter wavelength of 257 nm, and is expected to find use in a variety of electronics manufacturing steps.

IPG's senior VP of worldwide sales, Trevor Ness, said in a release from the US company: "Our success pushing deep-UV lasers to new reliable power frontiers is enabled by IPG's proprietary nonlinear crystal technology, which is both more robust and [more] flexible than conventional frequency conversion materials."

Also new from IPG this year is a series of six high-power, high-efficiency diode laser systems that are being tipped to replace infrared bulbs and gas-fired furnaces for industrial heating and drying. Available with output powers of up to 40 kW, the sources offer wall plug efficiencies in excess of 50%, with the potential for major savings in energy consumption while high energy costs persist.

"A diode heater operates cold, wasting no energy warming insulating walls or the factory floor," says IPG. "Between batches the diode heater is off, not idling, so no energy is consumed when it is not needed."

The company adds that laser light is able to dry below the surface of a target material, adding further to the efficiency when compared with a thermal convection oven. IPG reckons that its systems will work four times faster than conventional approaches, while taking up only a quarter of the floor space.

For more details on the deep-UV fiber lasers and new diode solutions, visit IPG at booth 327.

MIKE HATCHER

Lumus shows off functional but aesthetic AR glasses

The new "Z-Lens" AR glasses from Israeli company Lumus feature lenses produced by key optics partner Schott. A prototype version of the technology can be seen at this week's SPIE AR|VR|MR exhibition in Moscone West. Credit: Lumus.

Israeli startup Lumus is showing off a prototype of its new "Z-Lens" augmented reality (AR) glasses at Moscone West this week, following a world debut at the recent Consumer Electronics Show in Las Vegas.

"In order for AR glasses to penetrate the consumer market in a meaningful way, they need to be impressive both functionally and aesthetically," reckons company CEO Ari Grobman. "With Z-Lens, we're aligning form and function, eliminating barriers-of-entry for the industry, and paving the way for widespread consumer adoption."

The latest iteration of the glasses features the "Maximus" 2D reflective waveguide technology that first appeared two years ago. "With all of its improvements, Z-Lens unlocks the future of augmented reality that consumers are eagerly waiting for," claims Grobman, pointing to advances including an optical engine half the size of its predecessor, and a new architecture that allows greater flexibility for glasses manufacturers to place the entrance aperture in various positions.

"This allows for significantly more compact AR optics for natural-looking glasses that reduce the weight and bulk associated with many of today's solutions," stated the firm, which is exhibiting alongside key partner Schott at the glass company's booth.

The latest features include 2K x 2K resolution and a brightness of 3,000 nits per Watt, meaning that consumers should be able to enjoy AR in daylight through a pair of glasses virtually indistinguishable from a regular pair.

The Z-Lens architecture also allows for direct bonding of optical elements for prescription glasses, something that can be licensed by manufacturing partners, and which would allow consumers to customize AR eyeglasses to their own prescription without the addition of bulky inserts.

According to Lumus the new bonding feature also provides dynamic focal lens integration — something that may help solve the nausea-inducing effects of vergence-accommodation conflict, caused by the brain receiving mismatched visual cues.

"Natural-looking glasses with augmented reality functionality will unlock the consumer market and propel the industry forward," Grobman predicts. "Manufacturers will need to create aesthetically appealing glasses before mass adoption can ever become a reality, and Z-Lens allows them to do exactly this."

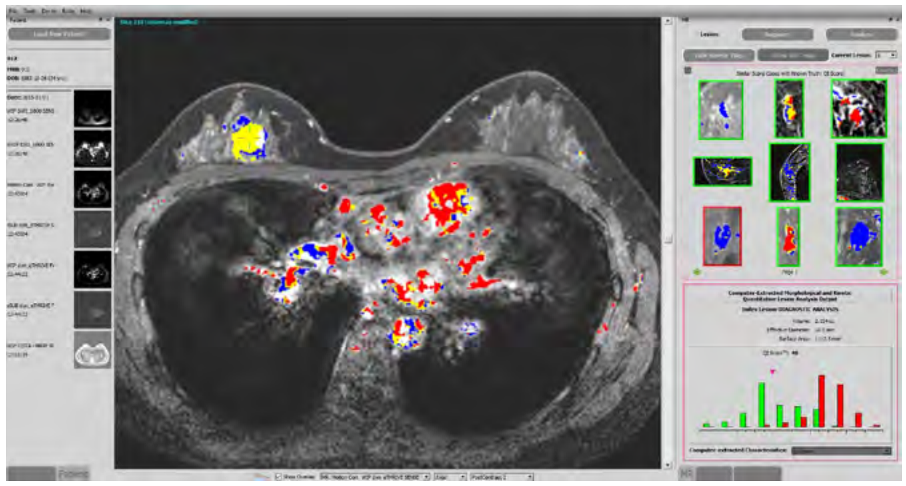
All Lumus reflective waveguides contain a series of 'cascading' partially reflective mirrors that guide the signal through the waveguide into the viewer's eye. These transflective, partial mirrors expand the image vertically and horizontally, enabling a large field of view with a tiny projector hidden in the temple of the eyeglass frame.

Initial prototypes of the Z-Lens feature a 50-degree field of view, although the company says it is planning to increase that to 80 degrees with future designs.

MIKE HATCHER

AI is driving innovation in healthcare and silicon photonics

Scientists at the forefront of artificial intelligence and deep learning anticipate a paradigm shift in photonics.



Qlarity Imaging's AI-based software helps radiologists to assess and characterize breast lesions. Credit: Qlarity Imaging / Business Wire.

Artificial intelligence is a game-changer with the potential to revolutionize industries far and wide, and photonics is no exception. Sift through the 2023 Photonics West program and you'll see AI-related algorithms have already been applied to optical computing, holographic data storage, photonic component design — even otolaryngology.

Indeed, healthcare is one field where AI and deep learning have already had a huge impact — evident during the Panel Session, 'Transforming Healthcare via AI and Deep Learning', held on January 28. Here, independent consultant and past Director of Imaging, Diagnostics, and Software Reliability, at the FDA (US Food and Drug Administration) Kyle Myers, chaired the session, which included former SPIE president, Professor Maryellen Giger, from Radiology at the University of Chicago, Charles Taylor of Heartflow, and medical start-up executives, Yair Riveson of Pictor Labs, and Lucendi's Zoltán Göröcs.

Kyle Myers. Credit: SPIE.

Talking to *Photonics West Show Daily*, Myers highlights how Heartflow has pioneered a system that analyzes CT images to estimate blood flow in coronary arteries. “This is a multistep computational modelling process that's a beautiful meshing of imaging physics, blood flow modelling and AI… and it estimates narrowing or blockages in the coronary arteries that could only be invasively measured with a catheter,” she says.

Myers also points out how Giger's start-up, QuantX — now Qlarity Imaging — developed a deep learning platform to screen for early-stage breast cancer by characterizing lesions in magnetic resonance images (MRI). During its journey to market approval, the device underwent the FDA De Novo process, which provides a pathway to market for novel devices.

“This was the first machine learning device to characterize breast lesions in MRI — the FDA wrote new guidance telling other companies what kinds of data would be required to validate such a tool,” highlights Myers. “This was a creative process between Giger and the FDA — she really created a pathway for a whole lot of different products that are now following in those footsteps.”

Design essentials

Never one to shy away from AI's complexities, Professor Rajeev Ram, head of MIT's Physical Optics and Electronics Group, looked at the use of electronic-photonic interfaces in deep learning systems, as well as quantum computing and next-generation brain-computer interfaces, in his OPTO plenary. As part of this, Ram will explore how AI and deep learning are becoming demand drivers and enablers of complex chip and system design.

For example, the MIT researcher points to how designers now think in systems rather than individual chips, and how end-applications drive everything. “Everyone is now asking, what it the end-use application, what algorithm will this run on, how do we translate the algorithm into an architecture and how do we translate that architecture onto photonic components?” he says.

Professor Keren Bergman, Director of the Lightwave Research Laboratory, Columbia University. Credit: K. Bergman.

And not surprisingly the tech-giants have led the way. For example in 2015, Google developed the Tensor Processing Unit — an AI accelerator — to super-charge machine learning tasks in its data centres. The TPU has since been used to power many Google applications, including Street View for Google maps, and RankBrain for its search results.

“Companies like Nvidia and Google have been doing this for decades — and then they realised they had to develop their own silicon hardware to sit in their systems,” points out Ram. “But we also now have other companies, such as Ayar Labs and Luminous Computing, that are deeply involved with algorithms, architectures and components.”

“It's a little bit different from the days when it was enough to have invented a new laser, a new detector,” he adds. “Photonic integration means you have to think about how [everything] works together.”

Along the way, machine learning has proven instrumental in the development of inverse design tools. Here, the ultimate function of a device is specified, with machine learning-based inverse design models then being used to optimise device performance.

As Ram points out, numerical simulation can provide an initial device design for on-chip optical coupling. But then inverse design can be used to raise the coupling efficiency of that device from say, 95% to 99%.

“It's that last few percent that can be important,” he says. “We can really benefit from inverse design tools that use machine learning mathematics to fine-tune the design and get that last bit of performance that really improves the overall [device] quality.”

Inverse design applied to silicon photonics

Dr Jason Ching Eng Png, from the Institute of High Performance Computing, Agency for Science, Technology and Research (A*STAR), Singapore, is no stranger to inverse design and has been applying this AI methodology to silicon photonics. In his words, this approach is 'having a tremendous impact'.

Together with colleagues, Png has developed a systemic framework of photonics device discovery based on deep learning and inverse design, which he discussed in his talk, 'Deep learning discovery of silicon photonic components' on 30 January in Session 3: Waveguide Design and Applications I, Silicon Photonics XVIII of OPTO. Using this approach, the researchers have devised a series of integrated silicon photonic power dividers, the fundamental building blocks of any photonic integrated circuit.

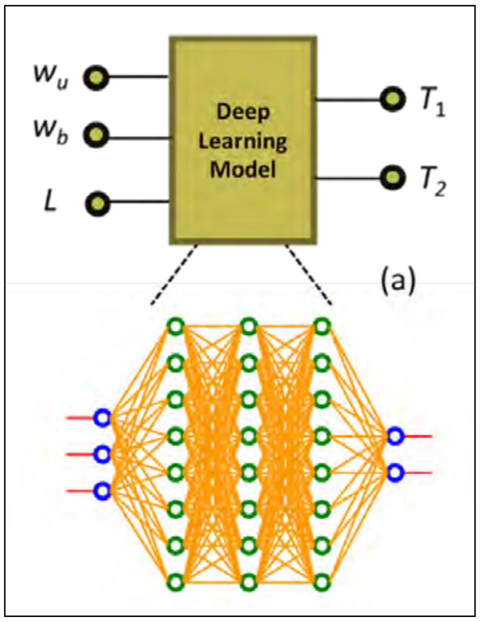
Dr. Jason Ching Eng Png from the A*STAR Institute of High Performance Computing, Singapore. The institute has developed a systemic framework of photonics device discovery for silicon photonics based on deep learning and inverse design. Credit: A*STAR, Singapore.

According to Png, the dividers have theoretical losses as low as 0.14 dB at a 1.55 mm wavelength, with a low loss bandwidth covering the entire telecommunication wavelength spectrum, from O- to U-band. He also points out how, critically, the devices simultaneously deliver low losses, wide bandwidth, an extremely small footprint and are very robust.

Thanks to circumventing computationally-expensive physics simulations, the trained deep learning inverse design models massively accelerate the design process, reducing computation processing times from days to minutes. “This is an impressive reduction,” says Png. “We're reducing the energy used and our carbon footprint, and swiftly coming up with a series of designs that we know can be realized and fabricated."

Png has applied his inverse design algorithms to the design of other devices, including silicon photonic arrayed waveguide gratings, halving the device footprint while meeting the necessary operating parameters. Given the smaller footprints of many of his designs, Png believes devices will be cost-competitive with today's chips, and is confident that foundries and component manufacturers will be keen to drive and implement designs within the year.

"I am being bullish about this, and in more challenging, cost-prohibitive applications, such as quantum photonics and flat optics, manufacturer adoption will take longer," he says. "But silicon photonics are comparatively mature and use CMOS [manufacturing] lines — so we'll see [adoption] take place in months."



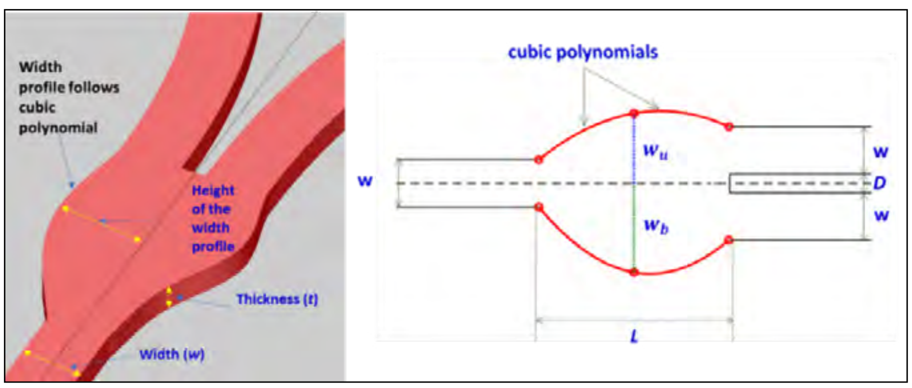
A*STAR's trained deep learning inverse design models massively accelerate the design process, reducing computation processing times from days to minutes. Credit: A*STAR, Singapore.

Energy relief

As business adopts more and more AI-designed systems, what is clear is that academia and industry alike will also lean more and more on AI. However, it's no secret that the computers that use AI require gargantuan amounts of energy. Recent figures from University of Massachusetts Amherst researchers indicated that 'training a single AI model can emit as much carbon as five cars in their lifetimes'. Clearly, when an AI model is improved by repeated training, the energy use will be significantly more.

As Professor Keren Bergman, Director of the Lightwave Research Laboratory, Columbia University, puts it: "Energy use is a huge problem and what is really key, is that the problem isn't static, it's a problem that is growing every year — in the last five years, the size of AI applications has increased by five orders of magnitude."

Given the scale of the problem, researchers have been eager to find out how energy consumption takes place. Studies from Bergman, other scientists, and industry players including Nvidia and Intel, have demonstrated that the movement of data devours far more energy than the actual computation itself. And this is where silicon photonics can help.



Left: 3D illustration of the Silicon photonic power divider developed by Dr. Jason Ching Eng Png and colleagues at A*STAR. Right: The planar layout for the power divider. Credit: Dr. Jason Ching Eng Png.

Many researchers have been developing silicon photonics-based platforms to enable efficient computing across a system. In an invited paper on 2 February, in the Next-Generation Optical Communication: Components, Sub-Systems, and Systems XII, Bergman's colleague, Dr Yuyang Wang from Columbia, will be describing a novel silicon photonic transceiver architecture that opens the door to ultra-high-bandwidth chip-to-chip optical communication for future hyperscale data centers.

As Bergman points out: "We're bringing the photonics interface to the chip, so it doesn't really matter if you're trying to move data centimeters, tens of meters or hundreds of meters — we're now in the optical domain so energy consumption and bandwidth remains flat."

In their very latest results, Bergman and colleagues have also created an entire silicon photonic link with less than a quarter of a picojoule-per-bit. "Our ultra-low energy, 250 femtojoule-per-bit link looks like it's going to be a world record," she says. "The bandwidth coming off the chip into today's systems is almost a factor of 100 less than that on the chip — but by bringing the photonic interface to the chip we prevent this and ensure the bandwidth on the chip is also anywhere in the system."

According to Bergman, she and colleagues still have to be careful of network latency but she reckons the technology will be commercialized in the next few years. An entire integrated photonic-electronic chip has already been fabricated at Taiwan Semiconductor Manufacturing Company Limited, TSMC, and her lab has also been collaborating with Intel and Nvidia. "This technology is revolutionary," she says. "[Our architecture] takes system scaling to a whole new paradigm."

Unsurprisingly, Bergman isn't alone in her conviction that the latest photonics technologies are breaking paradigms. MIT's Ram also believes that photonics researchers at Photonics West and beyond can look forward to a very interesting future. As he emphasizes, in any quantum computer, the qubits reside in a quantum state that can be described by linear algebra — the language of matrices and vectors — making it almost a natural system for performing machine learning — and AI-type functions.

"We're seeing the rise of quantum systems that didn't exist a decade ago, commercially. We're seeing AI applications that are completely changing data center workloads," he says. "It's an exciting time, and all of this means it's also a paradigm breaking time."

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3D sensing beckons for longer-wavelength edge-emitters

During Wednesday's industry sessions, analysts from Yole Intelligence will discuss three emerging market areas. Ali Jaffal will cover 3D sensing, with a focus on the emergence of indium phosphide edge-emitting lasers:

Show Daily: What's the motivation behind using InP-based edge-emitting lasers (EELs) instead of GaAs-based VCSELs in 3D sensing?

Ali Jaffal: The transition to a bigger display area in the smartphone is the core motivation for the move from GaAs VCSELs to InP EELs. Apple's iPhone roadmap confirms the committed development to enlarge the screen to the total size of the phone, by reducing first the current notch (for imaging, proximity sensor, flood illuminator, and dot projector functionalities) to a smaller pill-shaped hole and then to a tiny punch-hole. It implies a shift from 940 nm to 13xx nm or 15xx nm wavelengths that are OLED transmissive, and therefore from gallium arsenide (GaAs) to indium phosphide (InP) sensors where the sensors will be below the OLED screen.

What other applications are suitable for this approach?

InP-based short-wave infrared (SWIR) devices could also penetrate in the rear lidar of smartphones for AR/VR applications thanks to their emission wavelength at 1380 nm. The longer infrared wavelength provides better contrasts, and reveals material details that are otherwise not visible with shorter-wavelength illumination, especially in outdoor environments. By designing a camera that operates at 1380 nm instead of 940 nm, we can illuminate the scene with greater brightness and still remain well within the margins of eye safety requirements. In addition, the atmosphere absorbs more sunlight at 1380 nm than at 940 nm, which reduces background light interference, greatly improving the signal-to-noise ratio and enabling cameras with longer range and better image resolution

Yole Intelligence analyst Ali Jaffal will discuss "The dawn of the InP market in consumer applications" during Wednesday afternoon's industry sessions on the Expo Stage. Credit: Yole Intelligence.

You mentioned the AirPod 3 earbuds in your presentation abstract: what is the function of the InP sensors in this product?

For earbuds, we would like to clarify that the light source in the AirPod 3 family is an InP LED and not an EEL. The AirPod 3s contain an improved in-ear detection mechanism based on skin-detection sensors that are equipped with four InP SWIR LED chips that have two different wavelengths, as well as two InGaAs photodiodes.

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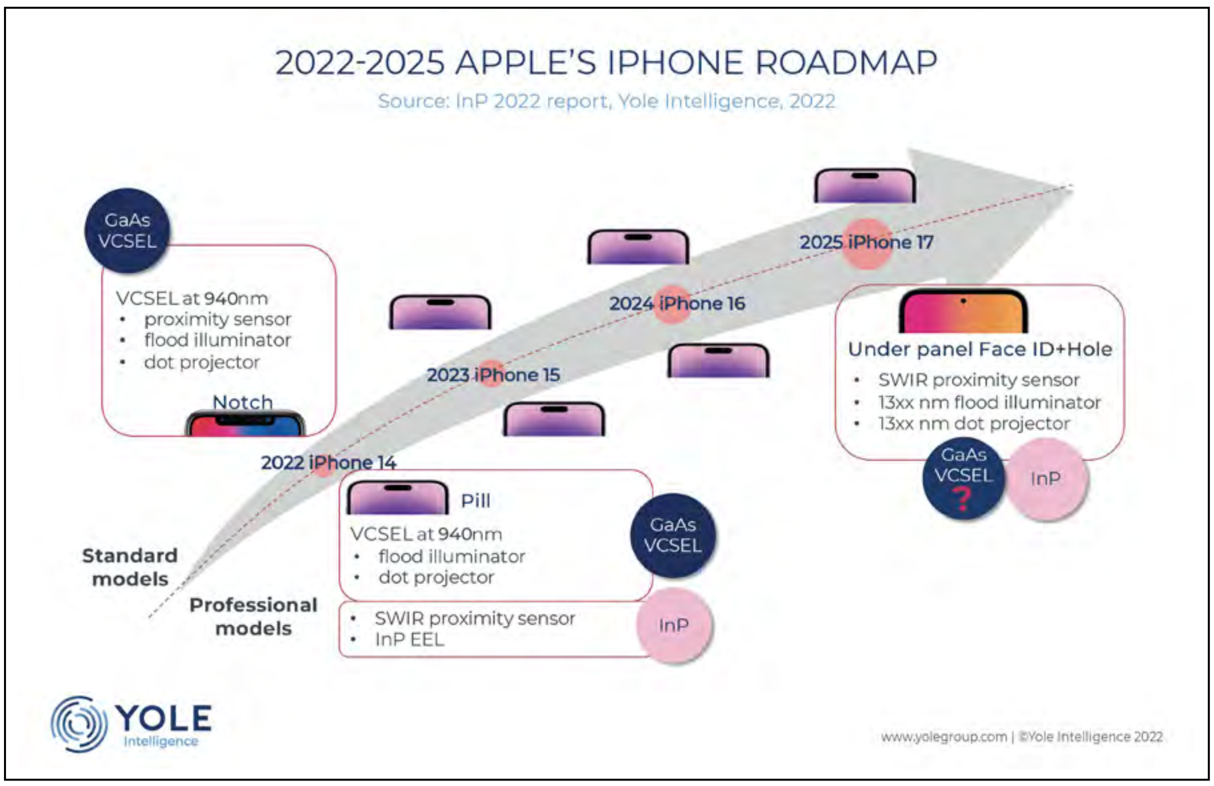

Future generations of Apple iPhones will see the black "notch" at the top of the smart phone, which contains sensor, microphone, and camera functions, shrink in size — thanks partly to incorporating InP-based EELs that are able to transmit through the display. Eventually the notch should be replaced by a small hole. Credit: Yole Intelligence.

3D sensing

continued from page 09

The InP-based devices in these earbuds are used as proximity sensors to differentiate the skin from other surfaces. The spectral response of human skin is characterized by peaks and valleys. The reflectivity of human skin is relatively high (typically about 50-60%) at a wavelength of 1065 nm and is relatively low (only 5-10%) at a wavelength of 1465nm. As a result, the presence of skin can be monitored by a sensor that emits light at 1065nm and 1465 nm, and measures the amount of light reflected from a target object at these wavelengths.

To what extent have InP EELs been adopted so far, and do you expect Apple to switch to InP EELs entirely?

As of today, the adoption of InP EELs for under-display 3D sensing applications has not yet happened. Nevertheless, a transition phase has already begun with the release of the iPhone 14 Pro model last year — it combines a SWIR proximity sensor and an InP EEL placed under the screen, with GaAs vertical cavity surface-emitting lasers (VCSELs) squeezed into a small pill-shaped opening. It is noteworthy to mention that the InP proximity sensor is for depth sensing, while the GaAs VCSEL is for 3D sensing. The pill shape is expected to remain for the next three or four years, for the next standard and pro iPhone models, before the eventual integration of the complete set of sensors (proximity and 3D sensors) under the screen in 2025-2026.

Released in 2022, Apple's iPhone 14 Pro model combines a SWIR proximity sensor and an InP EEL placed under the screen, with GaAs VCSELs squeezed into a small, pill-shaped opening. Credit: Apple.

Regarding the material platform for the under-display 3D sensing modules, as of today we see only InP EELs and detectors thanks to their emission in the SWIR wavelength. But new developments are being made to overcome the limited bandgap of GaAs. For smartphone under-display 3D sensing, IQE is currently working on a very promising new laser technology based on dilute-nitride GaAs, targeting a 13xx nm wavelength. However, this technology could take a few years to enter the market, leaving InP enough time to establish itself comfortably in this field. We do not believe that InP will cannibalize the GaAs VCSEL business. Our understanding is that both technology platforms will co-exist in the future in different smartphone models.

What about companies other than Apple, are they also adopting this technology? Can you give any examples?

Android OEMs initially followed Apple's example in implementing a 3D-sensing feature. However, with limited end applications, for example AR/VR, Android OEMs were less proactive in including this feature in smartphones in the 2020-22 period. In addition, Huawei, one of the most active Android OEMs in implementing 3D sensing, was impacted by the US-China trade war and lost share in the handset market. Beside Apple, we see Honor using 3D sensing modules in their high-end smartphones, although their technology is based on a time-of-flight approach rather than the structured light technology of Apple.

What will be the impact of this trend on the market share of GaAs VCSEL suppliers like Lumentum and Coherent? Do these companies also provide the InP EELs, or are different suppliers required?

The adoption of InP-based devices instead of GaAs VCSELs for 3D sensing applications could heavily impact the photonics semiconductor industry. Indeed, potential adoption of InP for 3D sensing applications could result in a drop in the market share of GaAs VCSELs, even if InP will not completely cannibalize the GaAs business in these applications.

Apple is a very attractive and innovative OEM, and everyone wants to be involved in its supply chain. Of the players already involved in that supply chain with GaAs VCSELs for Apple, such as Lumentum and Coherent, those two already have InP capabilities that are mainly used for datacom and telecom applications. They can provide InP EELs for consumer applications.

Apple's third-generation AirPods already include InP-based LEDs that are used as skin proximity sensors to optimize sound quality. Credit: Apple.

The adoption of InP in consumer applications in 2022 has created a lot of excitement in the InP industry. We have already seen traditional GaAs players, such as Freiberger, expanding their product portfolio to InP, and this is driven mainly by consumer applications.

What about InP VCSELs instead of edge emitters? Is this technology likely to find commercial use in consumer applications?

InP-based VCSELs are also potential candidates for the 3D sensing applications. However, as of today the main technology used here is EELs. In our understanding, InP-based VCSELs represent a very small market. This is based on our discussion with some market players where we have seen a strong penetration of InP in datacom and telecom applications, EELs having the advantage for higher data rates and longer reach. Over the last years, officially Vertilas and Bandwidth10 are two of the very few companies producing InP-based VCSELs, for gas sensing and optical communication.

However, the story is likely to change in the coming years. Recently, we have seen Trumpf, a traditional GaAs player, demonstrating InP VCSELs emitting at 1380 nm on 4-inch InP wafers with 85% yield at the bare-die level. The expansion of Trumpf to the InP business is mainly driven by the prospect of InP adoption in the consumer market.

MIKE HATCHER

MicroLED displays: applications emerge but major manufacturing challenges remain

During Wednesday's industry sessions, analysts from Yole Intelligence will discuss three emerging market areas. Eric Virey from the company will cover microLEDs and their potential for new displays. Virey outlines his thoughts here:

Yole analyst Eric Virey will discuss the emergence of microLEDs during Wednesday's industry sessions on the Photonics West show floor. Credit: Yole Intelligence.

Show Daily: What exactly is a microLED? Is there a strict definition?

Eric Virey: There is no commonly accepted definition for microLED. Size alone is not sufficient. Some refer to microLEDs as any chip with a size below 100 microns. Others consider 50 microns or sometimes 30 microns to be the limit. At Yole Intelligence, we define microLEDs by a combination of size, die architecture, manufacturing technology, and application (see figure 1). In terms of die structure, one key difference between micro — and [conventional] miniLED is that in the former, the original epitaxial substrate (for example sapphire) is removed. The die is, therefore, very thin — typically less than 5 microns — compared with miniLED, which is usually 80-100 microns thick.

Do they perform better than existing LED or OLED displays?

Like OLEDs, microLED displays are self-emissive; every single sub-pixel is an independently controllable light source. As such, microLED retains all the benefits of OLED, such as excellent contrast with deep blacks, wide viewing angles, high refresh rates, etc.

MicroLED, however, could deliver further improvements in brightness, power consumption, color gamut, lifetime, and environmental stability. Because the size of the emitter is very small compared to the pixel area, they also have a high aperture ratio, so they can be highly transparent. This extra room in the pixel also allows the integration of various in-plane sensors. Key players are working on gesture recognition, in-display cameras, proximity sensors, and more.

Unlike LCDs, which require a seal on the edge, and OLEDs, which need encapsulation to protect the fragile organic materials from oxygen and moisture, microLED displays can be bezel-free. This allows the building of seamless modular displays of any arbitrary dimension, including very large sizes that are impossible with traditional display technologies. For example, Samsung's 89-inch microLED TV comprises 49 individual 12.7-inch modules (in a 7x7 array).

Apple is working with its supply chain partners to start manufacturing microLED displays for its smartwatch in 2024. The microLED chips will be produced at ams-Osram's site in Malaysia, in a brand new, €800 million, 8-inch wafer fab for microLEDs.

What is now required for this technology to migrate to regular display panels in TVs or similar?

Cost is the major roadblock. Depending on the application, the cost needs to come down 20-50 times to realistically be considered for consumer applications. The challenge appears daunting. However, looking back at the history of LCD volume production, LCD costs decreased by a factor of 300, from $30,000/m2 to $100/m2, in 25 years (see figure 2, page 23).

However, the situations for LCD and microLED are different: LCD started from a blank canvas, and cost reduction opportunities lay across the board: materials, equipment, processes, etc. Once the low-hanging fruits were harvested, the bulk came from generation scaling, in other words substrate sizes. MicroLEDs, on the other hand, exist at the intersection of the mature semiconductor, LED, and flat panel display industries. This means that major reduction opportunities are less obvious. Still, in many cases, microLED

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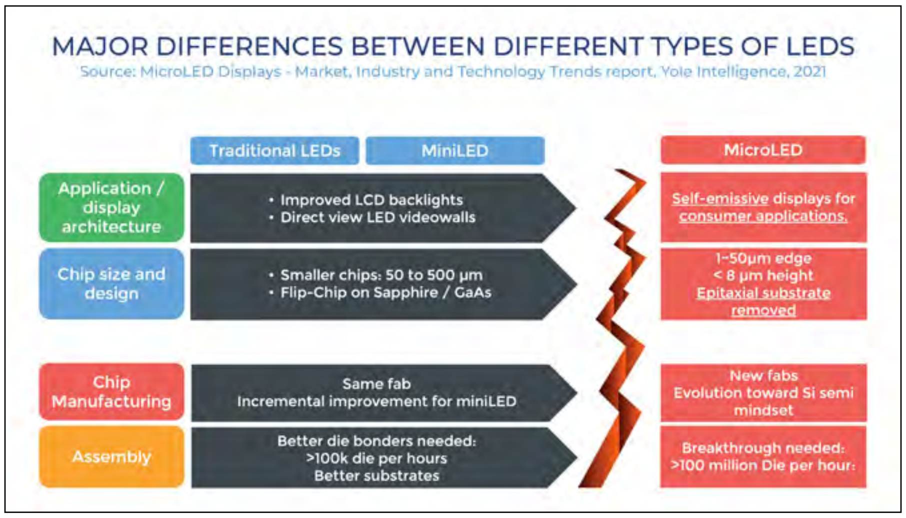

Figure 1: MicroLEDs, as defined by Yole Intelligence analysts: manufacturing challenges remain, but the emerging display technology looks like the only one capable of providing the right combination of cost, brightness, efficiency, and size for AR glasses. Credit: Yole Intelligence.

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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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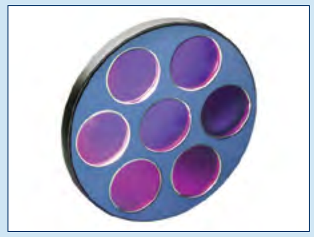

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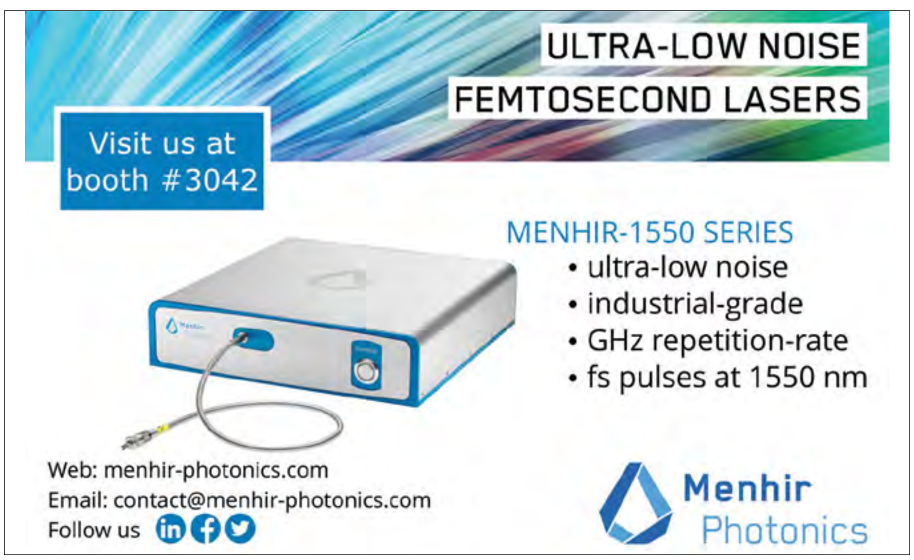

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polymer optics perfected

MicroLED displays continued from page 13

hasn't yet leveraged the many existing technology bricks and wafer processing equipment that could help deliver a 20-50x reduction at a faster pace than it took LCD.

The single largest contributor is the microLED die itself. The die cost essentially scales with its area. The first generation of Samsung's 110-inch microLED TVs used a die size of 75 microns by 125 microns. Decreasing the die size to, say, 10 microns by 10 microns would decrease die cost by almost 100 times.

Manufacturing yield is also a significant cost contributor. MicroLED displays can be assembled cost-effectively using a mass transfer process where tens of thousands of microLEDs can be assembled in a single pick-and-place operation. But even if you achieve a 99.5% yield on an 8K TV with close to 100 million microLEDs, you will still have about half a million defective sub-pixels! Since these are randomly distributed across the surface, they have to be replaced individually, and the repair cost becomes unmanageable. The industry must, therefore, make significant progress in yield management and repair technologies.

What are the major technological hurdles that need to be addressed before microLEDs can be mass-produced?

At this stage, I would say that all the fundamental technology bricks exist. MicroLED is no longer a science project — it is a massive manufacturing and cost-reduction project.

An increasing number of established semiconductor and equipment makers have developed and are now offering commercial microLED mass transfer, repair, and testing equipment and solutions. This is a paradigm change: until 2020, a company interested in developing microLED displays first had to invent its own transfer process and build the corresponding equipment. Fast forward to 2022, and more than a dozen tools are available off-the-shelf from reputable display and semiconductor equipment manufacturers. The availability of these off-the-shelf tools is lowering the barrier to entry and accelerating development cycles.

What role do you expect industrial lasers to play in microLED manufacturing?

Lasers will play an essential role in microLED display manufacturing. Use in TFT (thin-film transistor) manufacturing for annealing, cutting, and circuit lift-off, similar to OLED, will remain unchanged. In addition, laser-based mass transfer processes to assemble the display are rapidly gaining ground. They are competing with slightly more mature "stamp-based" processes. The two are often opposed, but each has its pros and cons, and we believe that both will actually coexist, sometimes within a single workflow. For example, a laser transfer can be used to detach the die from a carrier and eliminate known bad dies, and a stamp-based process can be used for the final assembly.

continued on page 23

Samsung has launched its 89-inch microLED TVs, but with each one costing $100,000 it will remain a niche product. Credit: Samsung.

Edmund Optics: global player with family values

Show Daily caught up with Marisa Edmund — the recently appointed third generation family member to head the Edmund Optics Board — ahead of Photonics West.

Edmund Optics has come a long way since the New Jersey company was founded in 1942. Initially named Edmund Salvage Corporation, amateur photographer Norman Edmund started the business to sell military-surplus optical parts like lenses. When Norman retired in the 1970s, his son Robert split the by-then much expanded consumer and industry arms of the business into two companies: Edmund Scientific and Edmund Optics (EO). Fast forward to today and EO has over 1200 employees and is a leading global manufacturer and supplier of optics, imaging, and photonics technology, offering more than 37,000 unique optical components to customers across the world.

With retirement beckoning, in 2022 Robert passed the torch on to two experienced EO executives Samuel Sadoulet and his daughter, Marisa Edmund, who are now CEO and Chairman of the Board, respectively. On announcing the appointment of his daughter to this new role, Robert said: "With her experience, leadership qualities, and inspiring vision, Marisa is uniquely positioned to guide Edmund Optics into the future. I am also proud to see our Edmund family legacy continue."

Show Daily: Are you enjoying your new role?

Marisa Edmund: I've worked in the business 25 years, ostensibly 46 years if you count growing up in my dad's office for weekends and anytime I was sick. When I was a child, they put a cot in my dad's office and I got to stay in there with him. So, I had a different childhood than most people, immersed in the business even at two and three years old. Having said that, I have big shoes to step into. My father made a huge impact on the industry and among our family. But I feel like I'm ready to take over and I'm enjoying the role.

How does it compare to your previous roles at EO?

The biggest difference is that I really have to take a big step back and look at the company from a much more strategic position. I have to think about what the company needs in five years, what the family needs (because we're still 90% owned by the family), and then figure out how to marry those two priorities in a long-term strategic plan.

What are the key challenges EO is dealing with right now?

Everyone at Photonics West is going to be talking about the impact of inflation, the impact of currency exchange rates, and certainly the geopolitical tensions we have in Europe and some other places. The interesting part about Edmund is that now we are global, we're able to mitigate some of those risks by having operations in 13 different countries and collaborating with partners, or other sister factories. For example, if there's a shipping issue in the UK, maybe we can reroute through Singapore. Or if a customer would prefer not to get their products from a certain country, maybe I can offer it through our manufacturing in Germany or the US. Logistically, we're able to leverage all those unique locations so that we tend to be able to overcome those hurdles pretty quickly and keep our lead times low.

Something unique about the optics industry is that the company you could consider as a competitor or a customer or a vendor often becomes all three to everyone. A lot of industries are very litigious or they're worried about IP, whereas our industry looks to see how we can help one another. I think the optics industry, which has always been based on collaboration, is going to be leaning on each other even more in 2023 to deal with these challenges.

Do you have plans to take EO in any different directions?

We're very committed to our foundation which everyone knows is service and providing the widest breadth of optics and photonics products in the marketplace. But some of the opportunities to improve the company are really around a lot of our new technologies, specifically laser optics. We're making a huge investment in our laser optics products, our technology, our experts.

We acquired a company a few years ago — Quality Thin Films in Oldsmar, Florida — and we recently moved it to a new facility that's three times bigger. So I have high hopes for this facility to do significantly more laser optics for us than what you see in the catalogue and also continue down that precision scale towards ultrafast laser optics.

What exciting new products are you working on at EO?

As I mentioned, we're doing a lot around ultrafast optics, and we'll have those at Photonics West and in our new spring catalogue that'll be coming out in January. One thing we're specializing in and that I'm pretty excited about is ruggedizing optics so they can be sent anywhere. Optics are going into all sorts of neat and interesting places today, including optics designed for really harsh environments. We've worked with customers using drones to ensure that their herd of cattle is in the right place and researchers conducting iceberg research.

Right now, we talk about space quite a bit and that just requires a level of ruggedization never before seen. If you think about the temperature differences and the things that happen when an optical assembly goes into space, trying to handle that and find materials that are space friendly is a huge challenge, and our team has been able to do that pretty successfully. We're taking what were once lab-grade optics, lab-grade capabilities, and then putting them into real-world super harsh environments like space.

Marisa Edmund, the third generation Chair of EO Board. Credit: Edmund Optics.

As the only female chairperson in the industry, are you keen to see greater diversity in the optics community?

I think optics and photonics is challenged in the same way that a lot of other STEM fields are challenged in terms of encouraging women and minorities to get involved and to look at it as a career path. One of the things I did when I began my full-time employment here in 1998 is evaluate how well we support female employees from our benefits and the things that we offer to them. And so I restructured the benefits program to ensure that we had daycare reimbursements, gym benefits, and the right types of healthcare that would support women being in work full-time. We spent a lot of time building what I would call a family-based culture of values, which contains DEI [diversity, equity, and inclusion] programs, benefits programs, and inclusive environments where everyone feels welcome. There have been times in our company where 60% of our technical-facing staff have been women, so it's been successful.

Something I now do personally is ensure that I'm meeting with all of our interns over lunch, and as new staff are coming in onboarding them and ensuring that they understand our values and that not only are we a woman-owned company, we are a woman-run company. I want them to realize that if I can do it, they can do it. I would just encourage everyone to look at their DEI programs and think about their benefits, what they have to offer, and what they could be doing to ensure their environments are more inclusive.

What are your priorities long term?

I'm not sure that optics is fully recognized in the way it needs to be, given its importance to the future and future technology. So I think it's incumbent on a lot of us as corporations and partners in the industry to have awards and recognition that enable a greater level of visibility. Our annual Educational Award and Norman Edmund Award are really trying to encourage innovation at schools and research labs, and also provide them the recognition they deserve for the projects that they're doing.

Our Educational Outreach Division also does a fabulous job of getting the message out there. We give out free optics kits to schools. We have schools, summer camps, and other youth organizations come on site here several times of month to do training and receive free optical kits. And about 60–70 employees volunteer their time outside of work to go and attend science fairs and other events throughout the US to educate young people about optics.

How do events like Photonics West contribute to enhancing the optics industry's visibility?

I think overall Photonics West and a lot of our global shows are an incredible opportunity to get visibility to the optics industry to people who don't know what it is or who think we make eyeglasses. The more people we can get to the Show, the more visibility we give our industry and the more opportunity for both funding and recognition in the future.

continued on page 23

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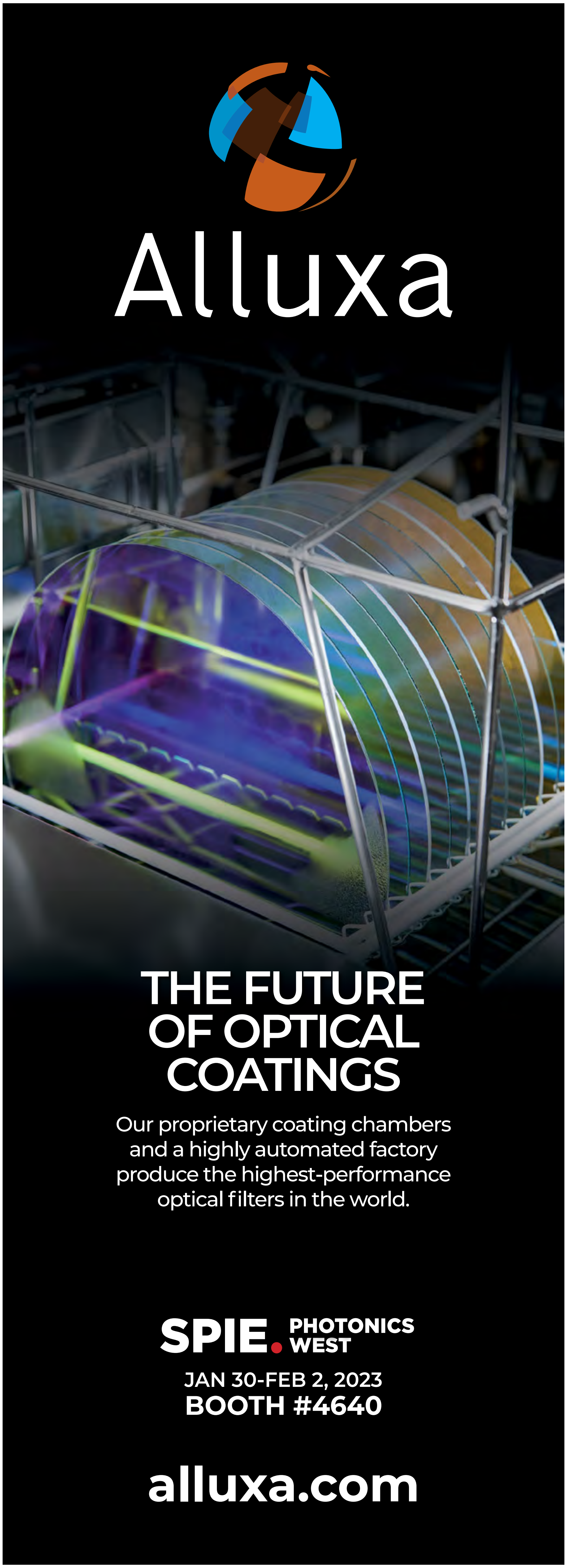
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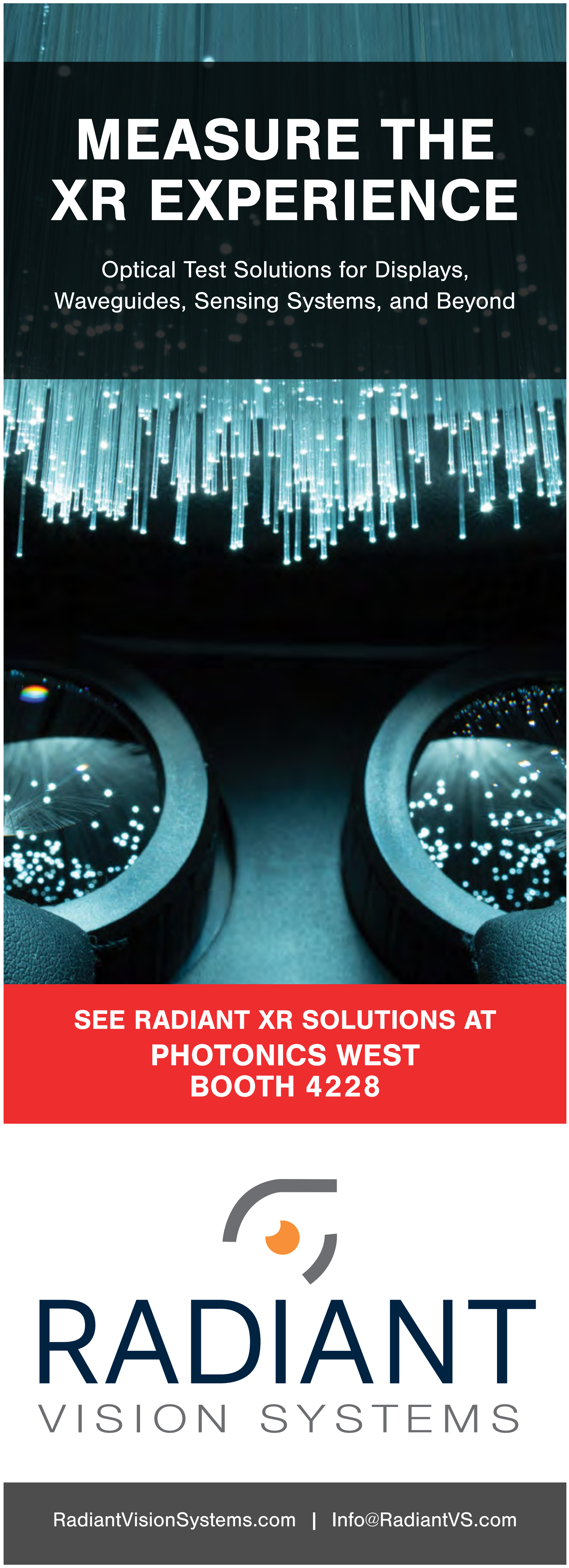
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MicroLED displays

continued from page 19

Laser transfer uses UV lasers, often excimer sources, although we're starting to see tools based on DPSS lasers.

When will we start to see mass production of microLED displays for consumer applications?

A few products are already available, such as Vuzix AR glasses and Samsung's 89-inch microLED TV. This TV costs more than $100,000, though, so it's not likely to move the needle much for the global display industry. We expect Apple's smartwatch to be the first real high-volume consumer product. Manufacturing ramp-up is scheduled for 2024, but that's an aggressive schedule. Any production ramp glitch and the schedule would slip to 2025.

We don't expect any meaningful adoption for TVs until around 2026-2027. Automotive applications could emerge around the same time.

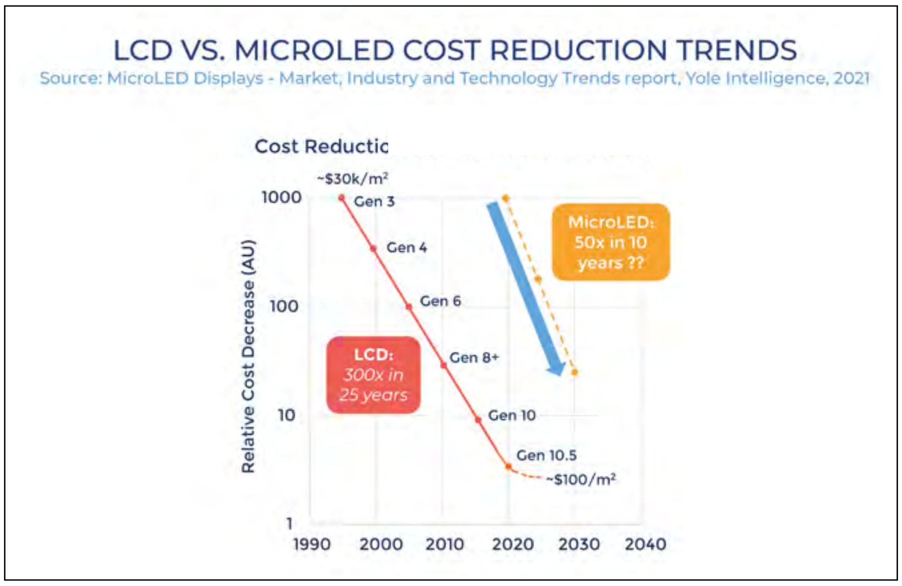

Figure 2: Matching the cost reduction pattern achieved with LCD panels will be a major challenge. The single largest contributor is the microLED die itself. Credit: Yole Intelligence.

Do you think that microLED will remain a niche technology, or to be adopted widely?

We struggle to provide a cost model where microLED could be significantly cheaper than OLED. MicroLED will likely never compete with LCD, which will probably remain the workhorse for TVs, monitors, and even automotive. If successful, however, microLED could be a serious competitor for OLED in high-end TVs, automotive, or smartphones, but that's still a way ahead.

Microdisplays for augmented reality glasses is another story. For this application, microLED is the only display technology capable of providing the right combination of cost, brightness, efficiency, and size. The challenge is in realizing full color microdisplays since there is not yet any good solution for producing all three colors on the same LED epiwafer and at the required size. Until full-color microLED microdisplays are available, liquid crystal on silicon and MEMS-based displays are set to continue dominating the field.

MIKE HATCHER

Edmund Optics

continued from page 20

Where can attendees connect with EO at Photonics West?

This year, we have two EO booths in the exhibition space. At the main booth, we'll be talking about custom manufacturing for aspheres and filters. In addition to that, we have this really neat high-resolution telecentric lens demo incorporating a lot of new sensor technology. Our second booth is going to be just about the new laser optics coatings that we're doing and it's going to be staffed by our unbelievably talented laser optics team from around the world. So they're going to be showcasing their talent and what we have to offer, as well as the new Florida facility and all sorts of exciting samples and demonstrations.

We're also sponsoring the Start-up Challenge, giving a few talks, and Edmund employees will be milling around talking to vendors and small companies to collect ideas for new products for our catalogue and marketplace. We'll be looking for innovative companies who can be added on our website and have global exposure to their products and ideas.

BEN SKUSE

SPIE works with industry and policy makers to update export control regulations

National security concerns and associated export prohibitions can conflict with technology manufacturers' hopes of selling their goods overseas — meaning that careful lobbying is needed to navigate a route to permissible international trade.

For many years SPIE has been hearing from our community on the impacts of export controls and the need to assist regulators to make informed decisions. We have worked diligently with businesses and universities in our community on proposals to make changes to the international agreements governing export controls for a significant portion of the developed world. This process, as one might imagine, is long and bureaucratic with many potential pitfalls along the way that can derail a proposal from being adopted. Thanks to a consistent and collaborative effort from SPIE and the business community we have recently seen positive updates to two regulations that will have direct impact to the optics and photonics community.

Wassenaar Arrangement

In December, 2022, the Wassenaar Arrangement (WA) announced the agreements that were adopted by the 42 participating countries for 2022. Among these proposals includes two laser proposals that SPIE helped shepherd through the system through our work as chair of the Sensors and Instrumentation Technical Advisory Committee (SITAC) at the Department of Commerce and co-lead of the WA Laser Working Group in conjunction with Spectaris.

One of the proposals adopted increases the power limit for high-powered non-tunable pulsed green lasers from 50W to 80W. SPIE worked closely with representatives from affected companies and the US government to bring forward this proposal. Commercial applications for these types of green lasers include photovoltaic production, micro-electronics manufacturing, glass processing, and other industrial applications. Power levels are key to faster manufacturing productivity. This is because to increase the pulse frequency you must increase the power level.

The limit of 50W of power in regulation put companies with manufacturing based in countries that comply with WA agreements at a competitive disadvantage because a license was required to export outside the country beyond this power limitation. However, there are multiple companies based in China that manufacture this type of green laser exceeding the power threshold of 50W, for example the companies YSL Photonics, Logan Laser, and Beijing ZK Laser. China is not a member of WA and therefore does not comply with the international body's export restrictions. Increasing the wattage limit to 80W puts companies based in WA countries on a more even playing field to compete with this Chinese companies in the international marketplace.

Single mode semiconductor lasers

The second proposal adopted makes changes to an entry controlling single mode semiconductor lasers with a wavelength greater than 1,510nm. SPIE worked closely with both Luminar and the US government on this proposal. In order to increase the power level for automotive lidar applications, we requested that the wavelength in the applicable entry to be changed to 1,570nm. This change moved lasers between 1,510nm and 1,570nm to a different regulatory entry. We then requested the power limit of this entry to be increased from 1.5W to 2W.


Jennifer O'Bryan.
Credit: SPIE.

Increasingly single-mode, eye-safe laser diodes have been used for automotive lidar applications. By increasing the power limit to 2W for these lasers, we have cleared the path for commercial development of this technology without fear of export restrictions.

"We applaud the US government, in particular BIS, and the participating governments for agreeing to update export controls on single mode semiconductor lasers in light of the significant scientific advancements being achieved," said Luminar Vice President of Sensor Development Joe LaChapelle. "Our Freedom Photonics team at Luminar can now demonstrate over ten watts of single mode laser diode output in the C-band. Updating CCL 6A005 will allow significant cost and power savings improvements for high performance lidar systems utilized in proactive automotive safety systems and we appreciate the efforts of SPIE to connect industry with government to ensure the photonics industry is represented in these important policy decisions."

Meeting at Photonics West 2023

At Photonics West this year, SPIE and Spectaris are once again hosting a meeting of the WA Laser Working Group to discuss export control proposals for 2023 submission. The meeting is part of the industry program and is open to the public. Stakeholders within the laser community are highly encouraged to attend and participate. Wednesday 9:00 AM – 10:00 AM PST | InterContinental Hotel, Sutter (5th Floor).

JENNIFER O'BRYAN


Credit: SPIE.

WANTED: Optics and Photonics Technicians

AmeriCOM proposes a solution to address the growing need for technicians

As the expansiveness of Photonics West shows, the optics and photonics industry is booming. Photonics is enabling an impressive and growing number of applications and industries. As this technology advances, the demand for skilled technicians in the fields of optics and photonics is also increasing. Optics and photonics technicians are responsible for designing, assembling, and testing products that use light-based technologies. These products include optical components such as lenses, mirrors, and prisms and photonic components such as lasers and detectors — many of the products seen on the exhibit floor this week.

This demand for technicians and the related shortages will be addressed at a panel discussion today hosted by AmeriCOM — the American Center for Optics Manufacturing. AmeriCOM is working with optics manufacturing companies, community partners, and academic institutions to create regional ecosystems as part of a Workforce Development Initiative to identify and train new technicians.

"Our goal is to increase the capacity and quality of skilled optics technicians by a factor of 16 — from less than 50 per year to more than 800 per year by 2025," says panelist and AmeriCOM's National Marketing and Workforce Development Operations Director, Josanne DeNatale.

In hosting the panel, AmeriCOM aims to show the impact a coordinated partnership between industry and academia can have on increasing the number of people entering the field. Hopefully, recruiting more companies to get involved in the effort; as DeNatale notes, "companies need to be our most vocal ambassadors for the field of optics, a field largely unknown to the general public. Other ways to support this effort include advising local colleges on optics curricula, encouraging experienced professionals to serve as adjunct professors, participating in apprenticeship programs, or offering shadow days or tours of their facilities to students interested in optics."

Partnering with academia is an essential part of AmeriCOM's mission as fellow panelist Dr. Amanda Meier of Front Range Community College (Colorado) confirms, "Our Optics Technology program must stay connected with industry partners and AmeriCOM to provide relevant skills training for optics technicians on state-of-the-art equipment, in addition to helping market our program and career options to fill the optics technician pipeline." As the Program Director and Faculty in Front Range's Optics Technology Program, Meier has seen firsthand how acute the need for technicians is. Since joining the program in 2020, she knows of only one student who completed the program not finding a job — and that was primarily due to citizenship requirements by the employers in the local area.

All the way across the United States from Front Range Community College, employers in New York are seeing the same demand for technicians. Director of Technology Mike Hyman says Optimax is looking to their local community colleges, trade schools, and traditional recruitment efforts but has also benefited from apprenticeship programs offered by AmeriCOM and others. He puts the number of technicians hired over the past three years over 200, making up a large part of their growing workforce. Hyman will be a participant on today's panel and will present on their strategic partnership with AmeriCOM, including as a technical collaborator with AmeriCOM's technology and development group. "This helps us communicate what skill sets we think are needed in the future," says Hyman. "These collaborations address our needs now and ensure there is alignment for our needs in the future."

SPIE is also working to help address this growing need with scholarships for students pursuing technician certificates or degrees. In addition, they are also hosting educational materials in partnership with OP-TEC and others, promoting the field and jobs through web advertisements, and creating marketing collateral for institutions or companies to use in their recruitment efforts.

With 1300 exhibiting companies at Photonics West all working to develop the next great product, our growing industry will need to come together and collaborate to find solutions to this need, and AmeriCOM hopes to be a catalyst to this collaboration. DeNatale notes, "For every optics engineer focused on innovation, we need ten optics technicians to bring that innovation to market."

And Hyman sees the benefit of having someone help form the collaborations, "other optics manufacturing companies should consider working with AmeriCOM to help leverage resources within their geographic regions. In areas where resources are not available, AmeriCOM can help those companies with guidance and strategic partnerships to help bridge gaps."

Business Development Manager at Thorlabs, Navid Entezarian, agrees, "AmeriCOM is the catalyst that can bring public and private sectors together to achieve something greater than the sum of their parts. They've formulated the many steps required to set up a new optics training lab in their Playbook, which I recommend reading for anyone contemplating getting involved."

Like many of the scientists and engineers in attendance this week, AmeriCOM is trying to solve a complex problem and is looking for passionate collaborators and industry partners at Photonics West. They are tackling a big problem, but the optics and photonics industry has repeatedly proven capable of meeting challenging targets and AmeriCOM and its partners are not backing down.

KEVIN PROBASCO

ATTEND TO LEARN MORE

AmeriCOM Panel: Where Have All the Technicians Gone? How Optics Ecosystems Are Bringing Them Back

February 1, 2023
2:45 PM – 3:45 PM
Moscone Center, Expo Stage, Hall DE
(Exhibit Level)


Credit: SPIE.


Credit: SPIE.

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Moscone West, Career Hub (Level 1)

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31 January 2023 • 10:00 AM–5:00 PM
Moscone Center, Level 1 West

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1 February 2023 • 10:00 AM–5:00 PM
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31 January 2023 • 10:00 AM–5:00 PM

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A casual mixer to chat with recruiters from the Job Fair and other industry and academia professionals about careers in the optics industry.

31 January 2023 • 4:00 PM–5:00 PM

SPIE Job Fair

Tuesday 31 January • 10:00 AM–5:00 PM
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Moscone Center, Career Hub (Level 1 West)

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Biomedical research into noninvasive imaging, monitoring newborns' bloodcells

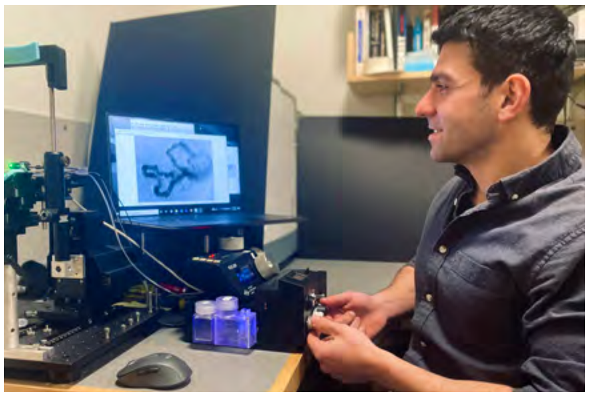
From a young age, Arutyun Bagramyan was driven by curiosity, a scientist's greatest tool. "I was always curious, always interested in understanding things," he says. "My mom was very patient, explaining pretty much everything to me." Years later, a self-directed path has taken Bagramyan through physics and engineering and into the biomedical field. "Working with living organisms is more interesting and more appealing to me than hard-core physics or pure optics," he says.

"Light is one of the most powerful tools with which to study living organisms, so mine was a natural convergence towards optics and photonics." Studying in that area also attracted him because of its interactive element: "I wanted something alive to work with!"

After gaining his PhD in physics and biomedical engineering, Bagramyan is now working in Charles Lin's lab at the Wellman Center for Photomedicine. Their translational project aims, in just one of its many potential applications, to innovate non-invasive imaging and quantification of white blood cells in neonates, an approach that potentially sidesteps the need for phlebotomy. The development of a compact, oblique back-illumination microscope (OBM) has garnered Bagramyan recognition as the 2023 recipient of the SPIE-Franz Hillenkamp Postdoctoral Fellowship in Problem-Driven Biomedical Optics and Analytics. The $75,000 fellowship, which supports interdisciplinary problem-driven research and provides opportunities for translating new technologies into clinical practice in order to improve human health, will help Bagramyan, Lin, and their team achieve an exciting and much-needed biomedical advancement.

Human research underway

"Dr. Lin was already working on this problem," says Bagramyan. "The existing benchtop device was quite big and bulky, and, when I arrived, I wanted to build something very compact — a mini-microscope — that is well suited for clinical applications." With neonates, says Bagramyan, size is very important: you just can't attach something big and heavy on a baby's arm or any other parts of their body that you want to image. So Bagramyan built a small-sized prototype microscope that his team is already testing. "We are doing a clinical study, a research study in humans, trying to validate our approach and show that it works. Then we are going to build a very compact version of our device and optimize it for neonates."



Dr. Arutyun Bagramyan: the 2023 recipient of the SPIE-Franz Hillenkamp Postdoctoral Fellowship in Problem-Driven Biomedical Optics and Analytics — which is worth $75,000. Credit: Bagramyan.

Part of what excites Bagramyan is that this innovation offers a variety of applications, holding promise for adult patients as well. His device is like an ultrasound device, he says. Ultrasound is a noninvasive approach, utilized in clinics to rapidly visualize and diagnose what's happening in a health-related context. "What we are developing is similar," says Bagramyan. "It's an imaging approach to noninvasive access of the immune system, without any exogenous markers involved."

"We are interested in your white blood cells," he continues. "How many there are, and what they are doing at any given moment. When you draw blood you have cells in a tube rather than in their natural environment of your body. Those cells have specific behaviors in their natural environment that you really should image in the human to see — like rolling, for example." Rolling is cell behavior that can't be observed in a tube. "This is one of the things that you need to do *in vivo*," notes Bagramyan. "You cannot see this in a tube because there is no blood vessel. The molecules expressed on endothelial cells of blood vessels increase adhesiveness between the white blood cells and vascular surfaces: this is where rolling movement comes in. It's one observational element of changes in white blood cell behavior. That aspect of this technology has a great potential diagnostic use: if there is a disease, infection, or inflammation present or developing, that can impact the cells' behavior — they usually become more adherent and roll more slowly. Sometimes, they even stop."

Technology offers 'great potential diagnostic use'

With real-time access to the immune system, clinicians can look at different pathogens, at autoimmune diseases, at cancer, and even at stress. "Stress has a major impact on the human immune system," says Bagramyan. "So does food: Fatty food can induce inflammation; therefore, you might have a certain reaction from your white blood cells. There are just so many branches of human health that can be studied using our device."

Moving into a more multidisciplinary approach with this translational work has also expanded Bagramyan's appreciation for collaboration. "Working in a team is way more productive. As engineers, we try to improve things and sometimes we are so excited about improving things that we don't ask ourselves, "Is this worth our time and effort?" For example, we try to improve resolution of an instrument and we put all our energy into that and work for a year, and then we meet with biologists or clinicians, and they say, "You know, we didn't really want this. Instead, we wanted this other thing." That's why it's important to work together and why a multidisciplinary approach is critical, so we can know ahead of time what is really useful. Working with other people definitely helps address this." His supervisor, Lin, has been instrumental in terms of support and mentorship; so, too, was Bagramyan's PhD advisor, Tigran Galstian, whose clear-cut curiosity, collegial professorship, and independent research approach continue to serve as inspiration. "That definitely changed the way I see research opportunities for myself," says Bagramyan. Ideally, the Hillenkamp Fellowship is just one in a long line of such opportunities.

DANEET STEFFENS

Lase plenary continued from page 01

in sensing what's on the road with the necessary precision, speed, and range. It's different to the telecom boom, he said, where success was possible with a focus on individual components. "We need to do this as a system," he stressed. "We need suppliers, and the volume requirements are going to be huge."

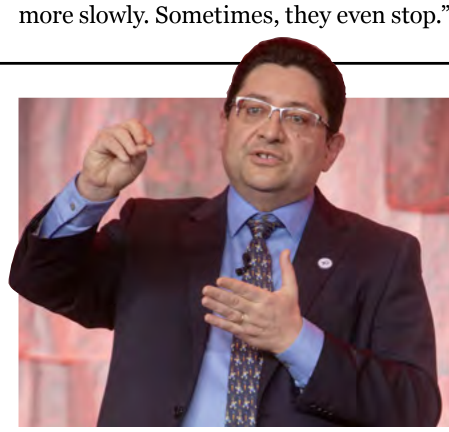
That system focus is evident in Luminar's strategy, which has seen the US firm expand with a series of acquisitions, giving it direct access to critical high-brightness lasers, photonic integrated circuits, software, and engineering expertise.

The enormous technical and economic challenges will also see a major shake-out among automotive lidar companies over the next couple of years, Eichenholz predicted, pointing out that at "peak lidar" there were as many as 90 companies active in the sector.

Rounding off the LASE session was plenary speaker Jean-Michel Di Nicola, who treated attendees to an insider's account of the National Ignition Facility's extraordinary recent achievements raising the prospect of fusion as a future energy source.

Di Nicola, NIF's chief engineer for laser science, outlined the past, present and future of inertial confinement fusion, saying that although the historic result from Dec. 5, 2022 was the culmination of six decades of pioneering work, it was "truly not the finish line."

As "Hot Topics" go, it doesn't get much hotter than the NIF fusion target, which reached 130 million degrees for a split second during the successful December shot. Even more impressive results could arrive as soon as this summer, with the NIF lasers set for an 8 percent increase in shot energy. Di Nicola also indicated that, as input energies rise over the next five years, the energy output yield from the 192-beam system should approach 10 megajoules. That compares with the 3.15 megajoule result from last year.



The fusion's so bright: Jean-Michel Di Nicola. Credit: Joey Cobbs.

The NIF team is already looking much further ahead, though. Di Nicola said that the team has just begun work on a design for the 2030-2040 time frame that would deliver an additional order-of-magnitude increase in yield, to 100 megajoules.

"Ignition has given us fresh impetus," he told attendees. "It's not going to be an easy road, and it will need collaboration with the [photonics] community, and both public and private partners."

The other key requirement is people, and Di Nicola issued a call to those in the audience who want to help deliver fusion as a bonafide commercial energy source. "We're hiring," he concluded. "Come and be part of it!"

MIKE HATCHER

SPIE global salary survey confirms photonics to be a lucrative career

With close to 20 companies at the Photonics West Job Fair and numerous others on the exhibit floor with signs indicating they are hiring, it's clear there is a market for optics and photonics engineers. This week at Photonics West, SPIE released its annual Optics and Photonics Global Salary Report which once again shows a career in optics is both rewarding and potentially lucrative.

The report, based on survey data from over 5,500 people in 101 countries, indicates optics and photonics professionals from around the world had a median annual salary of $80,000 in 2022, a 1.7% increase from the previous year's median of $78,644. SPIE delivers the salary report each year, free of charge, as part of its mission and community support efforts. This is the thirteenth annual survey and report, the largest such study in the optics and photonics community.

Full-time salaries cluster around the median of $80,000, with half of respondents being paid between $44,746 and $135,000. The overall distribution of pay is very wide, with 5th percentile workers earning $9,382 while those at the 95th percentile earn $245,000. Some of the main factors associated with differences in wages include geography, organization type, career stage, professional discipline, and gender.

Workers in Israel ($139,714), Switzerland ($136,625), and the United States ($135,000) enjoy the highest median salaries. For most countries represented in the survey, private sector workers report higher median wages than their colleagues in academia. In the United States, for example, full-time employees at for-profit companies earned $150,000 while their academic counterparts were paid $102,000 median salaries. At the other end of the wage spectrum, the countries with the lowest median wages are India at $14,574 and Egypt at $5,886.

Open for applicants: SPIE Job Fair. Credit: Joey Cobbs.

The standout country for wage growth over time is the Peoples Republic of China, where median salaries have risen from ¥90,000 in 2011 to ¥250,000 in 2022, an increase of 178%. Over the same timeframe, pay in euro and US dollars has grown 27%, from €47,200 to €60,000 and $106,000 to $135,000 median salaries. In the shorter term, Chinese yuan and Japanese yen wages were flat from 2020 to 2021, while euro and US dollar pay grew 15% and 4% respectively. Pay in British pounds declined 3%.

Over the course of their careers, optics and photonics workers receive steadily increasing pay. At academic institutions employees were paid $37,188 as new hires, $52,656 at mid-career, and $105,923 with 30 or more years on the job. At for-profit organizations, starting employees received $62,161, $100,887 at mid-career, and $160,000 after 30 years at work.

Most full-time workers surveyed (65%) identify as engineers. Within this group, 60% have engineering degrees and are working as engineers, 24% have engineering degrees but are not working as engineers, and 16% work as engineers without having engineering degrees. These subgroups of engineers earn respective median salaries of $90,773, $75,659, and $95,876.

The most popular engineering degrees in the optics and photonics community are electrical, accounting for 25% of full-time survey respondents, followed by optical (19%), and mechanical (12%). Electrical engineers earn a median salary of $91,201, while optical engineers earn $96,874. In terms of the type of work they do, 41% of survey-takers are engaged in optical engineering, followed by electrical at 10%.

Women make up 23% of the respondents to the survey, 33% of students, 19% of fulltime workers, and 31% of part-time workers. Median salaries are 19% higher overall for men than for women, up from a 16% difference in last year's survey. Women earn median salaries of $69,000 versus $73,225 for their male colleagues. Men have higher median salaries at all types of employers, though women at 5-10 years and 16-20 years of employment have higher median salaries than their male colleagues.

To see the full results, pick up a report booklet at the SPIE booth (3238).

ADAM RESNICK

FULL-TIME SALARY SUMMARY STATISTICS

Mean = $99,566
Median = $80,000

- 5th percentile = $9,382
- 25th percentile = $44,746
- 75th percentile = $135,000
- 95th percentile = $245,000
- 99th percentile = $380,000

n = 4,047

Source: SPIE

Quantum Association continued from page 01

secure communications sectors," said Taro Shimada, Chair of the Board for Q-STAR.

Since early 2022, the consortia have been meeting to exchange ideas. Together, it was determined that the consortia could more effectively drive the industry forward by collaborating on events and increasing the lines of communication among their respective member companies. In April 2022, the consortia released a joint statement for World Quantum Day with the goal of finding new ways to work together to advance the greater quantum ecosystem.

"Quantum innovation and quantum markets are emerging worldwide," said Celia Merzbacher, Executive Director of QED-C. "The formation of this council creates lines of communication and collaboration that will help our members in countries and regions with common values and with many economic linkages to develop supply chains, open markets, exchange talent and support policies that benefit the emerging industry and society."

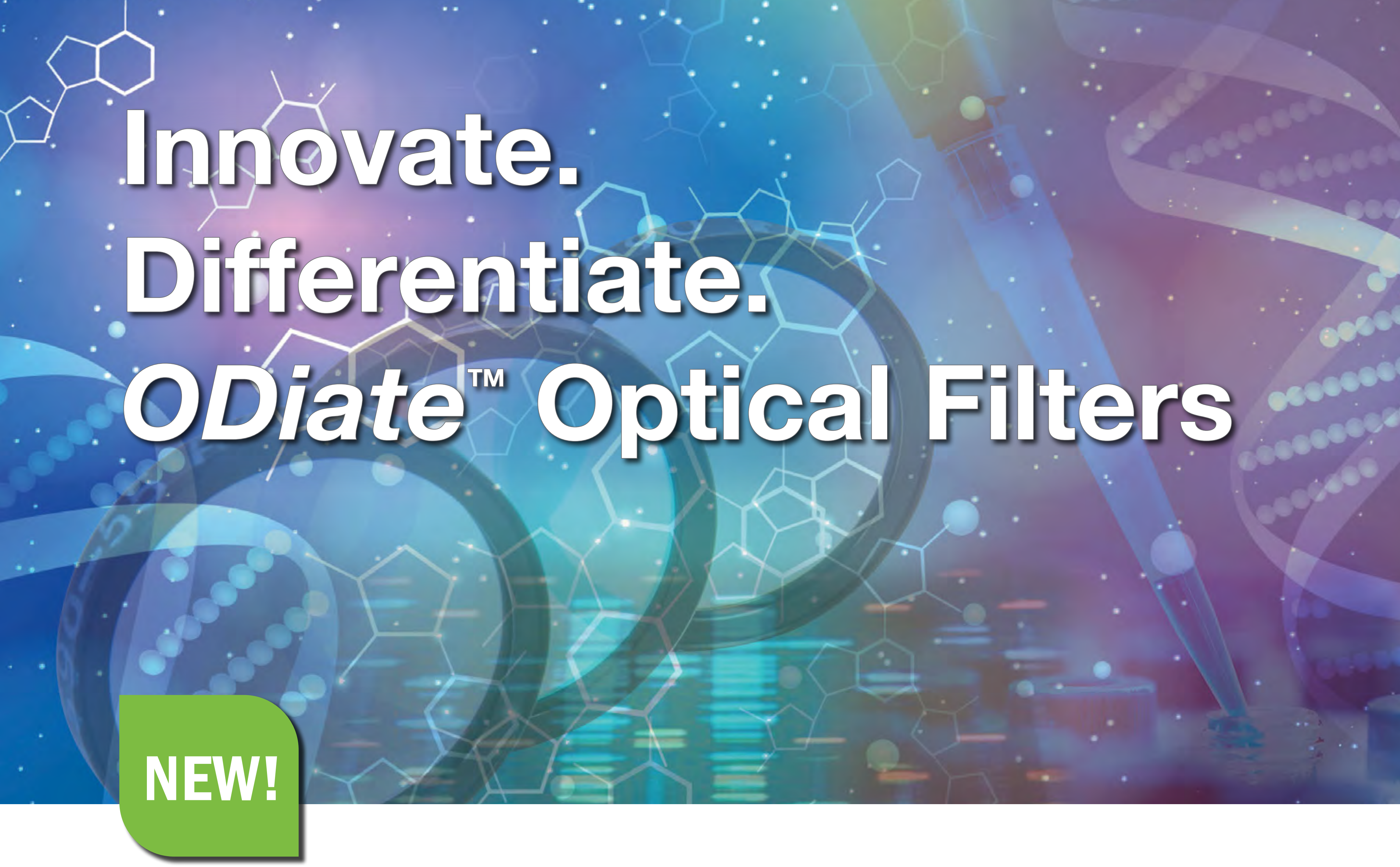
The current participating consortia are hopeful that the council will continue to grow. Michele Mosca, Chair of the Board of Directors for QIC said, "We look forward to working with our counterparts around the world to continue to grow and strengthen the quantum ecosystem at an international level."

Thierry Botter, Executive Director of QuIC added, "We are at the beginning of a global technological revolution. Forming the council and working together promotes equity and reciprocity in the advancement of the international quantum ecosystem. It allows our communities to discuss areas of common interests, such as international standards, intellectual property and access to funding."

The consortia also welcome new member companies and interested organizations can learn more by visiting their respective websites.

The consortia deciding to sign the MOU at a break in the Quantum West programming this week at Photonics West is an indicator of the impact photonics will have on the future of quantum technologies and its growing presence on the exhibit floor.

KEVIN PROBASCO



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