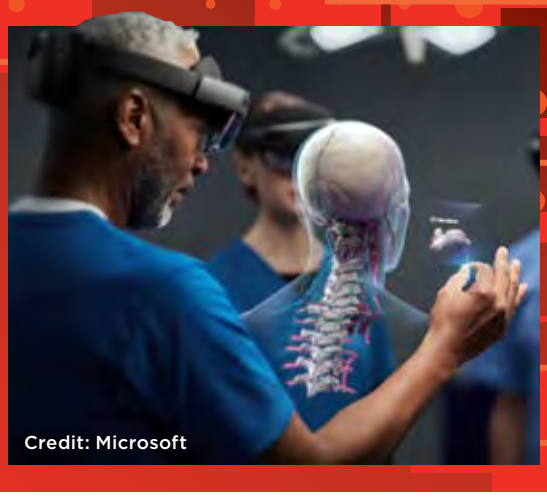
TUESDAY
EDITION

SPIE. | optics.org | TUESDAY JANUARY 25, 2022

PHOTONICS WEST SHOW DAILY

AR|VR|MR: Enter the metaverse
p. 12


Credit: Microsoft

SPIE, University of Rochester create $1M fund

On Monday, during the LASE plenary, SPIE, the international society for optics and photonics, and the University of Rochester announced the establishment of the SPIE Graduate Fellowship in Optical Sciences and Engineering. The $1 million endowment — a $500,000 gift by SPIE has been fully matched by the university — will provide financial assistance to selected University of Rochester graduate students at the Institute of Optics working towards their PhDs.

(l-r) Thomas Brown, Kent Rochford, and Anita Mahadevan-Jansen. Credit: Joey Cobbs.

"The SPIE Graduate Fellowship in Optical Sciences and Engineering will create transformative opportunities for PhD candidates at Rochester's Institute of Optics," noted SPIE President Anita Mahadevan-Jansen. "Rochester has a long history of successful optics education and many of today's leading optics researchers have emerged from its Institute of Optics. This endowed fund is a critical partnership between SPIE and the University of Rochester, one that will help ensure that pipeline of leaders continues for generations to come."

"We are so grateful to SPIE for making this kind of investment in graduate education in optics," said Interim Director at the Institute of Optics Thomas Brown. "Our alumni have had important leadership roles in SPIE through the years, and this will be a huge help in preparing the next generation of leaders in the optics community."

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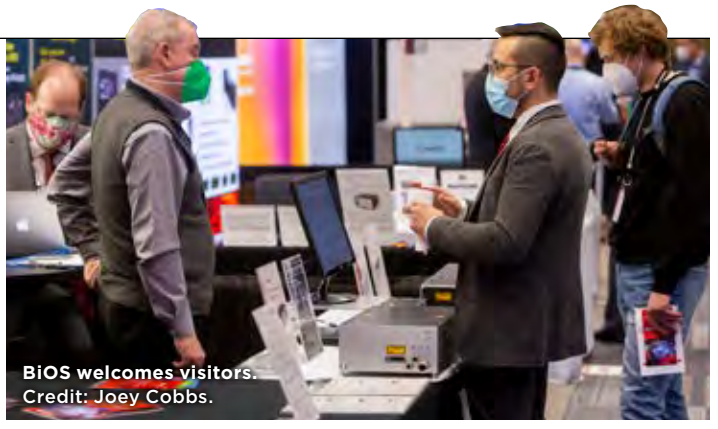
Back to business...

BiOS opens with exhibitors eager to meet their customers and showcase their latest products after a long hiatus.


BiOS welcomes visitors. Credit: Joey Cobbs.

Masks and hand sanitizers were prevalent on the BiOS exhibition floor at SPIE Photonics West this week – but so were the products, innovations, and customers that keep the industry growing. Exhibitors were happy to be back, relishing a long-awaited opportunity to re-convene and do business in person.

"I was very thankful that SPIE decided to hold Photonics West this year," said Lumibird Regional Sales Manager Andrew Larsen. "I felt that it was important to get out in front of the customers again. We've had future conferences that have already been cancelled, so it was great for SPIE to make the necessary changes and take the necessary precautions to get us in front of customers."

Since Photonics West 2020, there have been a number of virtual conferences and exhibitions, but none of them were able to

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DON'T MISS THESE EVENTS TODAY.

PHOTONICS WEST EXHIBITION
10 AM – 5 PM, Moscone North/South Exhibition Halls

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

NANO/BIOPHOTONICS
10:30 – 11:30 AM, Rm 207 Moscone South, Level 2

FIRST TIMERS MEETUP
10:30 – 11:00 AM, Membership Info Booth, Moscone West

STARTUP CHALLENGE: PHOTONICS STARTUP FUNDRAISING PITCHES
11 AM – 12 PM, Expo Stage, Hall DE

INDUSTRY INITIATIVES FOR THE COMMERCIAL QUANTUM INFRASTRUCTURE
2 – 3:30 PM, Quantum Hub Stage, Hall A Lobby

STARTUP CHALLENGE FINALS
2:15 – 4:15 PM, Expo Stage, Hall DE

PANEL DISCUSSION ON QUANTUM COMMERCIALIZATION: PHOTONICS FOR QUANTUM
4 – 5 PM, Quantum Hub Stage, Hall A Lobby

LASE POSTER SESSION
6 – 8 PM, Moscone West, Level 3

For the full schedule, see the SPIE Conferences app. Some events require registration.

IN THIS ISSUE.

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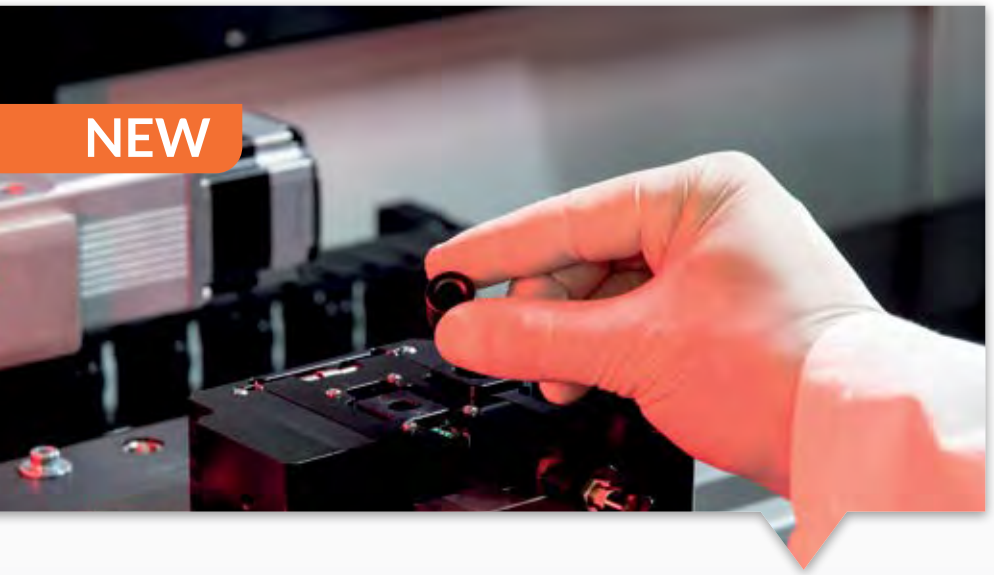

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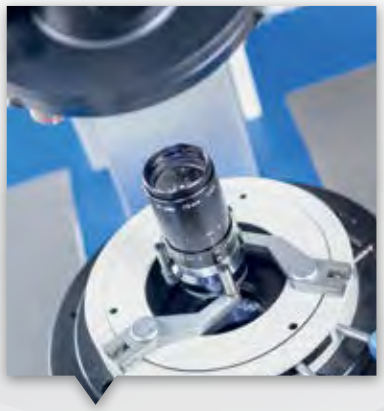

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Testing of image quality

Alignment and testing of camera modules

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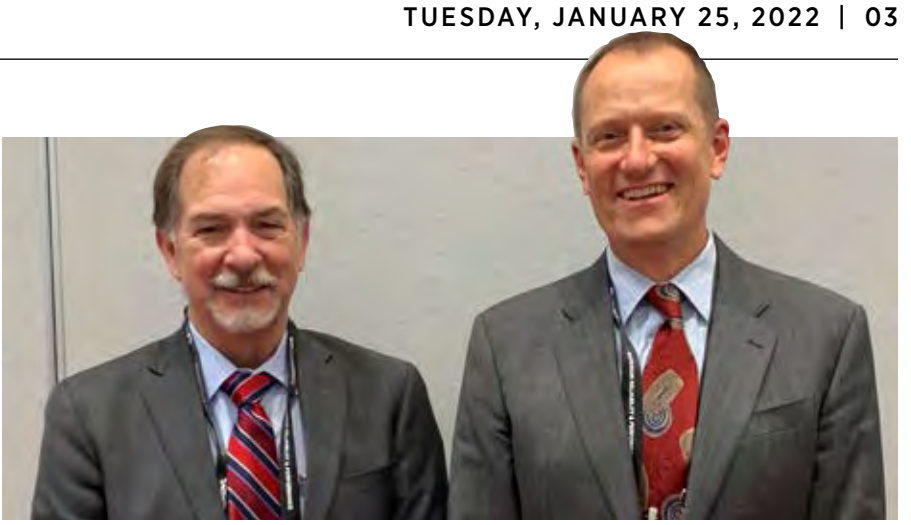
Charting 20 years of high-power diode laser progress



Nuburu Inc.'s Mark S. Zediker, and consultant Erik P. Zucker. Credit: William Schulz.

This year's Photonics West marks the 20th anniversary of the "High-Power Diode Laser Technology and Applications" conference, co-chaired by Nuburu Inc.'s Mark S. Zediker, and consultant Erik P. Zucker. "And it's still going strong," Zediker remarked at Sunday's session. He noted that from a one-day conference in 2003 that featured 19 papers, the 2022 conference features some 50 papers spanning two days of the meeting.

Zediker said the co-chairs thought it would be fitting to begin this year's conference with a 20-year retrospective that looked at major topics and trends in the diode laser industry since 2003. For example, he noted that diodes for industrial solid-state and fiber laser pumping and direct diode have driven much of the progress over the years, with focus in the 9XX nm wavelength band.

Over the years, Zucker continued, researchers have presented work on a wide variety of topics: applications, optical, thermal, and mechanical modeling; die attach and micro-optic assembly; reliability and failure analysis; long and short wavelengths; and more.

Power and reliability have been major themes concerning single emitter diode lasers, he continued, noting that single emitter power is now increasing to 25W-per-chip and beyond. Typical 9XX nm diode efficiency was mid-50 percent in 2003, reaching 73 percent peak efficiency by 2005, thanks mainly to research funding from the US Defense Advanced Research Projects Agency. Today's commercial devices, he said, have reached 60 to 70 precent operating efficiency.

Brightness, as measured by fiber-coupled output, was another big topic, he said. Progress has evolved from a single emitter diode at 5W in 2004 to a six-emitter diode at 60W by 2009. "We are now pushing powers up to 400W," he said. In terms of costs, he noted that a fiber coupled diode of 100 µm aperture has come down from thousands of dollars to less than $100 today.

Zediker discussed laser diode bar history. He noted highlights including maximum power has evolved with improvements in chip power/efficiency and cooling technology; and that direct diode laser systems have found significant applications in brazing, cladding, heat treatment, and annealing.

The future is bright for diode laser technology, he said, noting that researchers will continue to improve brightness and power of diode laser bars; that high-power visible wavelengths have emerged as new tools for welding and additive manufacturing; and that high-power diode laser technology is used in many applications including industrial, medical, display, illumination, and defense all of which will continue to drive advances in coming years.

WILLIAM SCHULZ

Courtesy Shy Shoham.

Imaging excited neurons reveal brain insights

The excitement never stops at Photonics West and Sunday's Neurotechnologies Plenary didn't disappoint. The first talk: "Exciting Insights into Neural Coding with Sculpted Wavefronts," by New York University's Shy Shoham, professor of ophthalmology, and of neuroscience and physiology, and co-director of the NYU Tech4Health Institute.

He described his lab's use of holographic optical neural interfaces to explore the brain's readout of encoded external stimuli. It is the process by which stimulus is presented to the nervous system, converted to activity patterns in the brain, and then the activity pattens are read out to inform behavior. Shoham said it is a process that researchers know little about and that has been the subject of great controversy in neuroscience.

Shoham's lab has had a longstanding interest in holographic optical neural interfaces, tools they have applied in the olfactory bulb of awake, behaving animals. "We would like to image odor responses and sequences and combine this with stimulation to probe perception and network structure," he said.

To explore the brain's readout function, studies that might also inform development of artificial neural networks and deep learning, "We would like to be able to reproduce the features of odor-evoked activity in [mitral] cells, monitor them, and measure how these patterns are interpreted by the mouse to guide its behavior, and do that in an all-optical fashion," Shoham said.

For their study, mice were trained to

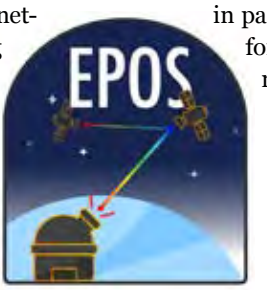
continued on page 29

G&H WINS ESA CONTRACT FOR NEXT-GEN SATELLITE-TO-GROUND AMPLIFIERS

G&H (booth 949), the specialist manufacturer of photonic components and systems, has been awarded a €2 million European Space Agency (ESA) contract to develop the next generation of optical amplifiers that will enable multi-terabit/s free space optical communication links (FSOC) between satellites and ground-stations.

Current high-speed communication is based on the encoding of data in laser light sent through fiber optic networks laid across the planet, and under the oceans. In FSOC, light is transmitted in laser beams through the atmosphere or the vacuum of space, removing the need for long distance fiber optic networks. As these laser beams propagate in straight lines, networks of satellites will relay data from around the earth's curvature, before transmission back to Earth.

G&H has long been known for its HI-REL couplers that are an essential part of undersea fiber optic networks. The firm has also long been part of the FSOC revolution – notably designing optical amplifiers for the JAXA LUCAS mission that in 2020 demonstrated a world-first Gbit/s optical link between a satellite and a ground station.



Project EPOS (Extremely Powerful Optical Sources), intends to develop two different amplifier systems, one for use terrestrially and one for use in space. The amplifiers will be support 25 channels emitting 1000 W (terrestrial) and 100 W (space) of diffraction-limited light in the optical C and L bands. These power levels far exceed the few watts level employed on LUCAS.

The project is part of, and funded by the ESA Scylight framework, and will commence immediately – running for 30 months. G&H is the sole entity on the project with all systems being designed and produced in the company's optical integration facility in Torquay, UK.

Matt Welch, Chief Engineer Fiber Optic Systems, commented, "The award of this contract is in recognition of G&H's heritage and world-leading expertise in fiber optical systems, and in particular optical amplifiers for free space optical communications. With the development of commercial FSOC, we will see a paradigm shift in how data links are created across our planet.

MATTHEW PEACH

Dairy Distillery in high spirits with Pleora inspection system

Full-fat vodka! Credit: publicenergy/ Creative Commons.

Canadian exhibitor Pleora Technologies has revealed that Dairy Distillery, a customer turning waste milk products into premium vodka, is saving costs on labeling thanks to its visual inspection system.

Dairy Distillery has pioneered a process using milk permeate — a sugary by-product normally thrown away after cream, fat, and proteins have been removed from whole milk, to make more familiar dairy goods like butter, ice cream, and yogurt — to create the spirit.

The Almonte, Ontario, business now ships over 100,000 bottles of its flagship Vodkow Vodka and cream liquors to customers around the world. During the pandemic it also produced hand sanitizer for hospitals and vaccination clinics in Ottawa.

According to Pleora, bottles of Vodkow feature machine-positioned labels with a distinctive emblem that is hand-placed by a human operator, something that demands accurate alignment of the emblem with other brand elements on the main label.

Neal McCarten, co-founder and director of marketing at Dairy Distillery, said: "When you say you're making vodka from milk, it can be a leap of faith for a consumer until they taste the product. Our packaging, fashioned after a traditional milk bottle, and eye-catching labeling is a real 'shelf talker' that helps a consumer connect with the story behind the product. Consumers often judge what's inside a bottle based on its appearance."

To help ensure brand consistency, the distillery uses Pleora's vision system to add decision-support for manual labeling processes. "The camera-based system integrates pre-packaged artificial intelligence plug-ins that are easily trained on a customer's unique requirements to visually highlight product differences and deviations for operators and inspectors on a display," notes McCarten. "The distillery trained the 'Image Compare' plug-in to identify key brand elements on the bottle, with a real-time on-screen image overlay, then guiding operators as they manually place the emblem. In addition, the system can be used as a training tool to teach new employees on brand quality standards."

Dairy Distillery's 'Vodkow' spirit, produced from milk permeate sugar, is labeled with assistance from Pleora's visual inspection system. Image: Dairy Distillery.

The upshot is that the distillery can reduce costs and avoid production downtime resulting from labeling errors. And as Dairy Distillery looks to further automate its production, it is now investigating more applications of Pleora's system for quality control.

The distillery's COO, David Geros, said: "Packaging errors translate into downtime, slower production, and higher costs. Pleora's system is easy to use, and helps remove ambiguity and stress for employees. We can check a product and know immediately if the labeling is within tolerance. As a QC tool, the inspection system helps increase our confidence in our processes."

Pleora's AI-enhanced camera systems are also being deployed in more traditional machine vision applications like electronics assembly, packaging, printing, and consumer goods production, and the company's portfolio is on view at Photonics West, booth 4322.

MIKE HATCHER

Healthcare startup panel gives business launch tips

Saturday's BiOS Healthcare Startups Panel on the Expo Stage attracted a substantial and engaged crowd. This was not surprising, considering the collective experience presented by the panel, comprising a seasoned investor and three biomedical photonics entrepreneurs.

Moderator Kyle Myers, an industry consultant, formally with the FDA, asked the panel to describe their startups and why they had made the leap of faith to launch.

Dr. Neil Ray, CEO and Founder of Raydiant Oximetry, said, "The problem we are addressing is the way mothers are assessed during childbirth based on fetal heartrate monitoring, which has not changed much in the past 50 years. A consequence of the typical high false positive rates means that we perform unnecessary c-sections.

"Raydiant is working on a new way of monitoring fetal distress by optically monitoring oxygen saturation non-invasively. We started the company in 2016 and my proudest accomplishment is how we have survived over the past two years. In fact, we are probably stronger from having to adapt to Covid," he said.

Dr. Rachel Kuperman is CEO and founder of Eysz, which is developing a digital health platform using passive eye-movements to assess neurological diseases such as pediatric epilepsy. She, too, identified a longstanding diagnostic shortfall in her field, giving her the idea for her business. "There's been no significant improvement in assessing childhood epilepsy patient outcomes in the past 30 years," she said. "My goal is to bring quantitative measurement capability to outpatient care in neurology. We set out to measure that and were able to show that we could identify a subtle seizure type. We are currently in clinical studies to refine our algorithms using eye movements and bring them to the FDA."

"My biggest accomplishment in the healthcare space, over the past two years, has been the hard task of aligning three objectives: Do good in the world, make money, and develop a regulated product."

The following panelist was Dr. Jay Reddy, founder of Advanced Optronics, which is developing flexible sensors to reduce surgical trauma during cochlear implantation (CI) in patients with severe hearing impairment. In 2021's SPIE Startup Challenge, Advanced Optronics was the winner in the medical technology division for its flexible surgical sensor.

He explained, "One of the problems with CI is that a lot of the structures in the cochlear area get damaged during the implantation surgery so that becomes a barrier to adoption by such patients. What we are doing is putting microscale sensors on the cochlear implant to provide a sort

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Tips from the top: Healthcare panel moderator Kyle Myers and panelists Neil Ray, Rachel Kuperman, Jay Reddy, and Bill Hyun. Credit: Joey Cobbs.

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We're happy you're here

SPIE CEO Kent Rochford welcomes attendees and exhibitors back to Photonics West

For us in the photonics world, "Happy New Year" is usually synonymous with "Get ready for Photonics West!" This year, for many of us, this meant finding luggage that's been in storage since the last Photonics West — in 2020 — and hoping our business attire still fits. It also meant a few new items found their way into our packing list — masks, hand sanitizer, and vaccination cards, to highlight the key ones. Despite the changes in required gear, this week is still going to be the educational, engaging, and energizing event we have all been looking forward to since the last day of Photonics West two years ago.

Of course, this year is a little different than years past. We are requiring vaccinations and masks for everyone in the Moscone Center, and we've made some changes in order to spread out activities and enhance safety. We've worked with our vendors and the City of San Francisco to make our event as safe as possible for the 10,000 people who have registered to attend throughout the week.

Kent Rochford, SPIE CEO. Credit: SPIE

Since we last got together, much has happened and it seems the world has changed. Yet at the same time, we have been constantly reminded of the importance of connection. While photonics has enabled ways for us to connect virtually, it's been clear that we need in-person connection as well. SPIE believes strongly in value of the in-person interactions that happen at our events; we believe in the benefits of getting smart people together to solve problems and make improvements to existing solutions. I truly hope that you are able to enjoy the company of colleagues and friends you have not seen in a while, and, despite not seeing them, are able to feel the smiles and connection behind the masks.

> Collaborating is vital to progress, and some of the most valuable outcomes of Photonics West are new connections and new ideas.

This week will of course be full of reunions and catching up with old friends, but hopefully you will also make some new connections as well. Everyone you pass in the halls or sit next to at a presentation is building or enabling some part of a future improved with photonics. From advancements in healthcare to the infrastructure of next-generation networks; from advanced manufacturing and quantum technologies to sensing, imaging, and displays; and from autonomous vehicles to space exploration, literally everything in our future technology ecosystem is featured here this week. Whether it's being presented in a conference room, showcased on the exhibition floor, discussed on a panel, taught in a short course, or debated at a reception, you can learn about the latest in just about everything photonics-related *somewhere* at Photonics West.

If this is your first Photonics West, welcome. We're happy you're here! We have a first-timers reception this morning at our Membership Info Booth in Moscone West to help get you prepare to make the most of the week. In addition, Moscone West will be home to our Career Hub where you will find a job fair, free headshots, and professional development courses. Whether you are just getting started or looking to change jobs, I can assure you that a career in photonics is quite rewarding. But don't just take my word for it — talk to any attendee or exhibitor and I'm sure they will the say the same.

This year we are partnering with the Quantum Economic Development Consortium (QED-C) to host Quantum West. Taking place on Wednesday, this one-day event has a particular focus on photonics in quantum and the path for building a related commercial ecosystem. With presentations and panel discussions featuring industry leaders and networking opportunities, the event promises to be quite informative for anyone looking to be a part of the future of quantum technologies.

We are proud of the fact that despite the pandemic, we have been able to continue our strong community support efforts. At yesterday afternoon's LASE plenary we announced our latest endowment, this one with the University of Rochester Institute of Optics. Our $500,000 gift will be fully matched by the University for a full $1million program, the *SPIE Graduate Fellowship in Optics*, which will support PhD students at the Institute. With this gift, our endowment program, which launched in 2019, has now provided nearly $4 million in matching gifts, resulting in over $10 million in dedicated funds. Giving back to our community is ingrained within the SPIE mission, and supporting optics and photonics professors and graduates will benefit us all as they mentor the next generations and build our future. These endowments are only a portion of our efforts to support the community, and a recent addition to our longtstanding scholarships, travel support, advocacy and policy work, and other programs aimed at strengthening the optics and photonics community now and for years to come.

Collaborating is vital to progress, and some of the most valuable outcomes of Photonics West are new connections and new ideas. I know many of us attend with a plan — who to meet, which presentations to listen to, which booths to visit — but be sure to try something new. Go to a presentation outside of your focus, strike up a conversation with a stranger, visit a booth of an unfamiliar company, or come to one of the many non-technical offerings throughout the week. You will benefit significantly by learning new things and meeting new people, just as others will benefit from your attendance or welcoming gesture. Thank you for being part of SPIE Photonics West!

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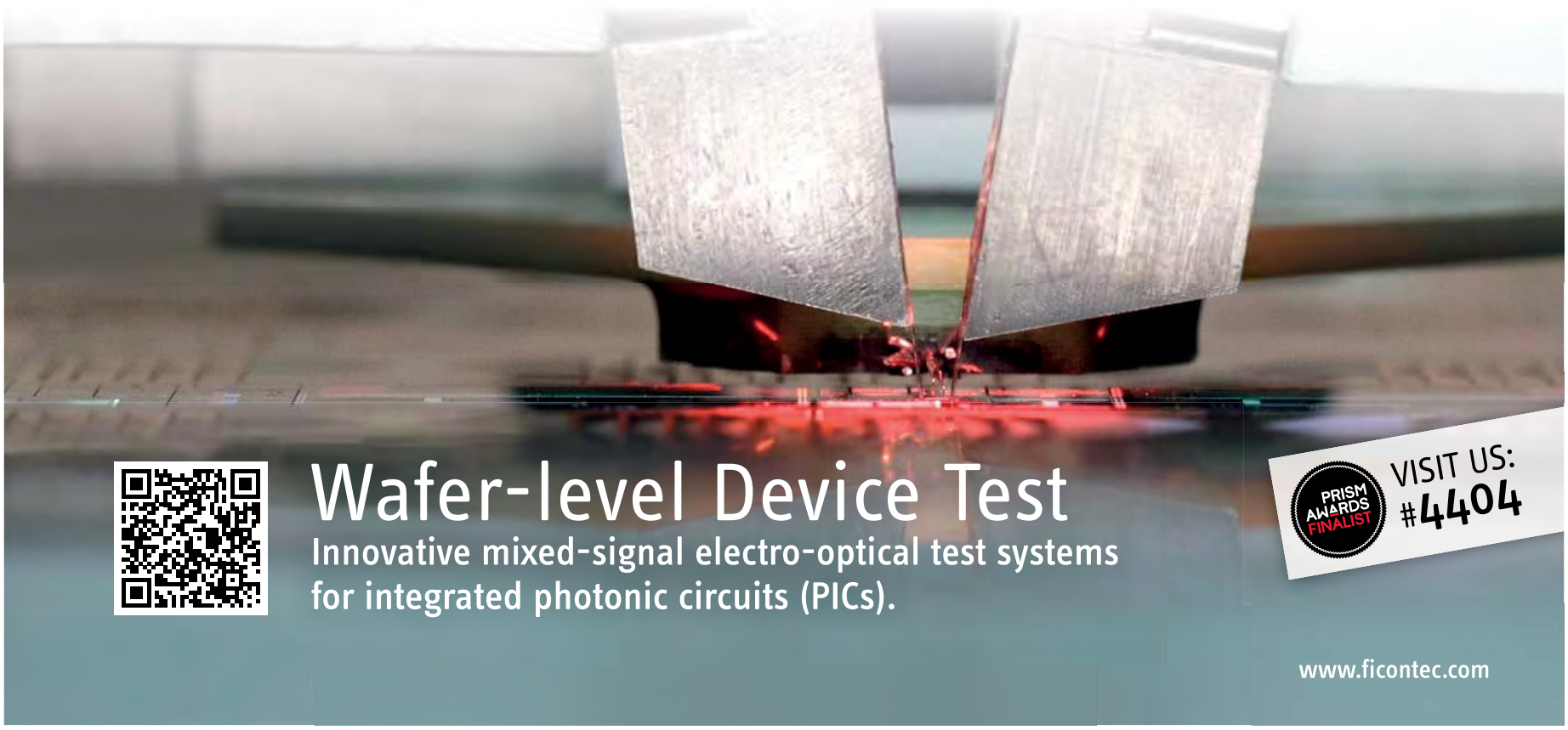

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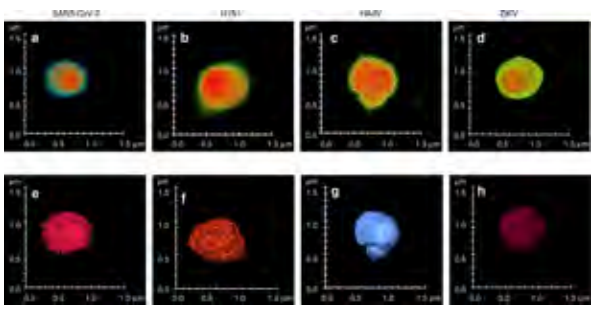
Covid-19: Optical scientists and engineers push back

As the world continues to battle Covid-19, researchers at Photonics West reflect on how the pandemic has fast-tracked photonics development.

It is hardly a surprise that this year's Photonics West conference sessions are peppered with presentations relevant to Covid-19. Be it methods to screen for the virus, systems that identify fast-flying Covid-19 droplets or non-invasive techniques to assess patients, researchers worldwide have been adapting existing instrumentation or developing new ways to tackle the pandemic.

When SARS-CoV-2 emerged, Professor Gabriel Popescu, Neha Goswami, and colleagues from the University of Illinois Urbana-Champaign and University of Illinois at Chicago knew they could apply their quantitative phase imaging method, Spatial Light Interference Microscopy (SLIM), to directly image unlabelled viral particles. Used with a conventional light microscope, a SLIM module converts interference patterns recorded by the microscope's CCD camera to quantitative phase images, producing incredibly high-resolution images of unstained cells.



Volume reconstruction of a) SARS-CoV-2. b) Influenza, H1N1. c) Human Adenovirus, HAdV. d) Zika virus, ZIKV. Surface reconstructions of e) SARS-CoV-2. f) H1N1. g) HAdV. h) ZIKV. Scalebars are representative of lateral dimensions of the respective particles. [Goswami, N. et al, *Light Sci Appl* 10, 176 (2021)].

However, they also realised that if they merged their method with deep learning, specifically trained to detect and classify virus particles, they would have a very fast, high-throughput and accurate method to identify SARS-CoV-2 in people. They trained a convolutional neural network to recognize SLIM, label-free images of SARS-CoV-2 particles and to discern the coronavirus from other particles including dusts, beads, as well as additional pathogens — influenza, adenovirus and the Zika virus.

"Our phase imaging is sensitive enough to pick up the structural information of a particle down to the nanometer level," highlights Goswami. "For example, Zika is much smoother than SARS-CoV-2 which is covered with protrusions — so the method is detecting those very small, nanoscale-differences and can differentiate between these different classes."

Pre-clinical studies using a CellVista SLIM instrument from Popescu's spin-out company, Phi Optics, have shown the neural network can identify SARS-CoV-2 versus the other viruses with a 96% accuracy. Clinical trials are now underway using face shields with integrated glass slides — breath condensates are transferred from a subject to the slide ready for analysis. According to the researchers, image acquisition and inference take 100 ms, so an entire test could be performed in just one minute. They also reckon throughputs can be easily scaled if slides are automatically fed into the whole slide scanners used in digital pathology.

"We're collecting breath samples from actual patients in Chicago right now," says Popescu. "If the breath testing [set-up] works, I think that every school would probably benefit from having one... We also envision that at an airport, someone could simply breathe on a slide that is automatically passed onto the imaging system and you have results within a matter of seconds."

The researchers' label-free method could also detect many infectious diseases, including bacterial infections. As Popescu points out, he and colleagues have been particularly interested in other label-free approaches where you can bypass sample preparation and reduce time to assay. Quantitative-phase imaging methods have already been applied to other viruses such as the herpes simplex virus (HSV) while scattering techniques are known to hold huge potential for virus detection.

"The pandemic has pushed technology development on faster tracks than usual and many researchers, including ourselves, have really benefited from US fast-track government grants," he says. "We've seen many developments on the photonics side that just wouldn't have happened on a regular time-scale."

Covid-specific photonic sensor platforms

Professor Benjamin Miller, from the University of Rochester Medical Center US, agrees, saying: "You have to get some good out of this and it's been amazing to watch how the scientific world has responded to Covid-19. The technological development that's occurred over the last couple of years has been amazing, particularly in the in the sensor realm." Since the onset of the pandemic, Miller and colleagues have been working on photonic sensor platforms designed to profile the human immune response to Covid-19 infection and vaccination. Miller will present his results in Photonics West presentation "Design and Quality for Biomedical Technologies XV".

In a first set-up, a multiplexed, label-free optical biosensing method — arrayed imaging reflectometry — analyzes human response to disease. In this, a silicon chip is coated with a near-perfect anti-reflective, silica layer that contains immobilized "capture" molecules, such as antigens (proteins), that can bind viral biomarkers in blood samples. The binding changes the surface thickness of the layer, causing incident light to now partially reflect — this light can be measured using a CCD camera and analysed to detect the presence of a virus in the blood sample.

According to Miller, the biosensor chip is sensitive down the molecular level and can handle many targets per sensor. "You can have so much data on a single chip," he says. "You get a full profile of what's going on with someone's immune system in half an hour." The set-up

continued on page 11

Covid-19 continued from page 09

has already been widely used to measure influenza immune response in humans. But as Miller highlights: "As soon as it became clear that SARS-CoV-2 was going to be important, we recognised this could be useful to study the antibody response to this virus."

He and colleagues selected proteins from SARS-CoV-2 and fine-tuned the biosensor coating to include antigen proteins that would bind the coronavirus and other viral biomarkers. This process took just two weeks, and the results so far are fascinating. The latest platform can detect antibodies to SARS-CoV-2, including mutants, SARS-CoV-1, MERS, three circulating coronavirus strains (HKU1, 229E, OC43, NL63), seventeen strains of influenza and respiratory syncytial virus (RSV), which can be fatal to children. "One thing that is nice about this is we can put large numbers of antigens on a single chip and study the response all at once," says Miller. "For example, we were curious about whether we would see a cross-reactivity between SARS-CoV-2 and other coronavirus antigens."

Ben Miller's graduate student, John Cognetti, adding a serum sample to the disposable photonics sensor card. Credit: Courtesy of Benjamin Miller / University of Rochester Medical Center.

While the world is familiar with the SARS-CoV-2 spike (S) protein, the biosensor also detects the virus' nucleocapsid (N) protein, which is abundantly expressed during infection. "The vaccine is all spike but if someone gets sick [from Covid-19], they're going to have a strong immune response to the N-protein — so we can very easily discriminate between someone who's been vaccinated and someone who's had the virus," says Miller. "Now we've put different mutant antigens of SARS-CoV-2 on an array, we can also say 'well we know they've been vaccinated against one strain but do their antibodies still bind to the antigens of other variants'," he adds. "So [the array] will let you know if there's a variant that people's antibodies are no longer binding to."

Dr Hui Min Leung from Massachusetts General Hospital, has been working with colleagues at Harvard Medical School and the University of Alabama at Birmingham to examine Covid-19's underlying mechanisms. Credit: Courtesy of Hui Min Leung / Mass. Gen. Hospital.

Miller is hoping to set-up a new venture to apply the technology to diagnostics applications and vaccine development. "We already have a commercial instrument that we can tune very quickly, and we can scale manufacturing to [print] thousands of chips very easily," he says.

Miller's second platform stems from a massive $1.7 million US Department of Defense Manufacturing Technology project with the American Institute for Manufacturing Integrated Photonics (AIM Photonics) and collaborators, US in-vitro diagnostics company, Ortho Clinical Diagnostics, and polymer optics manufacturer, Syntec Optics. Additional research input comes from the NY CREATES 300mm microelectronics research facility in Albany, New York, the University of California at Santa Barbara and the US Naval Research Laboratory in Washington DC.

In a similar vein to arrayed imaging reflectometry, this platform detects antibodies in Covid-19 patients and vaccinated subjects, and tracks post-vaccination changes to SARS-CoV-2 antibodies over time, but this time the emphasis is on cost and speed. "When you interact with researchers from government and industry, there's another set of success criteria that drive interesting research goals," highlights Miller. "For example, Ortho Clinical Diagnostics would say to us, 'the results are great but how can we get this down to 10 cents a test?' And this led us to our disposable photonics platform."

This biosensor comprises a rice grain-sized (1mm × 4 mm) silicon nitride ring resonator to analyze serum samples for the antibodies that humans develop within two days of exposure to the SARS-CoV-2. The sensor chip is coupled onto a plastic micropillar fluidic card that pulls a sample through its winding chamber via capillary action, enabling cheap, high throughput Covid-19 antibody detection in a minute.

The researchers continue to work with commercial partners, honing the platform for swift, high throughput clinical diagnostics and large-scale manufacturing. "This is a completely new diagnostic platform — we think it will be valuable in very broad applications for clinical diagnostics, not just Covid-19," says Miller.

From antibodies to mechanisms

Photonics West is also hosting many presentations that will reveal novel ways in which optics are being used to examine Covid-19's underlying mechanisms. Dr Hui Min Leung from Massachusetts General Hospital, has been working with colleagues at Harvard Medical School and the University of Alabama at Birmingham, including Professors Guillermo Tearney and Steven Rowe, as well as Healthcare Innovation Partners researchers, to develop label-free micro-optical coherence tomography (μOCT) to image the nasal airways of Covid-19 patients.

As Leung points out, the latest Covid-19 work follows ten years of development of the technique for cystic fibrosis, in which sticky mucus builds up in the lungs and digestive system. Many of the entry factors that SARS-CoV-2 relies on to enter human cells are also expressed in nasal epithelial tissue, making the lining of the nose a key target to understand how infection takes place.

As part of the set-up, a fiber-optic catheter is connected to an imaging console, based on spectral domain OCT, to study nasal airways and provide live images of

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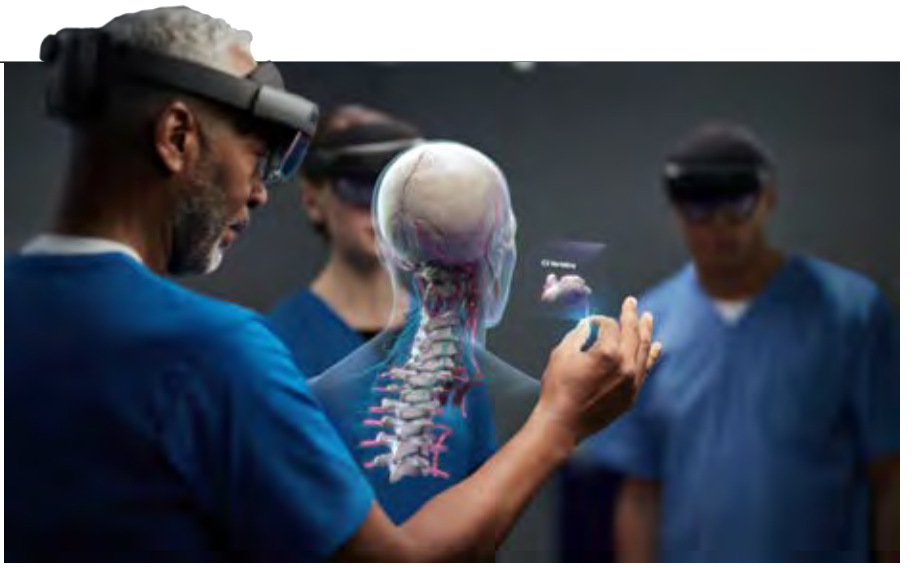
AR|VR|MR 2022: the metaverse is coming

The metaverse promises a revolution in how society communicates, but hardware hurdles remain. SPIE AR|VR|MR is the place to discover how these hurdles are being overcome.



HoloLens 2 smart glassses feature industry-leading resolution to minimize eye fatigue, so users can read text and see intricate details on 3D assets. Credit: Microsoft.

When Mark Zuckerberg announced in October his vision for the future of Facebook, and rebranded the company as Meta, it generated a lot of buzz. Meta would recruit tens of thousands of workers to build a new version of the internet — the metaverse — where physical, augmented, and virtual worlds converge, a space where real and digital representations of people seamlessly interact at work and play.

To outsiders, it seemed like Meta was stealing a march on its competitors, defining an exciting new future for the digital world. But for those in the know, the announcement was more like an advert for an entire budding metaverse industry, whose exponential growth in the past two years had not been triggered by Meta, but in fact came from the deprivations we have all faced in dealing with a global pandemic.

Bernard Kress, Director of XR at Google and co-organizer of SPIE AR|VR|MR conference, running alongside Photonics West. Credit: Google.

From the smallest startups to global behemoths including Meta, but also Apple, Google, Microsoft, Amazon, Sony, and more, huge investments and tremendous efforts have been put towards building a metaverse fit for a Covid-changed world in which real physical interaction is not always possible. “All this was accelerated by the pandemic, by the global urge for people to connect and to have that social interaction, that sense of presence with a human being,” says Bernard Kress, Director of XR at Google.

Kress is co-organizer of SPIE AR|VR|MR, a standalone conference running alongside Photonics West. SPIE AR|VR|MR is the premier conference globally for XR hardware — the tech behind augmented, virtual, and mixed reality (AR, VR, MR, together referred to as XR) experiences.

This year’s conference has the tagline ‘Discover the hardware that will enable the metaverse’. “The metaverse is on everyone’s lips today, but SPIE AR|VR|MR has been focused on bringing this concept to reality for the past four years,” explains Kress. “It will be a multi-trillion dollar opportunity for consumers and enterprises, and the biggest names in that industry.”

Judging by the huge sums being invested in XR hardware innovators, the industry agrees with Kress’s assessment. For example, just this past year, Snap acquired XR display maker WaveOptics for over $500 million, TikTok parent company ByteDance bought VR headset maker Pico for a rumored $775 million, and Magic Leap raised $500 million toward developing its AR headset technology.

Yet even with all this excitement and spending — and increasing adoption of Google Glass, Microsoft HoloLens, and other smart glasses in enterprise applications — the hardware to enable the metaverse is still not quite ready for world domination.

Comfort in the metaverse

Kress boils the problem down to three key challenges: wearable comfort, visual comfort, and social comfort. The hardware needs to be light and comfortable to wear. It needs to provide a view of the digital world as we see the real world, without making users dizzy. And it all needs to be packaged in smart glasses that look just like regular glasses. “That’s a big challenge for technology you wear on your head without you ending up looking like RoboCop,” he adds.

“This is why this conference is so important—it’s really the only conference for XR hardware,” says Pamela Robertson, SPIE AR|VR|MR Event Manager. “Each segment, even how we are ordering speakers, tells this whole story about how the industry is building the hardware of the metaverse.”

Initially part of Photonics West and just a one-day event featuring a handful of technical talks and a few headset demos in a single room, Kress and SPIE were bowled over by how the meeting was received. “The room was blown out,” says Robertson. “The fire marshal had to step in and remove attendees.”

Due to this popularity and the event’s more applied focus, AR|VR|MR now runs for three days, separate but parallel to Photonics West. This year, there are over 70 invited talks, five keynote addresses,

five panel sessions, and 50 technical presentations, plus seven short courses, 30 company exhibitions, and a job fair.

"We haven't been able to be in person one-on-one and so much has gone on in the past two years that everyone is eager to get together and share all this cool stuff they've been working on," says Robertson.

One bit of 'cool stuff' many attendees will be eager to hear about is Magic Leap 2. Magic Leap's Vice President of Optical Engineering Kevin Curtis will deliver a keynote address offering a peek behind the curtains at the company's new AR headset coming to market in 2022. In the past, Magic Leap has been notoriously secretive. So, a deep dive into the technology behind Magic Leap 2 is not to be missed.

Magic Leap 2 has an entirely new projector architecture, doubling the field of view in a significantly smaller and lighter form factor. Credit: Magic Leap.

"I'll be describing the unique display performance of Magic Leap 2, and some of the optical innovations that enable that," highlights Curtis. "In particular, it's got an entirely new projector architecture where we were able to double the field of view in less than half the volume of Magic Leap 1." Curtis will also detail improvements, particularly in the eyepiece, to make display image quality "many times better" than Magic Leap 1, as well as innovations, such as a dimmer that enables the headset to be used in brightly lit settings.

Bridging the physical and virtual worlds

Though Magic Leap and other big companies in the XR space tend to launch new products at their own conferences, the likes of Google, Meta, Sony, Tooz, Microsoft, and others will also be presenting recently launched devices during the show. Moreover, many startups will be timing their product launches to coincide with AR|VR|MR.

But the conference is not just about showing off new technology. In fact, most talks delve into how researchers and innovators are overcoming remaining challenges to bridging the physical and virtual worlds.

For example, Christophe Peroz, Corporate Distinguished Engineer at Sony and co-chair of AR|VR|MR, chairs a session titled 'Perceptual Research in AR, VR, MR'. With a keynote delivered by world-leading expert Professor Marty Banks from UC Berkeley, this session grapples with questions that remain unanswered at the most fundamental level. "If you want to do AR/MR, you have to be able to see the digital world as you see the real world today," says Peroz. "We don't see the real world in a rectangular shape and our field of view is not a simple number — so understanding human perception better will help us develop hardware which respects our natural vision."

Christophe Peroz, Corporate Distinguished Engineer at Sony and co-chair of AR|VR|MR. Credit: Sony.

Going beyond elemental research are talks looking at industry-wide challenges in XR hardware design and some of the companies who have found promising solutions, like the 'Prescription Smart Glasses' session. Up to now, smart glasses have not generally had built-in prescription lenses. For those without 20:20 vision, add-ons have been scrabbled together, often creating wearable or visual discomfort. In her keynote address, Microsoft's Grace Hwang GM, Design & UX Research of Mixed Reality, will discuss how the industry can move towards increased social acceptability by developing solutions for common pain points like prescription smart glasses, and how this will also create equity and drive greater adoption amongst under-represented populations.

Several other industry talks delve into solutions companies have found for innovative smart glasses display engines (microLEDs, laser beam scanning, OLED, etc), waveguide combiners (optics that combine the real world with the virtual world), and marrying the two in a way that optimizes field of view, eyebox size, brightness, image quality, latency, form factor, and power consumption.

Of these, perhaps the one that stands out is the 'Design and Manufacturing' keynote address by Omkaram (Om) Nalamasu. As CTO and Senior VP of Applied Materials — the world's largest semiconductor equipment manufacturer — Nalamasu is at the heart of efforts not only to realize XR technologies but to also mass produce them.

"You need two critical elements for XR to be the next ubiquitous device," he says. "One is waveguide combiners, and I will describe how we are making tremendous progress in building scale, building technology, building tools, building processes, and building new materials, to get the waveguide performance of bulk optical elements in engineered films, and really take this technology from lab to fab."

The second element, says Nalamasu is high resolution, high brightness, energy efficient displays. At the last conference, he presented Applied Materials' innovative solution to this challenge: microLED displays that convert UV to

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New frontiers in laser 3D printing

Developers of additive manufacturing techniques continue to push the boundaries.

The primary driver behind growth in additive manufacturing (AM) and laser 3D printing is the design flexibility and freedom that the approach allows, although taking full advantage is not always a straightforward matter.

"Laser 3D printing is an innovative process, illustrative of the new technological advancements now being achieved within the field of manufacturing generally," contends Bo Gu of Bos Photonics. "However, AM does create new challenges. Knowledge of the materials and the manufacturing process itself becomes critical in achieving desired product design and part performance."

At SPIE Photonics West, the Laser 3D Manufacturing conference, co-chaired by Gu along with Hongqiang Chen of GE Research and Henry Helvajian from The Aerospace Corporation, will include a session on Frontiers of Laser 3D Manufacturing at which some of the cutting edge developments in the field are to be discussed. The intention is to inform attendees about newly developed laser sources; new or improved process monitoring techniques; and the current state of materials development, especially regarding metal alloys, refractory alloys and highly reflective metals. It will also describe current trends in the real-world application of these techniques, especially the latest uses in space systems and space manufacturing.

Recent progress in novel AM techniques has exploited developments in the laser systems involved, including the use of shorter wavelength lasers with green or ultraviolet emissions, and of shorter laser pulse widths from ultrafast sources. Using a laser beam with a wavelength in the visible or ultraviolet spectrum, as opposed to infrared emissions of around 1 micron, enables laser AM of highly reflective materials like copper, aluminum, gold, silver, platinum and iridium to be more effective and efficient, according to Bo Gu. Techniques for 3D printing of glass have also now opened the door to novel structures with both unconventional structures and tailored composition.

Castheon is developing 3D printing-based processes suited to AM of refractory metal alloys to enable superior materials properties. Credit: Castheon.

"Use of ultrafast lasers, along with optimized process parameters such as laser power, scan speed, hatching space, layer thickness, and patterning strategy, can lead to high density samples of a variety of materials, including refractory materials," he says. "Refractory alloys, with their extraordinary resistance to heat and wear and superior durability, are often the desired material for extreme-environment applications such as space craft, missiles, and hypersonic vehicles. Due to the difficulty and high cost associated with traditional manufacturing in complex shapes, their utilization has been hampered even in the most demanding applications. Laser 3D printing, on the other hand, has demonstrated a superior shape-producing capability that is unattainable with traditional manufacture. 3D printing of refractory metal alloys can greatly enhance the extreme environment performance of the parts and reduce the costs at the same time."

The aerospace industry presents one good example of an expanded application envelope for AM techniques, says Gu, in which new challenges have been set and then tackled.

"Laser 3D printing is transforming all segments of the aerospace industry, including commercial and military aircraft, space applications, as well as missiles systems," he notes. "Such transformation is due to the unique ability of AM to produce parts with complex designs, reduce manufacturing costs by improving material waste and allowing fewer tools and fixtures, and fabricate parts with premium materials with small production runs and short turnaround times. In addition the capability of AM to fabricate free-form designs makes it very suitable for the aerospace industry."

For metal parts, the main AM technologies in aerospace applications are directed energy deposition and powder bed fusion. However, as with all commercial materials and processes, variation in part quality and mechanical properties due to inadequate control of dimensions, microstructure, potential defects, surface roughness, and residual stress can result in designs that limit a part's use in high-value or mission-critical applications. This means that ensuring quality and consistency, and enabling more widespread use, requires robust quality control with stringent qualification and certification procedures.

Bo Gu is co-chair of the Laser 3D Manufacturing conference at Photonics West. Credit: Bos Photonics.

"Unfortunately, few quality documents are publicly available, forcing aerospace companies and organizations to establish their own guidelines," says Gu. "Furthermore, where parts and systems require regulator certification, requirement interpretations are still evolving. These challenges to the control of part quality, dimension and mechanical properties are also quite common in laser 3D applications in other industries."

A lack of industry-wide standards features on Bo Gu's list of the common challenges currently being addressed by AM developers serving a range of end users. Others include production speeds and printing costs; inconsistencies in material properties; and the need for software that exactly matches the requirements of the technique. The rapid growth of the sector has also led to issues around copyright protection, the skill set of the workforce, and an industry ecosystem, which remains relatively disjointed, compared to other manufacturing sectors.

Tackling these challenges

The hurdles can all be tackled by industry-wide efforts and specific technical advances, comments Bo Gu.

"Many current industrial 3D printers still lag behind traditional mechanized equipment in terms of speed and efficiency," said Gu. "This is particularly an obstacle for adoption in industries driven by mass serial production, such as automotive and consumer goods. In these industries, products need to be manufactured and delivered in as short a time frame as possible, in order to maintain production efficiency."

High printing costs have become a hurdle for AM in comparison with traditional manufacturing techniques, which have built up refined and extremely efficient processes over the years; and for some uses 3D printing may simply be too expensive for a few more years to come, as processes are simply not streamlined enough.

The 3D printing platforms required by large companies can cost tens of thousands of dollars, and when they are used the process is slow and costly. The time taken to 3D print depends on the number of layers that need to be printed and the speed of the printer itself, with even the best 3D printers able to build only between 5 and 60 centimeters per hour, according to Gu.

Limited raw materials and inconsistencies in material properties are another consequence of the relative youth of AM manufacturing, which lacks the decades of materials development which traditional manufacturing processes have undergone. "3D printing's own material development has just begun," says Gu. "While it can create items in a range of plastics and metals, the available selection of raw materials is not exhaustive, since not all metals or plastics can be temperature controlled enough to allow 3D printing. In addition the industry currently lacks a solid database of materials with proven printing parameters and defined specifications. As a result, it becomes challenging to achieve a consistent and repeatable 3D printing process."

Thriving and evolving

A lack of industry-wide standards, another issue connected to the history and development of this advancing market sector, is a further problem, not least because it introduces the potential for sub-standard products to ultimately enter the manufacturing chain and find their way to end users. Many manufacturers worry that their products, or the parts of those products being produced via 3D printing, will not be on a par with other manufacturing methods in terms of quality, strength and reliability. This creates a wariness of 3D printing technology

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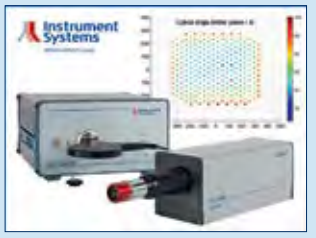

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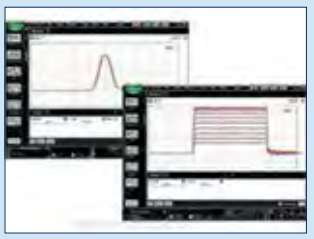

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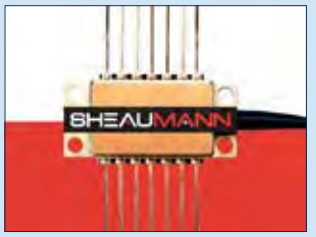

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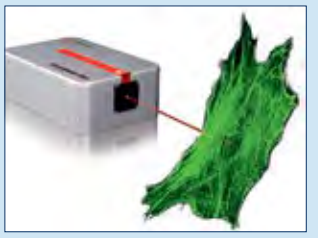

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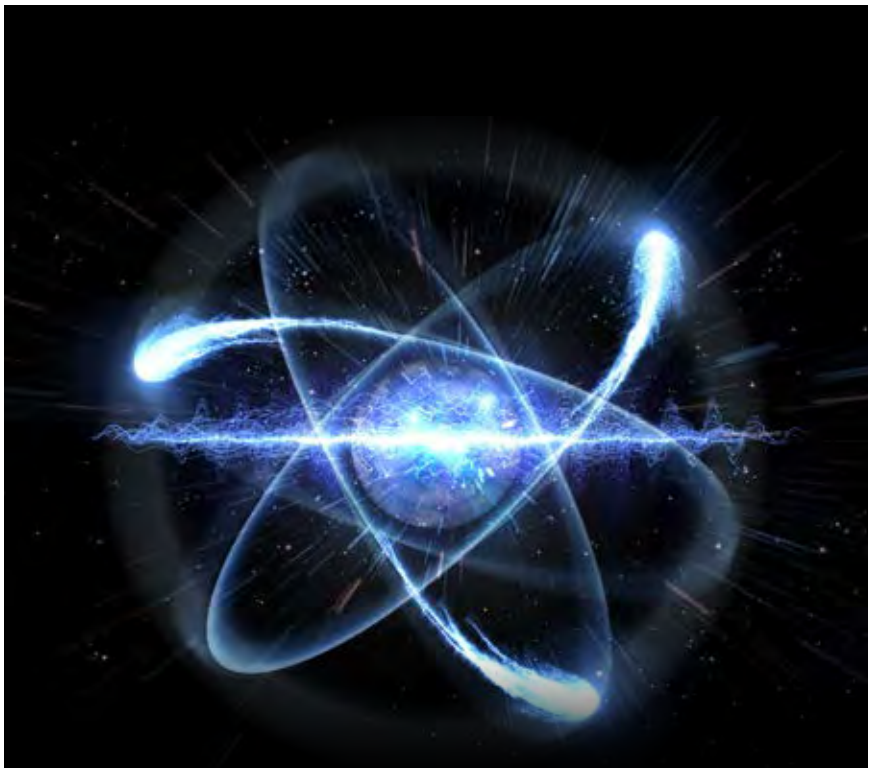

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Nuclear Fusion: NIF's hall of mirrors may solve world's energy crisis

Physicist Tammy Ma describes how improvements in laser optics played a role in last August's record 1.35 megajoule output, and how further innovations will take the world closer to the Holy Grail of safe, clean and sustainable power.

Inside this building 192 lasers each bounce around for a mile, traveling past 7500 large aperture optics before zapping a peppercorn of deuterium and tritium and coaxing the isotopes to fuse. Credit: NIF / Lawrence Livermore National Laboratory.

The elusive goal of nuclear fusion has represented the great hope for the world's energy future ever since physicists began seriously pursuing it in the 1950s. Fusing atoms together rather than splitting them apart, as today's fission reactors do, portends relatively limitless, safe, environmentally friendly energy. No less a mind than Stephen Hawking once said, "I would like nuclear fusion to become a practical power source. It would provide an inexhaustible supply of energy, without pollution or global warming."

This cylinder, called a hohlraum, contains the BB-sized (~5mm) fuel capsule. Credit: NIF / Lawrence Livermore National Laboratory.

But the rap on fusion: it's been 30 years in the future for over 60 years now.

There are dozens or more of ongoing initiatives, some state funded, some privately backed. Many of them — including one at the US government's National Ignition Facility (NIF) that uses 192 lasers to pull off the feat — have successfully fused different forms of hydrogen. But the underlying challenge remains: they have all put more energy into the process than the amount that has come out. None have achieved break even, known in the business as a gain of one.

That's a huge hurdle, considering that experts believe that the energy out will have to be not "one", but, rather, somewhere on the order of 100 to 200 times the energy-in for fusion to be economically viable. So the days when a fusion reactor might be tied into the electricity grid feeding your home or office could still be a long way off.

For now, the next milestone would be "one."

And on that front, NIF made a great stride last August when it coaxed more energy out of its massive 192-laser apparatus than it — or, according to NIF, anyone — ever had before. Its 1.35 megajoule output was about 71% of the 1.9 megajoules that it poured in. While 71% — 0.71 — is still a fair distance from one, it was a huge advance over the 9% that was NIF's previous best.

Improvements in optics

Yesterday at Photonics West, NIF's Tammy Ma delivered a plenary presentation describing the improvements in optics that helped to achieve the stunning leap to 71%. She will also outline the emerging optical breakthroughs that should help her and her fellow physicists reach "one" and beyond.

First, a quick primer on how the apparatus works at NIF, a giant facility which is 10 stories tall and covers an area the equivalent of three football fields. Like many fusion projects, NIF is combining isotopes of hydrogen known as deuterium and tritium. Synthesizing those two into one entity yields helium, a neutron, and — crucially — heat. In most fusion projects, the heat is the energy out that would drive a turbine or deliver heat for other purposes such as industrial processes. (Another approach to fusion, called aneutronic, actually delivers electricity directly, cutting out the turbine).

The lasers converge at this point as they near the target. Credit: NIF / Lawrence Livermore National Laboratory.

Historically, there are two methods for mating deuterium and tritium, although other approaches have emerged over the last couple of decades.

NIF uses the newer of the two, called "inertial confinement." It places the two isotopes in a tiny BB-sized pellet, packed to 100 times the density of lead. NIF fires 192 lasers at this target, with each laser traveling a mile in a back-and-forth pattern, passing through slabs of optical glass that boost the laser's power by over quadrillion times on its way to the target. The combination of the high powered lasers and the intensely confined space triggers temperatures that flash to as high as 100 degrees C, prompting the isotopes to fuse. The fusion happens in perhaps less than a billionth of a second.

Inertial confinement contrasts with the original idea for a fusion machine, called a tokamak. There are probably scores of experimental tokamaks around the world. The technology is still in development today and is epitomized by the 100-foot tall, 830-cubic meter tokamak under construction in Cadarache, France, backed by the EU and by six member nations China, Russia, Japan, South Korea and the US; a total of 35 nations are involved, including non-members. In the tokamak design, a sparse deuterium-tritium plasma roams a comparatively big but magnetically confined space and is super heated until fusion happens.

So how did NIF get to its best ever 1.35 megajoules in August?

Ma notes that while improved optics played a role, much of the boost came from significant refinements in the design of the target pellet, which was smoother in material and more densely packed than for any previous NIF shot.

Optically, it didn't hurt that NIF had improved its master oscillator room — the originator of a single relatively low power laser that becomes 192 separate and extraordinarily more powerful lasers. It also managed to attain an exceptionally good power balance and power accuracy across the 192 lasers — sometimes, the performance of a laser can stray from what the engineers prescribe for each one in a shot, but on this occasion, as Ma notes, they behaved well.

Laser amplification

Ongoing refurbishment of the slabs of thick optical glass that amplify the lasers' power certainly helped. NIF shoots its lasers every 4 to 8 hours not only for fusion energy experiments but for other purposes as well such as nuclear weapons research and studying planets, stars and the universe. The 40cm x 40cm glass, which is a few inches thick, can take a beating. In the amplification process, first the glass is energized, and then the glass conveys that energy to the laser passing through it. Damage incurred during that process can grow and throw off the

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Nuclear Fusion continued from page 19

accuracy of a laser in subsequent shots.

"We run the lasers right at the hairy edge of what those optics can actually handle," says Ma. Thus, NIF routinely pulls out the glass slabs for the purpose of examining them and polishing them.

The amplifiers are one example of some 7500 large aperture optics that the lasers pass through. The place is awash with optics; maintenance is critical. But the time taken for upkeep, as well as the limitations of the glass, are factors in both curtailing the number of shots and in undermining both the power levels and efficiency of them.

That's where NIF is eyeing improvements. Glass amplifiers that can handle higher powers and that can more efficiently boost laser power, should ultimately make better use of the "energy-in," and thus lead to a better energy-out ratio.

Improving the optics

Ma, who is NIF's program element leader for high intensity laser science, has identified several technologies that could improve the optics.

One method involves shortening the amount of time it takes for the glass to cool down after a shot. Prolonged cooling today is one of the main reasons why shots can't happen more often than every four to eight hours. With NIF examining the possibility of moving to lasers that can fire at 10 Hertz — 10 times a second — it will need glass that is easier to cool. Hope lies in the form of chopping the optics into strips and running cooling gas between the strips.

That's one idea.

Another entails upgrading the material used for optical glass so that it is more effective at gathering a laser's photons and energizing them. Ma is hopeful that new "gain media," such as thulium-doped, yttrium lithium fluoride, will make a difference.

Likewise, improvements are underway in the lasers used to energize the glass in the first place. Today's glass take its energy from flashes of white laser light. That's a highly inefficient process, because the glass absorbs only certain wavelengths out of the white. As Ma notes, "you are wasting every other color of the rainbow except the one's that useful to you."

The flash light is a double whammy, in that it also gives off excess heat, requiring energy-consuming cooling systems to eliminate.

Maintenance and reuse of optics is critical to precision operations at NIF. Credit: NIF / Lawrence Livermore National Laboratory.

The solution? Color laser diode pumps that emit only the useful color would eliminate the waste, and would run at cooler temperatures.

Work is underway in all areas at various institutions. There is plenty of promise and potential, and also some concerns. For instance, color laser diode pumps of the magnitude needed for the optical glass in fusion is much more expensive than the flash lamps used today.

In fact, all these improvements would come at a certain monetary cost. In the near future, NIF is not planning on using any of them.

"We're not tearing things out," says Ma. Rather it will concentrate on improving the maintenance, and on the hardening of existing optics. That alone should help NIF to achieve an input power of 2.6 megajoules and to get to a gain of one within a few years, in Ma's estimation.

But the new stuff, says Ma, will have to wait. In fact, Ma envisions it not going into the existing NIF, which opened in 2009 at a cost approach $4 billion, after a decade or so of construction and delays. Rather, she says, it's time for a new NIF.

MARK HALPER

3D printing

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generally, since the risks involved are judged to be too great compared with the benefits. Bo Gu says that this uncertainty will be removed as firmer standards are brought in across the AM sector, and that efforts to do so are now underway.

"Design and data preparation are still a bottleneck in this industry," he continues. "The need to transfer AM design data through multiple software solutions results in a time-intensive and error-prone design process. Although great progress is being made on the AM design and print preparation front, there is still room for improvement. Providing designers with the ability to modify 3D models within the CAD environment and to quickly iterate them without cumbersome data conversion will be key to making the design preparation challenges a thing of the past."

Post-processing is likely to remain a key aspect of AM techniques, since most 3D printed parts need some form of cleaning up to remove support material from the build and to smooth the surface to achieve the required finish. The amount of post-processing required depends on factors including the size of the part being produced, the intended application and the type of 3D printing technology used for production; and this is where optimizations are possible.

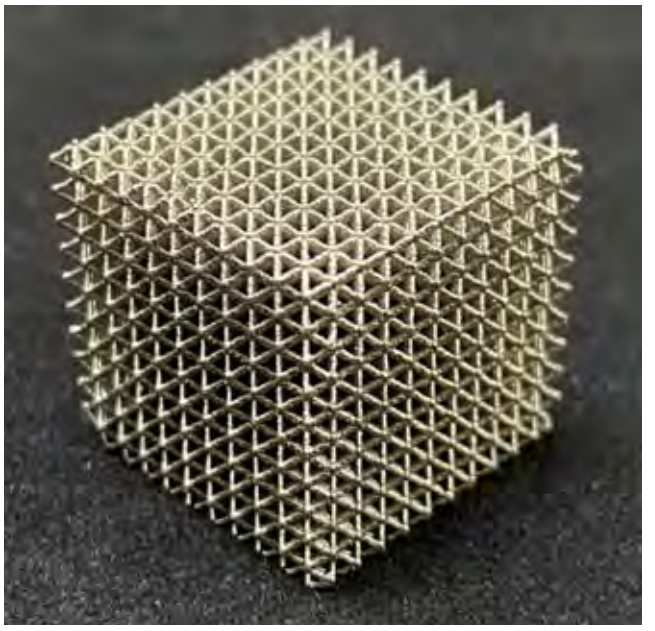
Intellectual property

3D printing is well known for bringing advanced manufacturing within easier reach of a greater number of individuals, but this has in turn made issues of copyright and intellectual property a substantial consideration. There is now an increased possibility for people to create fake and counterfeit products, and it will almost be impossible to tell the difference.

The structure of the industry itself is also a key factor, and Gu says that workforce elements are really critical right now. "There are not enough engineers, managers, executives who truly understand the technology well enough to work and develop a strategy to get what they need to get out of it," he says. "A lack of thorough understanding of the capabilities of 3D printing technologies can create many barriers to entry. Currently, there is still a knowledge gap in terms of what 3D printing technologies are, what their capabilities are and how they can be used. As a result, businesses which could benefit from the technology are unwilling to adopt it, as they struggle to develop a business case or use case for 3D printing."

Reorganizing the entire AM ecosystem so that it is less fragmented will remove the frequent obligation for solutions to be built from a number of individual small solutions and companies, a key step for AM processes to scale at the industrial level. The AM value chain, which begins from conception to production and post-processing of the product, needs to become more consolidated, according to Gu, who commented that the market is saturated with many different solutions, which ideally could be integrated to create a comprehensive offering, and simplify adoption of the technology. Companies looking to adopt AM are currently faced with the need to buy disparate solutions and then try to make them work together, a lack of integration in the value chain that creates inefficiencies in the workflow.

"As a young technology, laser 3D printing still has many challenges, even though the industry has made a quantum leap forward by developing better and faster systems, characterizing more materials and creating many automation solutions and expanding the list of approved standards over the last twenty years," concludes Gu. "Now we are seeing the growth of a new generation of AM professionals, and consolidation within the industry as companies are looking to partners in a bid to create comprehensive solutions. This is a thriving and evolving industry, which will continue to grow and evolve rapidly in the years to come. The best is yet to come."



Castheon is developing 3D printing-based processes suited to the additive manufacture of refractory metal alloys to enable superior materials properties. Credit: Castheon.

Best kept secret in AM

Other discussions in the Laser 3D Manufacturing conference will include a presentation from Youping Gao of AM developers Castheon about the impact of the technique on the manufacture of components for use in hypersonic flight. The refractory alloys needed for such environments have extraordinary resistance to heat and wear with superior durability, and so are often a desired material for extreme applications such as spacecraft, missiles, and hypersonic vehicles. But the difficulty and high cost associated with manufacturing them in complex shapes has hampered their utilization.

Castheon is developing manufacturing operations "suitable for AM of refractory metal alloys through 3D printing processes with superior materials properties, and envisages a significant leap in producing highly sophisticated geometries at lowered manufacturing cost," notes the company of its SPIE Photonics West presentation. "A case study of performance gain in sophisticated C-103 niobium engineered hardware will be presented."

The use of alternative laser wavelengths in AM operations, mentioned by Bo Gu as an example of recent technical progress, will be the topic discussed by Eliana Fu of Trumpf in a presentation on the use of green lasers in this sector — the "best kept secret in laser additive manufacturing," according to Fu. "Green Laser technology developed from the traditional laser cutting and welding sector, when applied to 3D printing, makes sense in terms of achieving results with better density, lower porosity, better surface finish, less spatter and improved productivity — depending on the part and parameters used, up to ten times faster than an infrared laser source with pure copper powder."

TIM HAYES

AR|VR|MR

continued from page 13

RGB with cadmium-free quantum dots. "I will share some of the progress that we've been making in that area," he teases. "We've been focusing on technology that can scale these devices so that you can make billions of them, drive the cost down, and make it a universal solution."

Beyond the main stage

Outside these gilded industry talks is a technical track brimming with significance. Unlike previous AR|VR|MR iterations, this year the entire technical program is in the form of a three-day poster session.

"During our last technical program, where each speaker just gave a 20-minute talk, we had 500 people in four rooms running at the same time — they were overcapacity," explains Robertson. "This year, there's a poster session every day right in the middle of the conference where the author's will be next to their posters, giving them more time to have one-on-one interactions and set up meetings."

Kress regards the technical program as central to the ongoing success of the conference. "The traditional technical presentations are a little bit less glamorous than the industry talks," he says. "But what we have seen in the past few years is grad students that presented papers in the technical tracks going on to become CEOs of startups."

A prime example is Stan Larroque. Larroque submitted a technical paper in 2018 that won the first Student Optical Design Challenge. This year, Kress and Peroz will be introducing Larroque on the main stage where the youthful VP R&D and founder of French startup Lynx will be describing the company's latest video see-through MR headset: Lynx-R1.

Though the industry talks paint a picture of the current state of play in XR hardware, and the technical talks provide detailed information for anyone interested in one particular aspect of XR technology, some attendees may want complete immersion in their topic of interest.

Expert training courses

For these participants, AR|VR|MR has dedicated 2–8 hour courses providing a whole spectrum of information linked to different elements of XR. "Some of these courses go deep into the technology," says Kress, who will lead three of the seven courses. "But we talk about markets, investment, use cases — it really touches everyone."

AR|VR|MR now also caters for attendees just starting their career or looking for a new job role, and companies hunting for talent. New for 2022, the job fair will feature industry-leading enterprises, from multinational giants — like Microsoft, Google, Meta, Amazon, and Apple — to XR startups like Lynx. "This industry needs people," says Robertson. "And the job fair is the perfect place for any company that's hiring."

The metaverse is coming — it's no longer a matter of if, but when. What will become clear to attendees over the three-day conference is that hardware is the hurdle to the metaverse, and AR|VR|MR is where the industry comes together to find ways to jump over it.

BEN SKUSE

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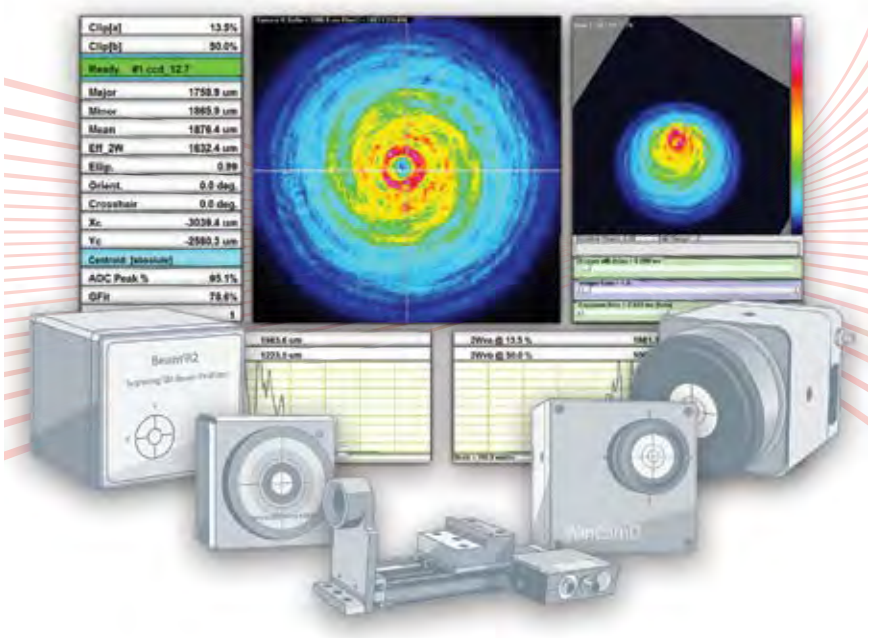

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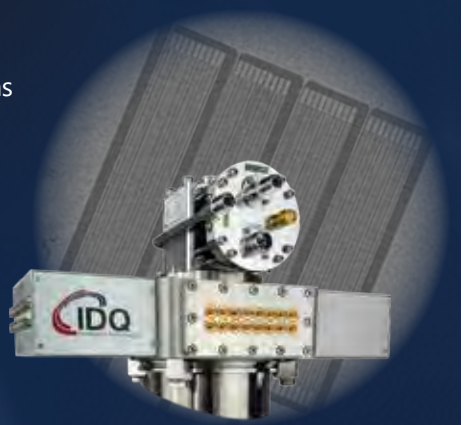

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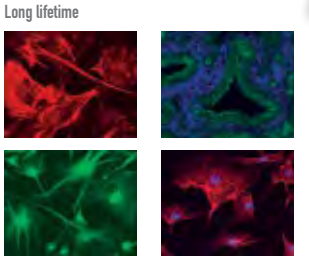

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It's a 3D world: Sensing a bright future for lidar

Industry experts are predicting an ever-greater enabling role for lidar, even if some steps will take a while — perhaps even until 2025.

Sensors used in the AEye lidar system are installed on top of this Jaguar, seen at AEye headquarters in Dublin, California. Credit: AEye.

The Photonics West panel "From Consumer to Space, 3D Sensing Adoption is Accelerating" on Wednesday will go well beyond lidar, to MEMS, beam steering and spectrum scan technology. Its audience will also hear about the software stack, sensor fusion and perception, and other topics expected to help deliver accurate 3D models, says Pierrick Boulay, of Yole Développement and 3D sensing conference chair.

The panel begins at 3 p.m. on the Exhibit Level's Expo Stage. Along with Boulay, it will include Luis Dussan, Chief Technology Officer and founder of AEye; Pierre Olivier, CTO of LeddarTech; and Gleb Akselrod, CTO and founder of Lumotive.

Key steps forward owe much to new photonics technologies on the emitter side, such as VCSEL arrays for lidar now using multijunction structures, Boulay said. With the same input current, the output power can be drastically increased. Regarding edge emitting lasers, or EELs, manufacturers are developing a limited wavelength deviation (EEL wavelength usually deviates with temperature). On the optics side, AR coatings are being developed to reduce signal loss between the laser emitter and receiver all along the optical path.

In short, lidar is popping up everywhere, says Dussan. He predicts that AEye's version of adaptive lidar will experience steadily accelerating adoption across markets — from automotive and rail to trucking, from intelligent transportation systems (ITS) to construction and mining.

Lidar, which stands for Light Detection and Ranging, uses pulses of laser light to take precise 3D measurements of road conditions for AD-equipped vehicles. Radar-based devices use radio waves.

Several new photonics and optics technologies are enabling key progress on lidar and 3D sensing, notes Akselrod. Lumotive is a leader in all-silicon lidar systems for consumer electronics, industrial automation, robotics and automotive applications.

"One of the big trends that we see in lidar," Akselrod says, "is the drive to higher levels of integration enabled by semiconductor technologies, and the move away from discrete and mechanical components, which brings down the cost of lidar.

"This means large detector arrays integrated with CMOS logic for processing, smart VCSEL arrays, and of course CMOS-integrated solid-state beam steering — which is what Lumotive pioneered."

Olivier of LeddarTech says the company is working on how to deliver better perception. "Our research projects aim at exploring different development axes, such as for instance beam steering, which

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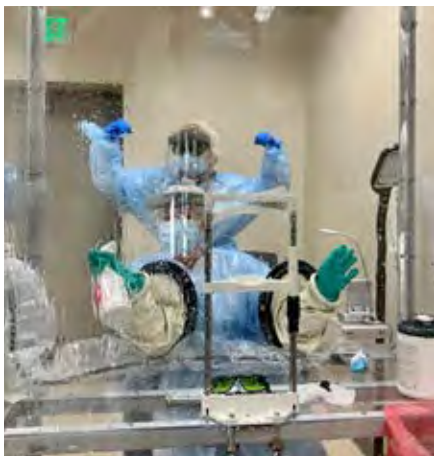
Covid-19 continued from page 11

unsedated patients to sub-cellular resolution. Studies take place in a negative pressure booth installed with HEPA filters, designed to protect both participants and clinicians. The Covid-19 patient will sit inside the booth while the clinician operates the intranasal probe from the outside through a glove port.

"It typically takes 20 minutes or less to perform intra-nasal μOCT on a person... and during that time we use the optical probe to take μOCT videos in different regions within the nasal airways," highlights Leung. "We can get high-resolution cross-sectional views of the epithelium, the thickness of hydration layers, motion of motile cilia and resulting transport of mucus."

"Data analysis is still underway but we've seen several abnormalities at the microscopic level in our Covid-19 study cohort," she adds.

As a technique, μOCT has been prized for how it can resolve highly detailed images of micro-anatomical features, such as cilia and mucus layers in airways, and holds great potential for Covid-19 analysis. For now, Leung says their research-grade instrument currently needs regular maintenance to optimize performance, but commercialization of the method is plausible.



Researching Covid-19's underlying mechanisms. Credit: Courtesy of Hui Min Leung / Mass. Gen. Hospital.

Echoing the sentiments of Popescu and Miller, the Harvard researcher adds: "The pandemic prompted us to apply our intranasal μOCT to study a relatively unknown disease."

"Being one of the few people to be able to see what happens to the airways of Covid patients at the cellular level, and having the chance to uncover new knowledge about this clinical phenotypes of this disease, is so very exciting," she adds.

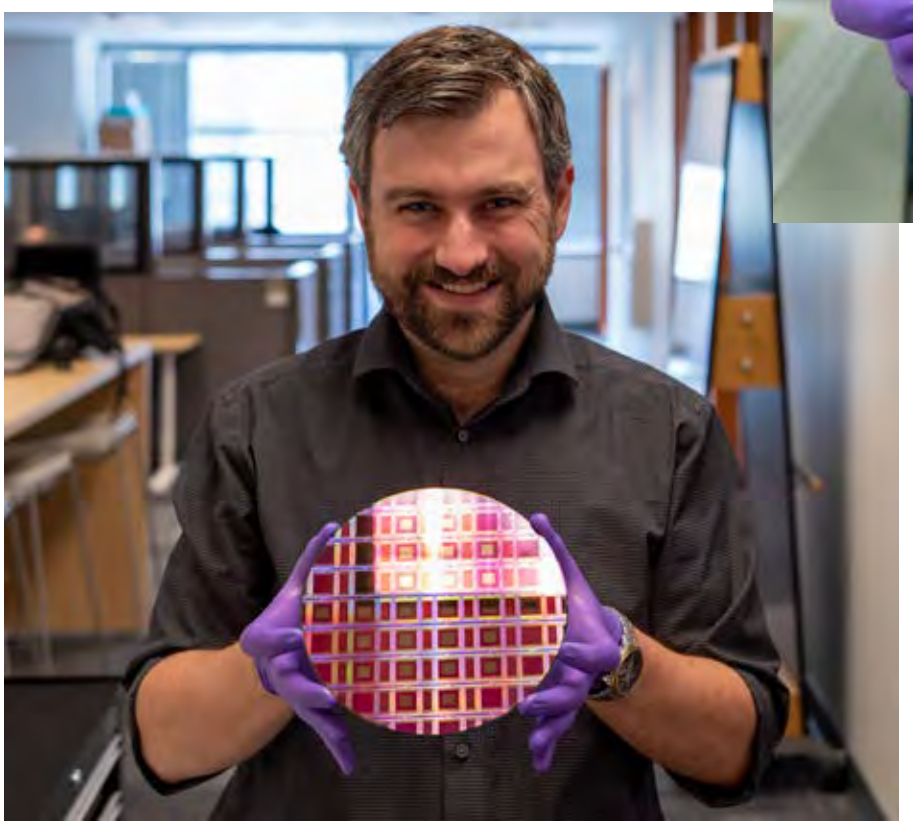
REBECCA POOL

Lidar continued from page 23

is a key enabling technology for lidar," he said. They orient activities around the key areas of uncertainty, like instance optical efficiency.

As a technology that's been around, in principle, in parallel with the laser, for 60 years, lidar's history is daunting.

"The main challenge has been to find applications that, taken individually, could generate enough volume to justify heavily cost-optimized solutions, and this is why platform solutions are so critical," says Olivier. He considers lidar technology still under-utilized.



Semiconductor technology is at the heart of the Lumotive Meta-lidar platform. An engineer in the lab with a wafer of the company's disruptive Light Control Metasurface (LCM™) solid-state beam steering chips. Credit: Lumotive.

Since 1971, lidar has been a mainstay of space missions. That year a laser ranger was on the Apollo 15 mission. Other such systems are working in space today.

A NASA report called lidar "a powerful tool in remote sensing from space." It recalled that lidars operate at a much shorter wavelength with a narrower beam and smaller transmitter and receiver compared to radar (for "radio detection and ranging.") It noted that lidars carry their own light sources and can continue measuring day and night. Some lidars are known by their targets, such as cloud, wind or CO2 lidars.

On the ground, experts predict lidar will play the leading role in everything from advanced driving support systems, known as ADAS, to autonomous driving, or AD, to autonomous mobility applications.

Thus, AEye has built its lidar platform to be flexible. For example, AEye's lidar enables software-configurable scanning patterns, allowing the sensor to adapt in real-time to different circumstances, such as city vs. highway situations.

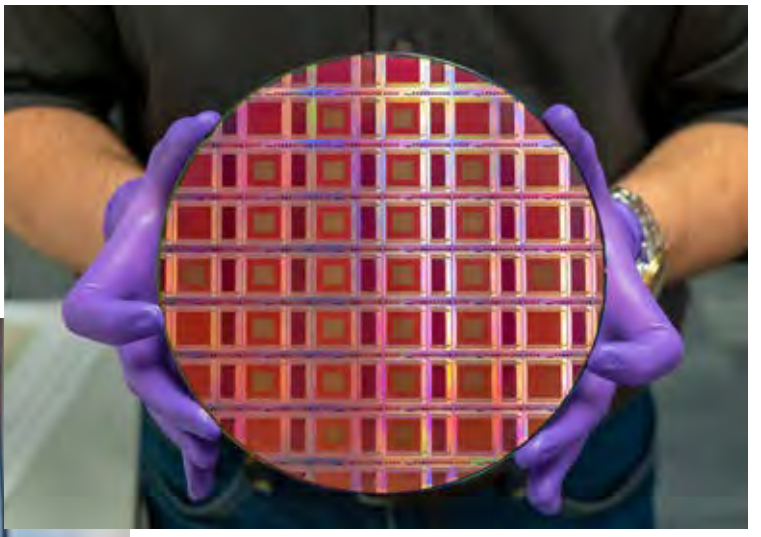
Previously, Dussan explained, a driver would be stuck with one sensor, in a static pattern for everything. Different hardware was needed in front and at the back for the car to operate safely in the city and on the highway. "That's no longer a limitation. With our system, you can just program it so when you are in the city you have a wide field of view. On the highway you have a narrow field of view, usually 10 hertz with really long ranges. That allows our customers to have the best of both worlds."

Generally, says Olivier, the attractiveness of the market for ADAS and AD, both for fleets and for privately owned vehicles, justifies "developing an optimized platform." But industry experts see some limitations and glitches in radar-based sensing applications.

'Autopilot, traffic jam-assist, and automatic braking'

"As a person who has kids," Dussan said, "one of the things I like about what I'm seeing now, about future vehicles, ones that are going to come out soon, maybe 2024 or 2025, is that we are talking a lot about autopilot, we talk about traffic jam assist, automatic braking. Those things are a minimum expectation of what people want from a smart vehicle.

"But when was the last time you were in an ADAS-equipped vehicle? Those are offering these things, but recent tests show that they only work in great lighting conditions, or when the person is wearing bright clothing. They just are not very accurate. There are a lot of false positives.



"And that's fundamentally due to the fact that the cameras are interpretive systems. They are great. We have one in our system. But radars have a lot of issues with respect to their resolution. So you are not getting reliable systems," said Dussan.

The good thing about lidar, the experts said, is that it's so much more deterministic — consistent, with no randomness.

"What you are going to see is, when there's a pedestrian in front, when it's dark, or light, whether he's wearing dark or light clothes, lidar brings its own light to the party," Dussan said. "So, it's going to stop, because it's going to be able to identify things, from the background, without confusion, and it is going to be able to make that decision."

What's exciting about the future of lidar is that all the features that the market is talking about are just going to "lock in and get much, much better," he said.

Luis Dussan, Chief Technology Officer and founder of AEye.

So people are going to say, "This actually does work, and it works all the time, when I need it to work. And it doesn't give me these false positives."

The more advanced lidar systems will likely reach automotive markets, Dussan predicted, by 2024 or 2025, at the dealerships for new autos. It will show up in industrial markets sooner than that.

Boulay agreed. "Today, we clearly see that mechanical scanning lidars are used mainly by automotive players, and this is expected to remain the case for a few years," Boulay said. "But in the meantime, solid-state technologies (MEMS-based lidar and flash lidars) are starting to be implemented by a few OEMs (original equipment manufacturers). However, other technologies based on FMCW ranging technology are not expected in the automotive industry before 2025."

Toyota is coming up with a model with some of the new short-range lidar features — working at about 30 meters, but the longer range lidar systems — ones that can spot a brick at 120 meters — will hit the market in the next few years.

With lidar being "the only deterministic sensor out there," it's like the cameras you see on your iPads or iPhones. The complexity of a lidar seeing objects in front of it is minimal, Dussan said. "It's always going to be there for you. It's reliable."

Furthermore, the cost is going down. "It's paralleling how radar started," Dussan said. That's expected to continue in rockets and spaceships as well as in smart lights at intersections.

For consumers, Boulay said, 3D sensing is being increasingly implemented in smart phones, vacuum robots, and payment applications. 3D sensing is progressing rapidly in logistics applications, such as warehouse AMR (autonomous maneuverable robots) and AGV (automated guided vehicles), delivery robots, and autonomous trucks. "Regarding smart infrastructure," he said, "applications such as intelligent transport systems (ITS), people-flow monitoring, and highway tolling are emerging."

For now, Olivier says, automotive has the potential to be the "killer app" for lidar. Some challenges remain unmet, such as achieving a larger field of view or sufficiently long detection range, but, Olivier said, LeddarTech, for one, has "unique and innovative solutions."

lidar's industry circles are expected to grow even wider, to include the new installations on the streets of "smart cities."

"We see a lot of analogues between what happened with cameras and what will happen with lidar," said Lumotive's Akselrod.

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Lidar

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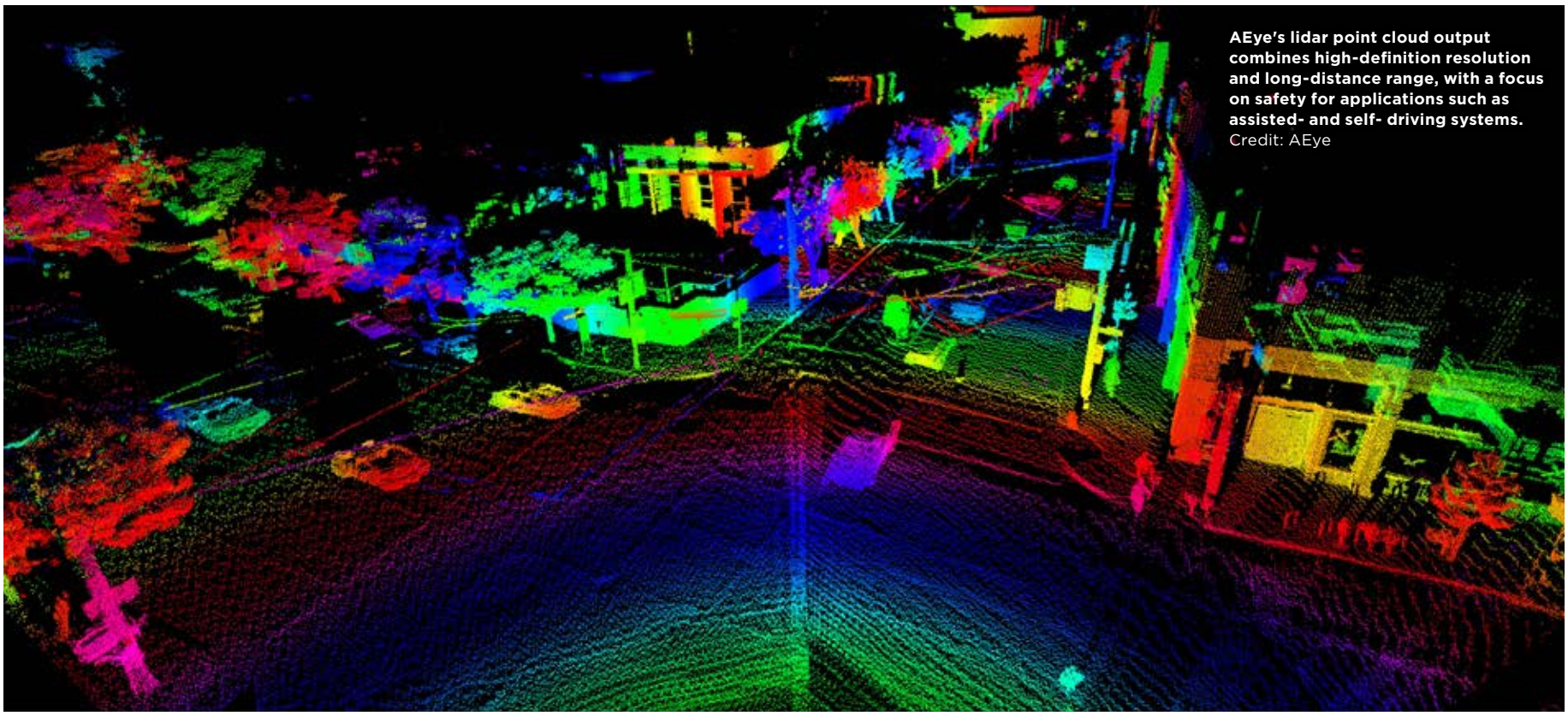


AEye's lidar point cloud output combines high-definition resolution and long-distance range, with a focus on safety for applications such as assisted- and self- driving systems. Credit: AEye

"Smart phones drove camera technology, and now there are billions of cameras enabling every kind of application imaginable. I think something similar will happen with lidar, where initially the interest is driven by automotive, but as lidars become cheap and tiny, 3D sensing will proliferate everywhere from robots to smartphones, to city infrastructure."

Added Dussan, "We know that construction wants to make vehicles safer, so they want the smart phones to be able to sense everything around them. We see cocoon lidars, an important ask from the general public — to surround everything with lidar, to be aware of everything around them.

"Our approach is helping to make the adoption of lidar happen faster. So we've removed the complexity from the hardware."

Lidar beyond automotive

That is going to lead to smoother adoption of lidar beyond the automotive space.

"We can apply that same idea of change in the software across different markets," said Dussan. "Trucking, heavy machinery, construction, mining, rail, intelligent transportation, retail, just to name a few markets that will benefit from lidar.

In short, construction apps seem to be a natural for growth.

AEye, Dussan said, offers "one of the most solid state systems out there," in terms of performance range and cost. One of the most exciting developments, he said, is that in AEye's work with the construction industry the systems can survive major vibration shock. "We are basically as solid state as your phone, and that allows these environments to be even rougher and harder, and the lidar systems will survive."

With that increased reliability, experts said the industry seems certain to see migration of these heavy-duty vehicles in harsh environments to lidar systems.

Three other companies were given high marks for integrating complete lidar based systems. They included Seoul Robotics, based in South Korea; TuSimple, based in San Diego; and Robotic Research, based in Maryland.

> We know that construction wants to make vehicles safer, so they want the smart phones to be able to sense everything around them.

Seoul Robotics' creates software products for robotic vehicle systems, intelligent transportation systems, ADAS apps, and processing of lidar data as a partner with major lidar companies.

TuSimple concentrates on trucking perception and vehicle movement generally.

Robotics Research develops systems for autonomous perception by vehicles, along with robotic technology. It says its platforms can be widely employed, from tugs, UAVs, and shuttles, to heavy-duty transit buses and full-size logistics trucks.

Calculating the costs

"Of course cost and functional safety are also important topics," said Olivier. "And once the industry addresses these issues the potential to leverage the technology in other markets is very large."

"Smaller, faster, cheaper, no question," said Dussan. "Lidar is emulating what's happened in the camera and radar space.

"The power of the market economy is going to drive down costs. That's expected and welcome, especially in our supply chain. As we increase volume, we are going to see lower component costs as well," Dussan said.

"Newer methods and techniques will change how we do lidar, or cameras, or radar. And that's going to further enhance the economies of the robotaxi or ADAS markets. That means smaller, faster, cheaper, and higher performing in general."

What about insurance discounts? When there's enough statistical evidence, the discounts will follow, the experts said, but there's not yet enough sample data.

"All you have is GM's Supercruise system, and Tesla's FSD (full self-driving) to some extent," said Dussan.

In all, the 3D panelists made it clear that it's not a matter of if but when lidar will be adopted across markets, and everybody should prepare for that. "We have collected a lot of data on autonomous systems now," said Dussan, "people are realizing its value."

Coping with 'corner cases'

Meanwhile, the auto industry is facing challenges for ADAS or autonomous driving systems from "corner cases" – situations where an autonomous vehicle has difficulty addressing or identifying an object or circumstance, which in turn can result in an accident or fatality. An example might be a brick in the road, at a distance, at night.

"People used to say 90 percent of the problems were solvable by a certain set of features," Dussan said. "And then you have the other 10 percent that are really hard.

"But now what we are seeing is that there is a set of corner cases that make up 80 percent of the problem in robotaxis or autonomous vehicles — and that 80 percent of corner cases is different all the time, and they can't be solved with just one type of pattern. And you need an adaptive, intelligent lidar system, to overcome them."

For all of these industries, says Olivier, the Photonics West event is crucial, since optics and photonics are an essential part of lidar. It gives, he said, an opportunity "to go down the different rabbit holes that may lead to new research activities. That is what makes it a must-attend event."

FORD BURKHART

Trumpf and Metalenz showcase polarized VCSEL possibilities

Laser giant Trumpf has teamed up with Boston-based Metalenz, the meta-optics spin-off from Federico Capasso's Harvard University laboratory, to show how a combination of the next-generation advanced optics and VCSELs (vertical-cavity surface-emitting lasers) might play a key role in future consumer electronics devices.

At the Trumpf booth during Photonics West, the two companies are hosting a live showcase featuring VCSELs with controlled polarization for illumination applications. "This new VCSEL will lead to much smaller construction space needed, for example, in smartphones for 3D scene illumination," they say.

Spun out of Harvard in 2016, Metalenz is regarded as the first company to commercialize meta-optics. Capasso and his colleagues came up with the concept behind the extremely thin, flat optical components, initially to save space and lessen the weight of optical systems on board drones.

Last year the startup signed a co-development and licensing agreement with semiconductor maker STMicroelectronics to integrate its meta-surface optics technology into STM's existing diffractive optics manufacturing process at its large-scale wafer fab in Crolles, France, initially for applications in near-infrared sensing. The lenses manufactured at the site feature nanostructures just one-thousandth the thickness of a human hair.

Trumpf, which acquired its VCSEL expertise through the 2019 buy-out of Philips Photonics, sees a growing range of advanced industrial and consumer sensing applications for the tiny emitters, ranging from oxygen sensing to facial recognition.

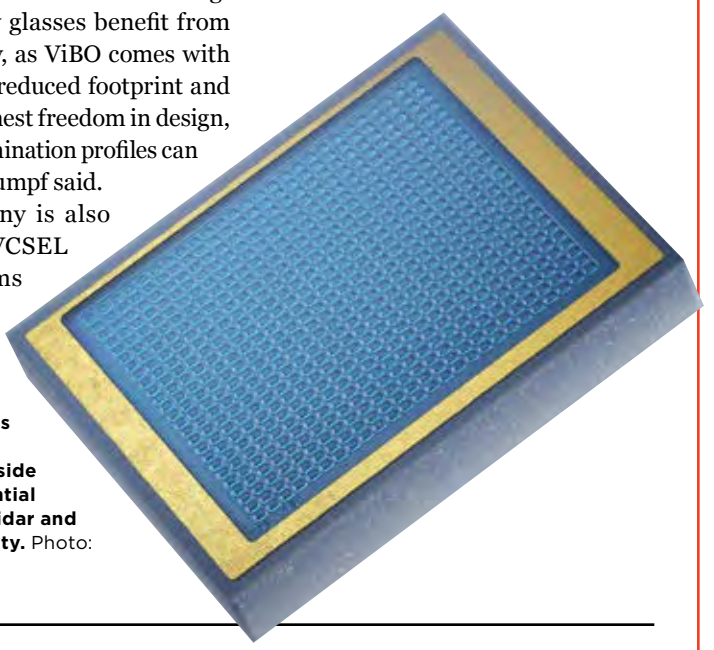
Under its Trumpf Photonic Components division, the laser firm's portfolio now features a new single-mode VCSEL for highly precise time-of-flight sensors. Another new offering is called "ViBO" (short for VCSEL with integrated backside optics), which includes monolithically integrated micro-optical elements and is aimed at emerging photonics applications in fast-growing end markets.

"Applications such as lidar or augmented reality glasses benefit from this technology, as ViBO comes with a significantly reduced footprint and offers [the] highest freedom in design, as tailored illumination profiles can be created," Trumpf said.

The company is also showing off VCSEL heating systems this week in San Francisco, an approach that enables direct heat treatment with fully controllable emission zones. The idea is said to offer huge potential for a variety of industrial applications, including more sustainable lithium-ion battery production, local softening of metal automotive parts, and photovoltaics.

For battery manufacturing, the high-power VCSELs enable faster and more energy-efficient drying of active material, which leads to a more efficient overall production. Finally, Trumpf has combined VCSELs and photodiodes for use in optical communications, more specifically for low power consumption and low latency in data centers.

MIKE HATCHER



The new "ViBO" offering from Trumpf combines VCSELs with integrated backside optics, for potential applications in lidar and augmented reality. Photo: Trumpf.

Shy Shoham, NYU. Credit: Joe Cobbs

Neural coding

continued from page 03

detect synthetic 2-photon holographic stimulation patterns, which revealed sensitivity to about 20 neurons and a crucial role for synchrony in neural readout. Different odors, Shoham said, activate different sets of receptors.

To stimulate and record, his lab used parallel opto-acoustic and transcranial ultrasound opened precision. It allowed bidirectional neural-interfacing by combining opto-acoustic functional imaging with precisely targeted ultrasonic neuromodulation.

Holographic optogenetics confocally unraveled sculpting along with fluorescence guided focused ultrasound enabled real time in situ mapping of the researchers projected excitation patterns and the resulting tissue distortions. Optical shams distinguished between the detection of neural activity of the optically induced off-target artifacts.

"We have developed technologies that allow us to examine the detection of multiphoton stimulation patters in very small amounts of neurons and to use that to probe the read-out mechanisms [in the mouse brain]," Shoham said.

WILLIAM SCHULZ

FREEDOM PHOTONICS CLAIMS 1550NM LASER POWER MILESTONE

Component maker Freedom Photonics says it has achieved a new world record by demonstrating more than 5W of continuous-wave optical power from a 1550nm diode laser amplifier with "nearly diffraction-limited" beam quality.

That result is double the previous record, which the company says was reported only three months ago. Commercial samples — including bare die, chip-on-submount, and packaged — are now available for purchase from the Santa Barbara firm, which is anticipating applications in lidar and remote sensing.

Paul Leisher, Freedom's VP of Research, said in a company release: "This achievement is a testament to the inherent scalability of our 'aura' product line, and demonstrates that this is just the beginning of a product life cycle that will see continuous improvements for years to come."

The aura products are intended to address applications including free space optical communications, sensing, and lidar, by enabling watt-level direct use output from a semiconductor chip source.

Freedom believes that systems based around the devices will offer an order-of-magnitude improvement in cost, size, and efficiency through the elimination of the erbium-doped fiber amplifiers (EDFAs) that are routinely used to boost optical output to watt-level powers.

The sources have been extended to operate in the 1300-1400nm range, delivering more than 3W of diffraction-limited optical power.

Leisher, who is co-chair of the *Components and Packaging for Laser Systems VIII* technical conference at Photonics West this week, was himself scheduled to present details of the 1550nm source during Monday's technical sessions. He describes the tapered diode laser amplifiers developed by Freedom Photonics as a disruptive technology breakthrough that is poised to revolutionize the lidar market. "Output powers which were previously only achievable using doped fiber, glass, or crystal laser architectures are now possible directly from the semiconductor chip," he reported in an abstract for the paper.

According to Jenna Campbell, who is the firm's director of high power and was listed to present a paper on similar emitters producing more than 9W of optical power at 885nm and 980nm on Sunday, applications of the devices also include fiber laser pumping.

"Our highly talented team has achieved these results through a patent-pending design which mitigates specific problems arising in the underlying device physics," noted Campbell. "We are extraordinarily excited to see where we can take this technology next."

MIKE HATCHER

Dr. Lutz Aschke elected as president of Photonics21

Dr. Lutz Aschke, Managing Director of the Mahr Group, has been elected to represent Photonics21, the European Technology Platform for photonics, for the next two years. Dr. Aschke earned his doctorate in physics at the Ruhr University, acquiring additional qualifications in business administration and labor sciences.

Today Photonics21 represents more than 3,000 individual members from across Europe and beyond. Members are typically experts active in the photonics industry, research organizations, and universities. Since Photonics21's foundation in 2005, the membership has developed a joint photonics strategy for future research and innovation in Europe. The group also advises the European Commission on research and investment programs.

Before joining the Mahr Group as managing director, Aschke was managing director of the Photonic Components division within the Trumpf Group. Throughout his career Aschke has been actively involved in Photonics21 as a member of both the Board of Stakeholders and the Executive Board. He has also been a Senior SPIE Member for almost 15 years.

Photonics21's Executive Board, in its latest session, also elected two additional members to the Board. Dr. Eric Belhaire will serve as the Chair of Working Group 5 – on Safety, Security, Space & Defence – and Dr. Chris van Hoof as Chair of Working Group 6 – Agriculture and Food.

Dr. Lutz Aschke. Credit: Mahr Group.

Belhaire belongs to the technical directorate of Thales Optronics Business Line. Its main specialties are the electro-optical technologies, infrared, and visible image sensors. He is currently leading an international transverse group dedicated to the management of those key technologies.

Van Hoof is the general manager of OnePlanet Research Center and is part of the management team of OnePlanet. He is responsible for the R&D direction and business strategy of R&D teams across four sites of Imec, the Belgium-based photonics, nanotechnologies, and high-tech research institute.

MATTHEW PEACH

Healthcare panel continued from page 04

of driver assist feature for the surgeon to reduce the trauma.

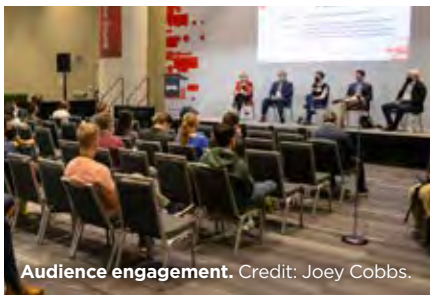
"Our biggest achievement from the past year is that we received our first funding in the form of a commercialization grant, so now we are able to work full time to develop this technology into a product."

The final speaker, Dr. Bill Hyun has progressed from serial technology company launcher to becoming a Venture Partner at Genoa Ventures. He commented, "With my venture hat on, surviving the past two years has been the challenge. From a trend perspective, on the investments side, there's a lot of money out there – good money that's looking for good ideas. Genoa was able to raise funds, and the valuations of the companies that we have invested in, are up about 30% and that's a big jump."

Dr. Myers then asked the panel to describe some of the key factors and external agencies that had helped them most in launching their companies.

Dr. Kuperman said, "My first step was to get internal grant funding from UCSF, which enabled me to do some of the preliminary work. I participated in a program run by the US National Science Foundation called I-Corps. It's a wonderful program with nodes all across the USA. It forces you to answer all the questions you need to ask to launch a business. I have talked to at least 200 clinicians and found that a key factor is that they do need to get paid in order to want to use a new solution you may be developing."

Dr. Ray added, "What we had to do was take our limited resources and derisk the technology, derisk the concept to get a little more money, then continue derisking. You need to understand who is going to pay for the development, and what the regulatory pathway is going to look like. I-Corps's program actually pays you – they will give you $50,000 to do customer discovery to ensure that what you are building is what people want."



Audience engagement. Credit: Joey Cobbs.

Dr. Reddy agreed: "I-Corps is an amazing program because it forces you to get out of the lab and talk to people. Also, one needs to see beyond technical solutions. There are a lot of non-technical barriers and the way you find out about those is by talking to people."

Dr Hyun added: "It comes down to two simple equations: the first is for the startup person is to define the market opportunity. An investor is always doing this return-on-investment analysis and I tell all of my entrepreneurs that I need our startup companies to pretend that they are the investor, to make that investor thesis for the startup so that you can talk their talk."

MATTHEW PEACH

Endowment continued from page 01

"One of the fun things about gifts like this is that it allows us to 'invest in the best,' to continue to search for future Nobel laureates, entrepreneurs, and engineers from all over the world to come to Rochester and be part of our growing family."

This marks the tenth such gift from the Society as part of its SPIE Matching Endowment Program. The program was established in 2019 to increase international capacity in the teaching and research of optics and photonics, and, with this latest gift, has provided nearly $4 million in matching gifts, resulting in more than $10 million in dedicated funds. The SPIE Endowment Matching Program supports optics and photonics education and the future of the industry by contributing a match of up to $500,000 per award to college, institute, and university programs with optics and photonics degrees, or with other disciplines allied to the SPIE mission.

DANEET STEFFENS

Back to business continued from page 01

recreate the experience of an in-person exhibit. Walking the hall, it was clear all were enjoying the opportunity to be back on the show floor.

"We are thrilled to be back," said Andover Corporation's COO Michael Tiner. "We've been coming to Photonics West for years and the BiOS exhibit is always a great precursor to the Photonics West show — a lot of the same people are at both. There's nothing like in-person, really: I think Zoom meetings add a nice layer of communication, especially for the technical aspects of our job, but there's nothing that instills trust like looking people in the eye and shaking their hand."

"We're really excited to be here and connect with people face-to-face even with masks," said Materion Balzers Optics Marketing & Communications Strategist Jennifer Lee. "It's exciting to be in a place where everybody's looking at the new technologies, to be able to speak to people in person, see what problems we might need to solve for them, and come up with synergies to work together."

But it's not only about customer-facing interactions. The conferences are fertile ground for potential hires, feeding an industry that's thirsty for skilled recruits. For Toptica VP of Sales and Marketing Thomas Tongue and his team, that meant being able to see a candidate give their technical talk and then have follow-up conversations with them in person. Everybody's having trouble recruiting right now, he noted: "Being here is a great way for us to leverage this opportunity."

"But this is also about what we call 'creative collisions,'" Tongue added. "It's not necessarily about the customer that you're expecting, it's the one that you're not expecting that this kind of event offers, that serendipitous finding of somebody who has a need that you can solve. That only happens by running into people and having those conversations, which only exhibitions and trade shows really allow you to do – and it's something that we have been missing for two years. So we're very happy that SPIE has soldiered through this. We were one of the first supporters when they started returning in person at Optics & Photonics, and that's because we believe that this is how the industry becomes stronger. We're excited to be a part of it."

As the BiOS show closed Sunday night, the exhibitors began to wrap up their booth and prepare for Tuesday's opening with optimism and a reaffirming of the value of being back in person.

"As you can tell, SPIE Photonics West is open and back in business!" said SPIE Director of Global Exhibition services, Bonnie Peterson. "We are thrilled to be in San Francisco supporting the photonics industry. To feel the buzz of Photonics West again after two years is amazing, and we want to thank all of the companies that make the BiOS and Photonics West exhibits happen."

DANEET STEFFENS

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