PHOTONICS WEST FOCUS

...the best place to see the industry and a brighter future on display.

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Welcome to

SPIE PHOTONICS WEST 2021 Digital Forum

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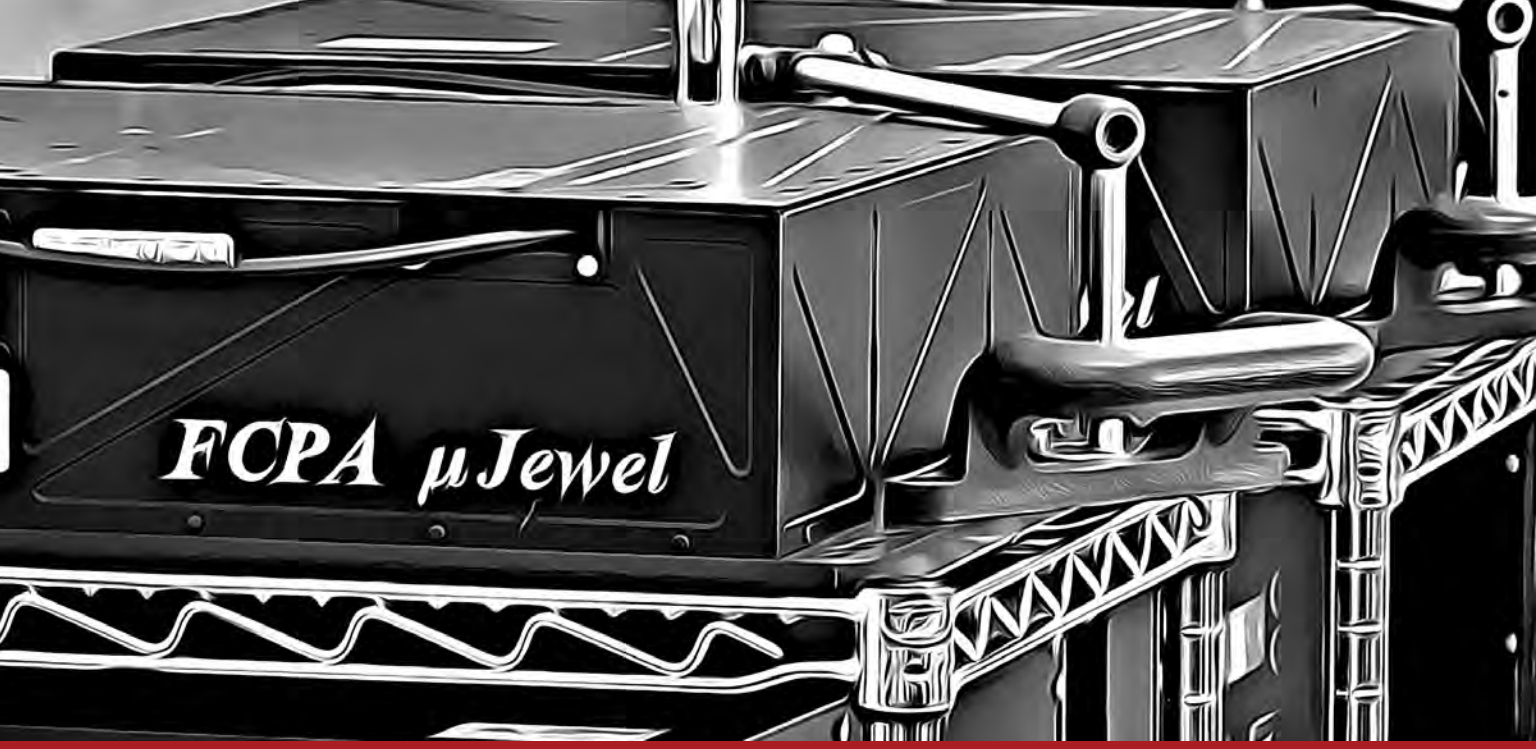

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Welcome to Photonics West 2021

An extraordinary event in an extraordinary year.

By Kent Rochford, CEO and Executive Director of SPIE

Credit: SPIE

Kent Rochford, SPIE's CEO.

In most years, when March rolls around, we in the photonics industry are *(almost)* fully recovered from the week of nonstop excitement and lack of sleep that is SPIE Photonics West. Like just about everything right now, Photonics West and the first week of March are a little different this year. Instead of recovering and following up with the new connections we made, this March we'll be logging in and engaging with each other online at the first-ever Photonics West Digital Forum.

Not having an in-person Photonics West means many things, including no *Show Daily* with its insights into the people, technologies, and companies that make the week so valuable. This *Photonics West Focus* magazine aims to recreate some of that behind-the-scenes buzz, introducing you to the great lineup of content that Photonics West will offer. Included here as a companion to our award-winning member magazine *Photonics Focus*, we that hope you find the articles in both publications enjoyable and informative as you prepare for Photonics West.

And while most things seem to be in flux, a few constants do remain. SPIE is still here, serving the optics and photonics community. The SPIE staff has been busy as ever, working to ensure that Photonics West and all of our other conferences, publications, and offerings continue at the high level you deserve and have grown to expect from us. We hold our mission dear, and while we're not able to host you in San Francisco this year, we still aim to give you a world-class experience and customer service that is second to none.

The photonics industry continues to thrive while, alongside the community of researchers and engineers it supports, making the future brighter. Photonics West remains the best place to see the industry and that bright future on display. From the groundbreaking research discussed in the technical conferences and the technology-enabling product launches in the Digital Marketplace, to business and market discussions in the Industry Program, the week's content is sure to inform and excite all who participate in the innovation ecosystem that drives science and technology.

Fruitful and engaging

Of course, this year will be less fun. There aren't 20,000 plus engineers together in San Francisco after all, but that doesn't mean it won't be fruitful or engaging. We have exciting events lined up throughout the week, the technical program is strong, and the Digital Marketplace will include over 300 companies showcasing the latest and greatest our industry has to offer, including product demonstrations and the ability to connect directly with company representatives.

New this year is Quantum West, a program running March 8-11, highlighting the growing quantum market and the role photonics plays as an enabler to the technology. The event, organized in partnership with the Quantum Economic Development Consortium (QED-C), will include invited talks, a panel, and discussion opportunities.

Take time to explore

We hope you explore all that the Photonics West Digital Forum has to offer and are able to recreate some of the conference experience, whether that's watching and listening to the technical presentations, hearing from visionaries in a plenary session, browsing the company offerings, or exchanging LinkedIn contacts during a networking session. I encourage you to take advantage of everything the week has to offer, listen to a talk in a discipline outside your expertise, and reach out to other attendees on Slack.

We have heard from many of you—and agree wholeheartedly—that online events are not perfect substitutes for real-world SPIE events. Yet we will continue to refine these offerings and look for ways to further emulate the connections, dialogue, and progress made possible when bringing smart and curious people like you together.

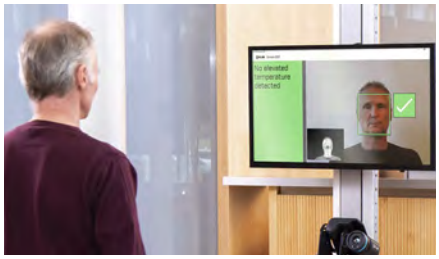
We hope you join us for the Photonics West Digital Forum; it's going to be a great week.

Covid impact: upbeat industry survey says photonics production continues

A recent SPIE survey of industry and academia reveals mix of challenges and optimism, but this versatile sector has adapted rapidly.

By Matthew Peach, Editor-in-Chief, optics.org

It's the question everybody wants answers to: what are the key impacts of the Covid-19 pandemic on the photonics industry and research? To discover what has been happening, SPIE conducted the "Covid-19 Impact Survey" in the fall of 2020, gathering responses from more than 250 senior figures in business and academia across the US. Many sectors are represented in the survey, with imaging, lasers, optics, and biophotonics topping the list.



Credit: FLIR SYSTEMS.

In June, 2020, FLIR Systems launched FLIR Screen-EST software to improve skin temperature screening for Covid-19.

"Our community has faced Covid-19 with resiliency, but the pandemic has affected employment, remote work, childcare, and other aspects of our lives," commented Adam Resnick, Marketing Analyst at SPIE, who led the survey.

Most respondents, 64%, agreed that the pandemic has had a significant or life-changing effect on their personal, professional, or academic lives. They report that life is more stressful, mentally draining, and that they are feeling more isolated. But 35% of respondents had been "less impacted" by Covid-19. According to the survey, some actually found benefits, such as being surprised how much their teams could still achieve while working remotely, and even reporting positive effects on health and family relationships.

Mixed responses

Resnick scrutinized the results and identified a mix of positive and negative responses: "Covid-19 has had negative impacts on much of industry and academia, though the degree of impact varies widely. In industry, more than half of companies (57%) reported operating at or above pre-Covid levels; 27% said they have been moderately impacted, while 17% have been impacted substantially or worse," he concluded. For academics, 77% of respondents had seen delays in their lab-based research of three months or more due to Covid, though only 21% expect these delays to endure past December 2021.

Surprisingly, many participants responded with optimism about the near future: 68% of industry respondents expect sales revenues to return to pre-Covid levels or to increase by December 2021; only 13% of respondents expect reductions in staffing in the next year, with 28% predicting an increase; almost half of companies (48%) had received support from US Government programs.

Considering professional and social interactions with other businesses and researchers, the survey respondents regard online exhibitions and technical conferences (which SPIE has been energetically developing and refining from the get-go) as "continuing to play a large role through 2021", Resnick added.

Most (83%) industry respondents expect that exhibitions in December 2021 will involve a mix of in-person and online participation and most academics (66%) expect that future professional conferences will also involve a mix of in person and online participation.

Credit: Teledyne e2v.

Safe hands: Teledyne Imaging is supplying charge coupled devices for Covid-19 diagnostic instruments.

Changing work practices

According to the survey, only 4% of workers had reported leaving their jobs during the pandemic (through October 2020), although higher percentages of women had left their jobs compared to men, 6% versus 3%. Seven out of ten respondents work full-time, while 20% are students.

Like many sectors of business, the photonics community has seen a big shift towards home-working. Prior to the pandemic, 57% of respondents reported not working remotely at all, while 22% worked remotely four or more days a week. By October, 60% were working remotely four or more days per week while just 16% remained at their usual place of business.

Many survey participants offered comments on their remote work, describing a variety of experiences. Some enjoy remote work, and reported that "Working from home is great. My productivity in work and life is improved." Others are doing their best to cope, missing real interactions such as "the water-cooler talks that are important for keeping up with the news and getting a sense of how people are feeling."

For most parents, Covid-19 led to more time spent on childcare, with 56% of respondents with children reporting an increase. The effect was noticeably stronger for women than men, with 46% reporting an increase of 10 or more hours of childcare per week during the pandemic versus 31% of men.

"As a full-time working mother providing supervision for remote learning to two children, I am constantly juggling the demands of my own work, managing an employee, supervising/supporting two educations, and domestic chores," said one woman.

Credit Toptica Photonics.

Bal masqué: Toptica's team showed how to safely celebrate the Laser At 60.

UK meets the challenge

In September 2020 the UK's Photonics Leadership Group (PLG) presented a similar, generally positive picture in an update of its own survey of the pandemic's impact on the UK photonics industry.

Dr. John Lincoln, Chief Executive of the PLG, shared the data, collected in September 2020 at the SPIE Photonex+Vacuum Expo Digital Forum, another popular virtual event. He said, "The really positive thing is that, six months into the pandemic, 92% of UK-based photonics manufacturers reported that they were operating at over 75% capacity.

"Almost everybody was operating at over 50% capacity and nobody had suspended operations any more, meaning a slight increase over April 2020 figures. By September, 16% of UK photonics companies reported that they were operating at increased capacity over the spring figures." Essentially, by the fall of 2020 UK photonics was fully operational, Lincoln concluded.

"We asked what issues had presented challenges to our business group. It was heartening to see that for one fifth of companies, they reported no major challenges. Where challenges are reported, the lengthening of the sales cycle was a problem. Supply chain issues still remained significant."

Looking ahead, Lincoln identified a major shift towards a positive outlook: 68% of UK respondents said in September that they envisaged company revenues would increase or at least level out in 2021.

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Dual-comb mode locking finding applications in spectroscopy and lidar

Plenary speaker Professor Ursula Keller, of ETH Zurich, Switzerland, opens day one of the Photonics West Digital conference with a talk on the applications and potential of dual-comb mode locking sources.

By Matthew Peach, Editor-in-Chief, optics.org

Optical frequency combs offer advances to a variety of optical sensing applications. However, their progress has been limited because of the complexity and high cost of existing OFC systems. This is doubly so in the case of dual-comb lasers, where a pair of frequency combs is needed.

A fully stabilized optical frequency comb provides equally spaced frequencies creating a precise ruler in optical frequency metrology, which has various functions in spectroscopy and lidar applications. Keller's plenary presentation at the Photonics West Digital Conference, on Monday 8 March at 06.45 AM PST, appraises her group's successes in dual-comb generation from diode pumped solid-state and vertical emitting semiconductor lasers.

To achieve the potential of dual-combs, innovation in the laser sources themselves is required to make them practical for use outside the laboratory, Keller told *Photonics West Focus*. The transition, from high-performance but cumbersome and highly expensive lab setups to robust but economical prototypes, requires further research and development. "Once this transition is achieved, yielding practical dual-comb laser sources, a variety of innovations in laser-based sensing will become possible," she said.

The first type of accessible system is asynchronous optical sampling, also referred to as equivalent time sampling. This is a technique that can replace traditional laser pump-probe setups for time-resolved spectroscopy experiments. These have application in studying ultrafast dynamics in biology, chemistry, and physics.

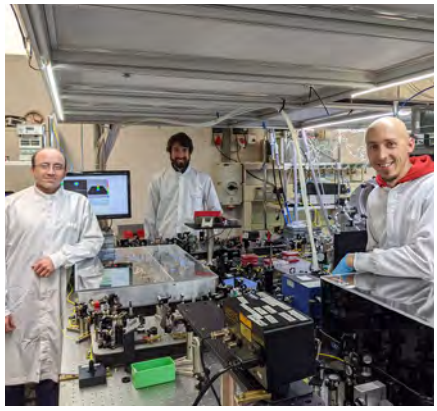
The use of gigahertz lasers for compactness and high speed together with ytterbium-doped gain media for efficient and low-cost lasers offers many advantages compared to Ti:sapphire laser-based systems.

"Our dual-comb laser approach offers another significant reduction in complexity since only one laser is needed to generate two modelocked pulse trains with an adjustable difference in their comb spacing," said Keller. "Combined with supercontinuum generation and nonlinear frequency conversion, a wide wavelength range is accessible as well and many applications do not even need any additional laser stabilization efforts. The free-running dual-comb laser is stable enough."

Lidar and spectroscopy

A key application area is lidar, which is currently a hot technology area for non-contact position measurements, and dual-combs can offer fast measurements, long range, with sub-micrometer precision.

Laser spectroscopy is another area with a lot of potential because of the need for detecting trace gases whether as pollutants from industry, or as indicators of disease in human breath. Keller commented, "We envisage these devices becoming ubiquitous in society, revealing the hidden and potentially harmful constituents of our environments or our own bodies."



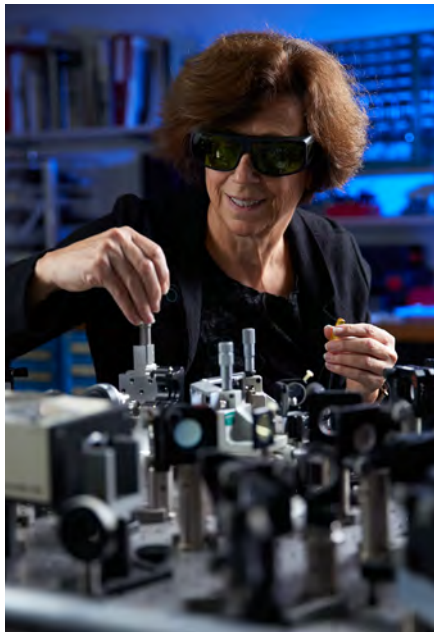
ETH Zurich

Prof Keller's team (left to right) Dr. Chris Phillips, Dr. Benjamin Willenberg, Dr. Justinas Pupeikis.

Conventional FTIR spectrometers using incoherent light sources have relatively low spectral resolution and low brightness, limiting their capability to detect or distinguish trace gas components. Laser-based techniques can overcome these drawbacks. "So we are targeting the development of a compact and portable device which can be widely deployed in industrial, medical, or other settings for real-time analysis of different environments," she added.

Plans and views

So what are the plans and objectives for her ETH research groups in 2021? Keller answered, "My group members, Chris Phillips [group leader], Benjamin Willenberg and Justinas Pupeikis [both postdocs] are targeting commercialization of this dual-comb technology via a startup. Initially we will start with diode-pumped Yb-doped solid-state lasers



ETH Zurich.

Photonics is fun: Professor Keller in her lab.

and depending on the application area we can further reduce complexity with optically pumped semiconductor lasers such as the dual-comb MIXSEL.

"An important ongoing task is prototype development, starting from our latest scientific laser results. The existing versions of the lasers are already robust enough for performing day-to-day with minimal maintenance experiments. However the lasers are still fairly bulky and they use separate benchtop electronics devices.

"Thus, rugged prototype development serves several purposes. It helps advance more application demonstrations, it opens up collaboration opportunities outside our labs, and it is expected to improve noise performance by providing reduced sensitivity to the environment," she said.

Cushioning Covid

Keller believes that the impact of the Covid-19 pandemic on her research and work in general has been cushioned by the benefits of optical networking development over past years. "Previous long-term research work into optical communication with high-speed internet access has made home office working on a larger scale possible. This has only been possible because of the photonics research and industrial development," she said.

To conclude, Keller was asked why she recommend a young physicist to consider working in photonics. She replied, "Photonics is a cutting-edge technology for many application areas, from fundamental science to many interdisciplinary application. With a good basic education in this field, many different doors can open for many different career choices. For me personally it is also simply very much fun."

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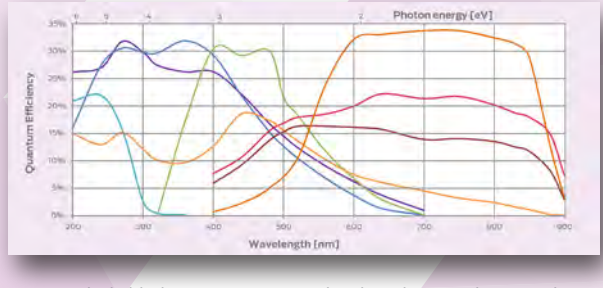

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AIMing high: a reboot for the US photonics foundry

A new year, a new leader, and a new structure at the US integrated photonics foundry.

By Ford Burkhart

For 2021, the US optics powerhouse called AIM Photonics has a new look. It now appears a lot more like a streamlined business. And that precisely reflects its recent leadership.

Its top leader for much of 2020, Michael Cumbo, says the new structure could be called "AIM 2.0." AIM 1.0, in his view, was its first five years as the $600 million partnership of the US Department of Defense, industry, and academic labs. Cumbo stepped down as CEO February 1st, 2021, to join a private equity company, but will continue as special adviser to AIM leadership. On the same day, John Bowers of the University of California at Santa Barbara became AIM's acting executive director.

Now, the speed of getting AIM's signature Multi Project Wafers (MPW) through the pipeline will be much faster, with six runs a year, up from three. "Some users will have to wait only a month or two, rather than up to a year," Cumbo said. "We are really excited about that."

And AIM's membership costs are going down. "Some members are pleasantly surprised," Cumbo said, "when they call us and see their costs down 75 per cent."

AIM is a partner in research that could lead to breakthroughs for such apps as military microsystems, big data, biosensing, self-driving vehicles, AR, 3D camera technology, and quantum computing.

AIM membership terms improved

When AIM 2.0 was launched in 2020, Cumbo says, "A bunch of things needed attention. As luck would have it, that was a US Presidential Election year." Right away, he set out to revamp the AIM Photonics membership agreement, which he says "was needlessly complicated." It had offered various institutional categories, four tiers of membership, different fees and credits. It now has just a basic two levels.

The leadership council will be reduced from an "unwieldy" 18 members, recruited from large and small industry, academic institutions and the DoD, down to "a more nimble and active" 12 members. The member agreement was a "legalistic" 60 pages. It's now 9 pages long, and the Tiers are down from 4 to 2.

The popular tier 3 fee will be cut by 75 percent, down to $25,000 year, AIM said, and the entry level tier fee will be $3,000 a year. There will no longer be a tier 1 or tier 2 as in AIM 1.0.

Cumbo predicts smaller companies, those with fewer than 500 employees, will want to buy into the new $25,000 membership fee, since they will receive credits for their spending on a Multi-Project Wafer, or MPW, project. "That will make it easier for them to become full members," Cumbo said. "The goal is to get their cost down to zero, for companies that utilize our services."

Photo Credit: Sonia Fernandez / UCSB.

John Bowers and postdoctoral researcher Tin Komljenovic with a wafer of integrated photonic circuitry to be manufactured by AIM. Bowers is now leading AIM.

AIM now has 127 members. "We expect more people will come in and participate and our ecosystem will continue to grow," he said. Users of the MPW do not need to be members, he emphasized.

One research outpost in the AIM spotlight will soon be putting advanced integrated photonic circuit lasers on silicon wafers. That is a bold project at the University of California Santa Barbara labs of John Bowers, the new AIM leader.

Bowers is the Fred Kavli Chair in Nanotechnology and a distinguished professor in the Departments of Electrical and Computer Engineering and Materials. He is also working on developing the West Coast outposts of AIM, which is headquartered in Albany, New York.

His lab's laser work is unfolding as part of a $19 million research award, under the Lasers for Universal Microscale Optical Systems, or LUMOS, program, through the US Defense Advanced Research Projects Agency, or DARPA. It will create end-to-end photonic functionality on single crystal silicon substrates.

The payoff will be increased optical gain – roughly, amplification – of a device.

"Optical gain on-chip is essential to enabling increased complexity and bigger photonic integrated circuits," Bowers said.

It was the same for fiber-optic transmission, he said. A device called an Erbium-doped Fiber Amplifier, or EDFA, enabled the revolution in Dense Wavelength Division Multiplexing, or DWDM, and increased transmission capacity by 100x.

"It was even more true for electronics," Bowers said. Without gain, that is, without a transistor, modern electronics and very large scale integration, or VLSI, would have never happened, Bowers said.

"This is our goal in the LUMOS project," he added.

Partners in the LUMOS program include Analog Photonics; IQE; and NAsPIII/V GmbH, based in Marburg, Germany. The LUMOS team will also develop a standard laser design for nontraditional, silicon-based integrated circuits. Analog Photonics, a tier 1 AIM Photonics member, will assist with system implementation.

Mike Watts, the CEO of Analog Photonics, and AIM Photonics chief technology officer, said, "Eight years ago, a team of engineers from the Albany Fab and Analog Photonics began implementing our first PIC (photonic integrated chip) designs and our first DARPA program.

"Back then, we didn't have the capabilities to even consider direct integration of gain on-chip. Fast forward eight years later, including five years with AIM Photonics, we are now accelerating this technology to a level of maturity approaching CMOS electronics, including lidar on a chip, which will ultimately make self-driving vehicles mainstream and 3D camera technology standard in consumer electronics."

LUMOS is a four-year program that launched in September 2020.

Microfluidics at Rochester

Another AIM Photonics partner with a Department of Defense grant is developing an optical chip on a disposable card that can scan a drop of blood and detect exposure to a number of viruses, including the novel coronavirus, and get results within a minute.

This grant, for $1.7 million under the Manufacturing Technology Program and using CARES Act funds, will channel through AIM, with work taking place at the Rochester, N.Y., lab of researcher Benjamin Miller, at the University of Rochester Medical Center in upstate New York.

"This is a completely new diagnostic platform," says Miller, who is the Dean's Professor of Dermatology and a professor of biomedical engineering, optics, and biochemistry and biophysics. "We think this is going to be valuable in very broad applications for clinical diagnostics, not just Covid-19."

Other partners in the project include Ortho Clinical Diagnostics, which develops and manufactures innovative laboratory testing and blood-typing solutions; Syntec Optics, a maker of polymer optics; the University of California at Santa Barbara; and the Naval Research Laboratory in Washington, DC.

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AIMing high: a reboot for the US photonics foundry

"This project has made very good progress," Cumbo said. "It will be able to detect COVID-19 antibodies with a device about the size of a grain of rice, just one millimeter by a few millimeters."

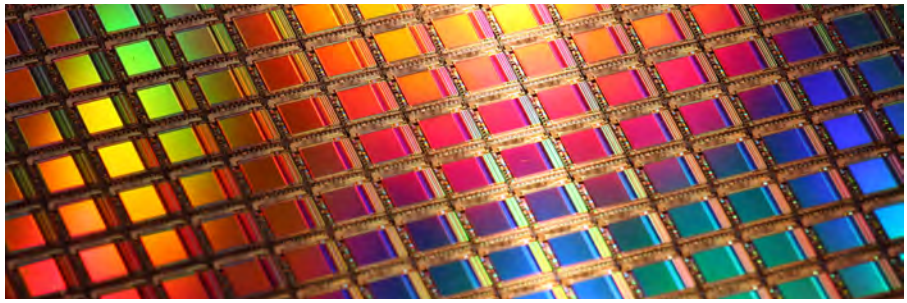
It's expected to be in full production soon at the AIM Photonics foundry, Cumbo said. "They are on their way to creating a product."

The work was moving ahead a year ago when the coronavirus struck, but that timing somehow worked out. Cumbo added: "Now we are turning a lemon into lemonade."

Cumbo has a simple goal for AIM 2.0. "It will be more balanced, with government sponsorship and sustained commercial reinvestment. It will sound more like a business."

"We will still need some government support to compete with international forces that are arrayed against us. But in how we plan and manage our program, we will be trying to be choiceful."

For AIM's Process Design Kit, or PDK, Cumbo says, "All our members are using the PDK, which resulted from a partnership of AIM and Analog Photonics.



Credit Northwestern University

Now, the speed of getting AIM's multi-project wafers through the pipeline will be faster, with six runs a year.

It's considered best in class, and is getting kudos from members across the economy. They say, 'Your stuff works.' That's a huge difference, relative to our competitors."

Neuromorphic applications

In Albany, NY CREATES' business development director, Bruce Toyama, said his team will be active in 2021 in neuromorphic applications, which mimic the brain's neural capacities, and quantum technologies, in addition to integrated photonics that will help enable breakthroughs in AI. "In all, I'm very optimistic about the convergence of all these opportunities," said Toyama.

Over the past 20 years, NY CREATES, a state-run nonprofit, has brought R&D centers to Albany and Rochester, like the IBM Research CMOS development facility and more recently IBM's AI Hardware Center, Tokyo Electron's Technology Center America, and the Applied Materials META Center. The organization had also helped facilitate significant investments in the state by companies like Globalfoundries, Danfoss and Cree-Wolfspeed.

NY CREATES's AIM Photonics Test, Assembly and Packaging (TAP) facility, located in Rochester, is closely coupled to AIM Photonics' wafer fabrication operations in Albany and is designed to offer broad and novel solutions to a wide range of customers who require photonics, and hybrid solutions.

New York State is expected to be well-positioned to take advantage of new federal opportunities under the Biden administration and new U.S. Senate Majority Leader Charles Schumer (D-NY), who has shown support for U.S. investments in emerging technologies.

Ford Burkhart is a freelance writer based in Tucson, AZ

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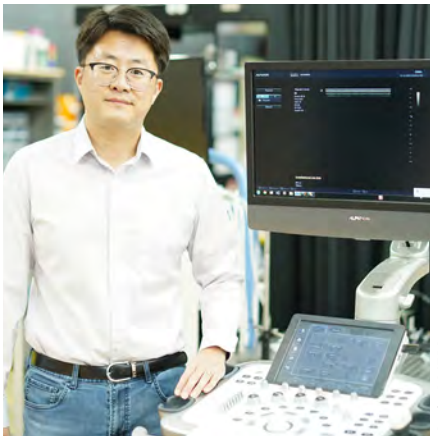
Multimodal imaging makes clinical impact

Chulhong Kim outlines developments in photoacoustics and other multimodal techniques in a BIOS Hot Topics session.

By Tim Hayes, Contributing Editor, optics.org.

If one is good, two or more may be better. Combining the strengths of different individual bioimaging techniques into a single multimodal platform can offer clinicians the attractive possibility of getting the best of both worlds when treating patients.

Often the multimodal approach is driven by the basic challenge of imaging in complex biological systems where different types of material sit in close proximity to one another, or where a disease has changed the nature of biological tissues and their response to a single technique. Multimodal information can then potentially provide both high-resolution structural images and superior disease sensitivities as part of the same image data set, with obvious clinical impact for diagnosis and treatment.



Credit: POSTECH

Chulhong Kim in his laboratory.

Chulhong Kim heads the Bio-Optics and Acoustics Laboratory at South Korea's Pohang University of Science and Technology (POSTECH), where multimodal imaging techniques are one focus of research. As part of the BiOS Hot Topics discussions at SPIE Photonics West, Kim will be describing current developments in this field with particular emphasis on the continuing advances in photoacoustic imaging (PAI), where light and ultrasound are combined to achieve high-resolution optical imaging in deep tissues.

Premier imaging mode

"PAI has become a premier biomedical imaging modality in the last two decades, based on the photoacoustic effect and energy transduction from light to ultrasound," commented Kim. "It can provide structural, functional, and molecular information about biological tissues in multiple dimensions. And due to the hybrid nature of PAI, it can potentially be combined with conventional ultrasound imaging, diffuse optical tomography, optical coherence tomography and fluorescence microscopy."

Some very useful synergies have arisen from the combination of these different modalities. If PAI is used alongside conventional ultrasound imaging, the combined techniques can share the same ultrasonic detectors; and when implemented alongside pure optical imaging, the integrated system can employ the same light excitation source or the same optics for light delivery. All of which helps to reduce complexity and cost.

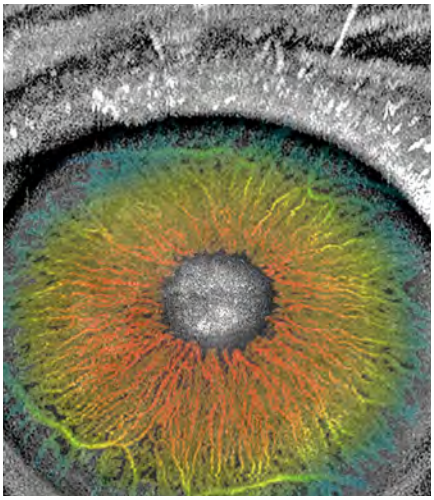
"Unlike other mixed platforms, such as PET/MRI and PET/CT, multimodal PAI systems are portable, relatively cost-effective, fast, and completely safe for human subjects," said Kim. "If PAI is integrated with various high-resolution optical microscopy functions, they can simultaneously provide multi-parametric optical absorption, scattering, fluorescence, and polarization data."

Developments elsewhere

Development of clinical PAI imaging has in turn meant tackling one of the key hurdles arising from the multimodal nature of the technology: the need for seamless integration of light excitation and acoustic detection. Recent developments in transparent ultrasound transducers have been particularly valuable, and helped the integration of PAI with other optical microscopy systems to be as flawless as possible.

Another challenge has been the need to simultaneously achieve high temporal resolution, spatial resolution, and signal to noise ratios from multimodal systems. In common with other bioimaging sectors, multimodal imaging has benefitted here from breakthroughs in data processing and computation alongside progress in the purely optical technologies. Kim noted that deep learning technologies have recently been adapted for PAI and used to significantly improve the end results of the imaging operation.

"These core deep learning approaches often stem from the research field of computer vision," said Kim. "Advances in that field can be versatile, and many developers in computational medical imaging can subsequently take advantage of them. We all contribute together to advancing these technologies, and if researchers are alert to developments elsewhere, then there are many deep learning and data handling techniques which will prove to be very useful in optics."



Credit: POSTECH

Combined photoacoustic and optical coherence tomography image of a mouse eye.

The key to success

Recent work in Kim's POSTECH group has included development of a clinical PAI and ultrasound imaging system, and its successful application in patients with thyroid cancers, melanomas, and peripheral vascular diseases. Another achievement has been the manufacture of a microscopy system incorporating PAI and ultrasound alongside optical coherence tomography and fluorescence imaging using a transparent ultrasound transducer, believed by the group to be the first such four-modality system of its kind.

Commercialization of these and other developments has led to the creation of a spin-out company, Opticho Inc. with Kim as CEO, to facilitate the translation of PAI technology from Kim's group into preclinical and clinical use. And in common with all CEOs in a similar position, this has lately required Kim to navigate the global financial turbulence caused by Covid-19 while also seeking to build a robust and clinically significant business.

"As a startup CEO, I see significant current interest from venture capital (VC) sources arising specifically from the Covid-19 pandemic, and the increasing value being placed on healthcare companies as a result," commented Kim. "I do believe that the healthcare business has remained fundamentally strong during this crisis and that it will remain so afterwards, with many VCs staying favorable to the startups in this sector. It was a similar story after the dot.com bubble in 2000, and when the financial crisis started in 2007. It is true of course that the risks in the current situation may yet increase further too, but a proper clinical application remains the key to success."

Quantum tools ready for commercial leap

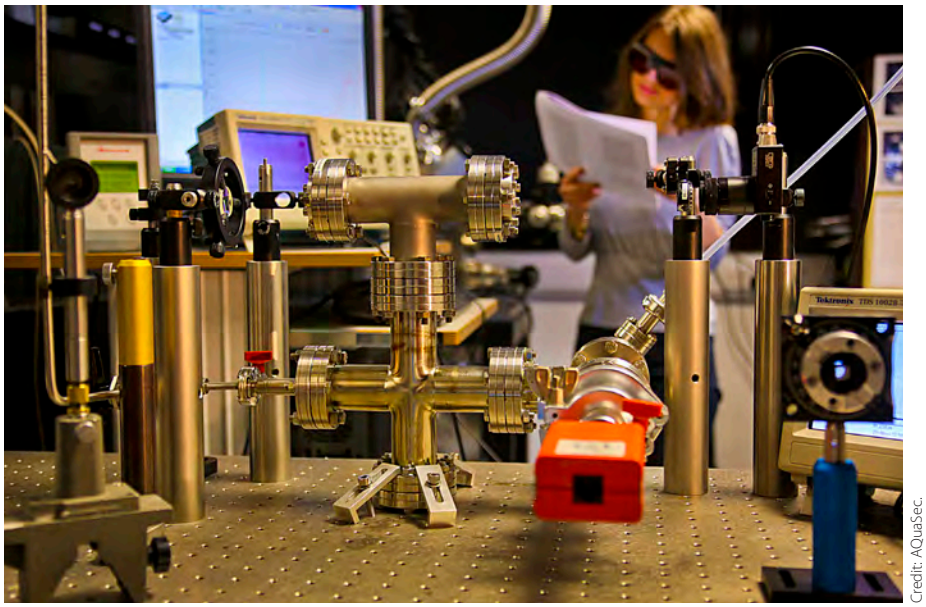
Long confined to the physics laboratory, 2021 should see real-world deployments in gravity imaging, encrypted communications, and greenhouse gas emissions monitoring. ***By Mike Hatcher, Business Editor, optics.org***

The 2020s will be the decade of photonics - so said Coherent's CEO Andy Mattes as he revealed plans to create an industry giant through a merger with Silicon Valley neighbor Lumentum. The same could perhaps be said of the emerging quantum sector, with the inaugural edition of the "Quantum West" strand within this year's Photonics West conference program providing a convenient marker to indicate the growing prominence of the field.

Chaired by Celia Merzbacher – associate director of the US-focused Quantum Economic Development Consortium (QED-C) – Quantum West kicks off with a keynote address from Sir Peter Knight. The Imperial College London emeritus professor is known best in photonics circles for his quantum optics research, but in recent years Knight has also taken a lead role within the UK's National Quantum Technologies Programme - helping to secure major research funding, and a welcome boost for the many photonics companies now involved.

Now more than five years into that program, the UK is widely seen as an early mover in the quantum world, with funding agencies keen to foster not just scientific expertise but commercial quantum-technology applications. As Knight has noted previously, that level of progress might reasonably be expected to take a decade rather than five years, but it does now appear that some quantum applications are indeed moving into the commercial realm.

Last November's Quantum Technology Showcase, an annual event emerging out of the national program whose presence has expanded well beyond the first "roadshow" event that took place inside an extremely socially un-distanced Royal Society building back in 2015, gave some strong pointers towards the likely commercial crossover points.



Credit: AQuaSec.

The £5.8 million Agile Quantum Safe Communications (AQuaSec) project is led by Toshiba Europe alongside telecoms giant BT, among others.

QKD: faster, further, higher

Although practical quantum computing remains some years off, its looming threat has always provided the impetus for the first truly quantum application to make commercial traction: encrypted communications with quantum key distribution (QKD). Cambridge-based Toshiba Europe has long been at the forefront of that development in the UK, and is leading work alongside telecoms giant BT, among several others, on the £5.8 million Agile Quantum Safe Communications (AQuaSec) project.

Part of the motivation behind AQuaSec is to demonstrate that although QKD requires some specialist technology, it can be deployed on commercial fiber-optic networks. Evidence of that crossover comes in the form of a recent trial involving the National Composites Centre (NCC) in Bristol. Speaking during the quantum technology showcase, NCC's Marc Funnell said that a secure link recently deployed by Toshiba Europe and BT showed that QKD could help enable the transformation to "Industry 4.0" digitalization.

Providing ultra-secure, near-real-time communication to and from off-site infrastructure, the installation allows NCC users to exchange sensitive data over an apparently "regular" link, where previously they would have been shared using portable data storage devices.

Describing the installation, Cathy White from BT said that the dedicated seven kilometer-long QKD loop put in place for the NCC deployment was based entirely on commercial off-the-shelf (COTS) technology, and installed by BT's regular OpenReach team rather than specialist engineers.

The 10Gb/s link is based on BT's "Optical Spectrum Access" wavelength-multiplexed approach, using one of the available wavelengths to transmit qubits. It relies on a high-speed encryptor from long-standing partner ADVA, with "Alice" and "Bob" terminals from Toshiba Europe exchanging 512-bit quantum keys between the NCC and the nearby Centre for Modelling and Simulation (CFMS) over a loop via a BT exchange in nearby suburban Bristol. "Toshiba and BT can both operate the QKD - but can't access the keys or the data," White noted.

In the same showcase session, Toshiba Europe's Robert Woodward highlighted how the company's QKD approach had now matured to chip scale, with a view to "bringing quantum technology into everyday life". After two decades of QKD development, the Cambridge subsidiary of the Japanese technology giant is now looking at how to deploy the approach over 500 km-long networks – and even on a global scale.

Its QKD system relies on polarization control, with the "plug and play" link deployed in Bristol able to provide a secure bit rate in excess of 1Mb/s, alongside an error rate lower than 4%.

Although the approach is based on the polarization state of individual photons, the hardware deployed does not in fact utilize single-photon sources. Instead, Woodward explained, output from a conventional distributed feedback (DFB) laser is attenuated close to the single-photon regime. In fact, a few photons are still produced per pulse – but so few that the source behaves just like a single photon when used in tandem with so-called "decoy states".

Other UK projects indicating the likely future direction of quantum security include a free-space QKD receiver under development at the University of York, home of the quantum communications development "hub", while other teams are working on Cubesat-compatible systems.

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Quantum tools ready for commercial leap

Cassandra Mercury, who heads up quantum technology developments at the aerospace engineering practice Craft Prospect, said that the "Responsive Operations Key Services" (ROKS) mission – slated for a demonstration flight next year – was designed to show that automated, efficient, and secure QKD services could be delivered via satellite.

With a critical design review imminent, the ROKS effort is intended to enable future missions to plan more efficiently, explained Mercury, partly by focusing on critical elements like security modeling and analysis. "CubeSat QKD is coming to a sky near you in 2022," she said during her showcase presentation.

imperfect excess gas combustion. "To reach net zero, continuous monitoring is required," he said. "The 'holy grail' is a versatile, light and portable, robust, sensitive, automated, visualization and quantifying solution."

QLM founder Xiao Ai and his colleagues have been able to piggy-back on the dramatic reduction in the size and cost of lidar technology over the past decade. A 13 kg system that Velodyne would have sold for $85,000 in 2007 is now produced in a 300 g, $100 package.

But to quantify methane emissions, you need spectroscopy. Millington-Smith describes the single-photon avalanche detectors, or SPADs, that provide the quantum aspect of QLM's approach as "Geiger-counters for light". QLM is using commercial SPADs from multiple suppliers, and is now looking to move from single-pixel devices to one- and two-dimensional arrays for faster imaging.

"We are working on new SPAD development

Credit: QLM Technology Ltd. With permission from Total.

Methane leak imaging with a QLM camera from a recent trial at energy giant Total in France. The images show clear visualization and concentration quantification as a heat map over a full-color background.

Methane detecting cameras

The next quantum technology to make the leap may be quantitative gas imaging, also based on single-photon detectors. Spearheading that development in the UK is the startup company QLM Technology, whose CEO Murray Reed is among the Quantum West speakers.

During the UK's November showcase, QLM's applications manager Doug Millington-Smith set out the case for continuous monitoring of methane emissions, which have a particularly potent impact on the Earth's climate. However, the silver lining is that the gas has a much shorter atmospheric life span than carbon dioxide.

"So if we can mitigate methane impact, [it] will have a big effect quickly," Millington-Smith noted. The problem is that it's difficult to monitor the myriad vents, exhausts, and flares caused by

as part of the Innovate UK-sponsored "SPLICE" [single-photon lidar imaging of carbon emissions] and QuEOD projects, working with researchers at Sheffield, Cardiff, and Heriot-Watt Universities, the Compound Semiconductor Applications Catapult, and multiple commercial partners," said Millington-Smith. "The goal is a UK commercial SPAD supply chain."

Based on InGaAs and operating at 1200-1700 nm, these SPADs are ideal for methane spectroscopy when combined with tunable laser lidar. "This is our potential holy grail," Millington-Smith said. "This is a low-power, eye-safe, laser spectrometer with an extremely sensitive detector, long operational range, mature technology - and therefore a low cost."

Scheduled for a commercial launch shortly after Quantum West, QLM's cameras are being

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Quantum tools ready for commercial leap

pitched as a competitor to the "gold standard" for emissions monitoring: differential absorption lidar (DIAL). While undeniably effective, DIAL systems must be transported by truck, and cost upwards of £100,000.

"It's brilliant, but it's huge," said Millington-Smith. "What QLM wants to do is to provide the functionality of DIAL at a much lower price point."

Within SPLICE, QLM is working with NPL, energy giant BP, and National Grid, among others. "The whole thing is underpinned by the UK National Quantum Technologies Programme," Millington-Smith says.

Initially, the methane cameras will be fixed, CCTV-like, on a mast, pole, or tripod, with rotational and up-down motion. They will offer fully traceable quantitative methane detection at gas concentrations between 100 and 150,000 ppm-meters, and a range of 200 meters. Users will see a "heat map" of methane concentrations superimposed on the site of the emission, in near-real-time - the leak rate of the gas can be measured and displayed after just ten seconds of data collection.

"We have received our first orders, and they are related to oil and gas industry emission monitoring," Millington-Smith said, adding that biogas and landfill gas-to-energy (LGTE) monitoring, plus environmental and agricultural applications are likely in the longer term.

Credit: Gravity Pioneer.

Dr. Michael Holynski, right, with members of the Gravity Pioneer Team.

Methane isn't the only target. QLM is also launching a carbon dioxide camera and looking to expand to other wavelengths for applications in the petrochemical, agricultural, and transportation sectors. Other research priorities include shrinking the technology – perhaps using MEMS in place of prism optics – to make the approach compatible with UAVs, robotic, and handheld platforms.

Meanwhile, the company is seeking to complete a £1 million round of seed funding intended to expand the firm's technical and commercial teams, achieve industrial validation and orders, and expand its patent portfolio.

Gravity imaging

An even more remarkable commercial development could soon arrive in the form of a quantum gravity "camera" capable of imaging underground hazards like pipes, voids, and sinkholes.

This is the target of the "Gravity Pioneer" project, scheduled for completion in September and with the aim of overcoming the huge technological challenges of taking cold-atom interferometry out of the lab and into a robust, reliable, and field-deployable instrument.

Michael Holynski, the University of Birmingham researcher who is coordinating the effort, said during his quantum technology showcase talk: "The key to accessing markets is getting smaller and lighter – going from 'washing machine' to 'shoebox' scale – and from static sensing to mobile sensing."

Qinetiq's Gillian Marshall, a potential end-user involved in Gravity Pioneer, sounded impressed with the progress made so far: "The team have built an exquisitely sensitive device," she said, highlighting key user requirements such as the speed of sensor data acquisition.

"Current gravimetry techniques in particular are very time consuming," Marshall added. "[We] don't actually care whether it is a quantum gravity sensor or not. What I'm interested in is being able to detect gravity. I want to know what's underground – are there tunnels, or bunkers? Is there infrastructure?"

Paul Wilkinson from the British Geological Survey highlighted just how useful a field quantum gravimeter might be. "One of the really nice things about gravity as a geophysical influence is that it's not shielded by structures within the ground," he pointed out. "So in some instances that enables you to see a bit deeper [than with] other geophysical techniques."

The downside of current gravity sensing technology is that it is typically very slow and unwieldy, Wilkinson added, while instruments suffer from drift during repeat surveys. He believes that there is plenty of potential for both cold-atom and MEMS-based gravity sensors, offering a leap forward when it comes to speed of measurement, stability, cost, and sensitivity.

Under Gravity Pioneer, the aim is to produce a cold-atom gravimeter weighing 17 kg. Asked if it was possible to push that weight below one kilogram, Holynski indicated that it would be, in time. "It's not something that we would be able to do on our own," he replied. "What we've done quite well is to choose technologies to get us down to the 'shoebox' level. The next stage would be to change key components such as the lasers."

More than a light generator: Jenoptik evolves into applications

Photonics West Focus interviews Dr. Stefan Traeger, president and CEO of Jenoptik.

By Matthew Peach, Editor-in-Chief, optics.org

Credit: Jenoptik

Notoriously optimistic: Jenoptik's President and CEO Dr Stefan Traeger.

Jenoptik is one of the world's leading photonics companies, which Stefan Traeger has led for the past four years. Besides the 2020 acquisition of Trioptics, and coping with the constraints of the pandemic, Traeger has big plans for the firm, which he asserts is nowadays far more than just a laser company.

Coping with Covid

We acted fairly quickly actually, we were in a way lucky enough to get an early warning from our colleagues in China. Our VP Asia is based in China and he told me early on that it was not a seasonal flu and to take it seriously.

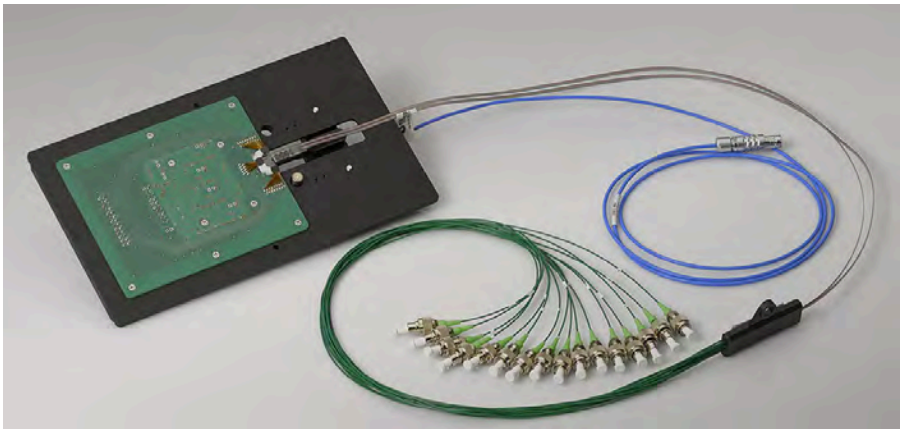
So we prepared early. We compartmented our production sites and put regional and local plans and measures into place at an early stage . Now there is a lot of testing and wearing of masks for all our people. From the early days we managed to keep our production sites open.

From a markets perspective, we have seen different impacts on the business arising from Covid. Some have seen really choppy waters, like automotive, and some of the biophotonics markets. Besides Covid-related research, certain markets have fallen considerably. But other areas have even seen tailwinds. In particular, semiconductors or anything to do with digitization have actually seen flourishing market environments.

We're focused on building our capacities and capabilities in terms of modern, digital environments. For example, we are investing in modern production facilities in our Dresden factory, where we produce microstructured optics for the next-generation of precision sensors for DUV and EUV technologies.

During 2020, Jenoptik acquired Trioptics. This gemstone is really the gold standard when it comes to test and measurement of high quality optical devices. Typically these are used in mobile applications; in the devices that we all carry with us these days. Modern mobile phones have a lot of optical sensors and cameras, which all require testing during the production.

This acquisition fits well with Jenoptik; our strength is not in the mass-production of parts. Yes, we do produce optics but, more than anything, we are now machine builders.



Credit: Jenoptik

The UFO Probe technology targets the market for semiconductor equipment and processes for wafer-level testing in microelectronics.

Product development

We're focusing on a number of things; pushing more image analysis using artificial intelligence and deep learning algorithms such as automatic vehicle number plate recognition for traffic control. Many firms now build good cameras but to analyze the image automatically and extract the information using a deep learning algorithm is a focus for Jenoptik.

We are also pushing our capabilities in micro optics and the high-precision optics arena. I alluded to the investments that we are making in Dresden.

At Photonics West Digital Marketplace in March 2021 we are showing our new products, among others our UFO Probe card, which helps to address the growing market for photonic integrated circuits. We will also put on display our new bioimaging system.

We are not a laser company, I think that's something that I need to stress. Jenoptik used to be a laser company and we still do produce lasers; I would classify us as a company that is at its best in applying photonics rather than just generating light.

Producing good lasers is a challenge – and I don't want to play that down – but light is a commodity and there are lots of people that can produce good lasers these days and laser production becomes more and more commoditised. That requires economy of scale effects.

If you go to places in Asia, there are companies producing great lasers. I think that for us with our heritage here in Jena and in Jupiter, Florida, our strength is not to squeeze the last penny out of every product. As a company, if we want to survive we need to go more towards leading edge or front-end applications.

It's funny that as an industry we're sitting at a perfect spot. We are the ones that turn analog processes into digital sets of data and at the moment as an industry we're almost giving away those data. It makes sense for us to do all this data analysis ourselves and produce closed-loop business systems and by that enable our customers to save resources – such as by efficiency gains to create health benefits and safer cities using fewer resources.

Acquisition ambitions

I think every company must be able to drive organic growth by developing good products and providing good service. However, if we want to be successful in the long run or in a consolidating market environment, one also has to spice it up with acquisitions. If and where it makes sense, we intend to continue doing that, maybe even intensify that.

We have the financial power to do it; we have a very strong balance sheet. We have demonstrated and continue to demonstrate our strength on the profitability side and the ability to generate cash. The acquisition of Trioptics showed that we are capable of making bigger steps and doing bigger deals.

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More than a light generator: Jenoptik evolves into applications

If I look through our portfolio and think about where I would see pockets of important investment into future technologies via M&A activities, I'd say in our Light & Optics division, in our core optics business, I see certainly potential for more.

Also in the Light & Safety division, information processing and machine vision would all fit very well into our strategy to move the company more and more away from fundamental optics and lasers towards solutions and applications.

Credit: Jenoptik

VECTOR P2P is Jenoptik's average speed enforcement solution, based on its SPECS range of cameras, as used at hundreds of routes across the UK, here at the Forth Bridge in Scotland.

Virtual business

At the moment it has been the right and, quite frankly, the only option to hold virtual conferences. There's no other way. It's better to do it virtually than to not do it. Also, I think we can communicate with more customers at once. Whether it is sustainable is a good question that we are all asking ourselves.

I think some of it will stick for some time and will stay with us but I don't think we will go completely virtual forever. We at Jenoptik just had our management conference or annual kick-off meeting with more than 80 managers from around the globe and we did it completely virtually and it was a great success.

However, at the end of the day, the chat that you have at the bar or the booth parties in San Francisco are very important. You can transfer information online, you can transport products, you can put products in a display online, but you cannot really meet new people online. That is the challenge. We will probably not be going back to the time when we are flying around the world all the time, but that will come back to some extent.

I am a notoriously optimistic person and I am still very optimistic, despite the pandemic. Yes, it is a severe crisis that we are going through but I'm pretty sure that we will emerge even stronger on the other side. We will learn a lot and often such catastrophic events produced the best in terms of human creativity. ■

Raman reveals viral mutation in real time

Professor Laura Fabris uses surface-enhanced Raman spectroscopy to study the genetic evolution of viruses in spectacular detail. She's nailed influenza and is now moving onto SARS-CoV-2. ***By Rebecca Pool***

Just before the the SARS-CoV-2 pandemic brought the entire world to a grinding halt, Professor Laura Fabris from Rutgers University published research that showed how she and colleagues could use surface enhanced Raman spectroscopy to detect viral mutations.

Credit: Don Hamerman.

Professor Laura Fabris from Rutgers University

Their switchable SERS nanoprobe comprised a gold nanostar functionalized with DNA hairpin loops bearing a fluorescent dye, and was engineered to identify and quantify RNA mutations in the influenza A virus. In the presence of the viral RNA, the DNA hairpin was designed to fold, bringing the fluorophore closer to the nanostar and triggering a SERS signal.

"We've known for years that using DNA hairpins in SERS is possible but only now have we been able to apply this to viruses in vitro," highlights Fabris.

"Looking at virus dynamics is new and exciting," she adds. "Five years ago I didn't know anything about viruses – there's been a learning curve but I see huge potential here for SERS."

Fabris' detour into viruses started with a DARPA programme called INTERCEPT, INTERfering and Co-Evolving Prevention and Therapy, set up to discover how the influenza virus mutates so more effective vaccines and treatments could be developed. Awarded a $820,000 grant in 2017, Fabris was tasked with developing intracellular SERS-based tools to track how the virus replicates within cells and tissue.

'Spectacularly sensitive'

Progress has been rapid. In the intervening years, experiments have indicated Fabris's SERS set-up to be spectacularly sensitive – it can recognize virus RNA in single cells. The SERS nanoprobes can detect mutations in the virus, generating weaker signals as these accumulate, and also identify so-called super-spreader cells with high viral loads.

"By detecting and isolating a cell that produces an outrageous number of offspring viruses, we can then study and understand its phenotype," points out Fabris. "With this information, we can reconstruct the conditions that create a super-spreader and learn which conditions could favor stopping viral replication."

"The idea of tools like the ones I develop, is really look at the outliers – that can give you a lot of information," she adds.

But of course, in the interim, coronavirus has struck and progress has slowed. As Fabris highlights: "In the beginning, I was struggling but also felt the need to provide emotional support to my group - many of my researchers' families live thousands of miles away, and they haven't been able to get home."

Still, difficulties aside, Fabris and colleagues also knew their Influenza A research could be applied to any number of viruses, including SARS-CoV-2, and have since been identifying regions of its genome that can be interrogated with SERS probes.

Fabris applauds her researchers for their dedication, and while progress hasn't been as swift as 'normal', research is well underway. "The laboratory closed in March 2020 with the Rutgers campus, but re-opened in early July," she says. "We've since been working at around 50% capacity as we have to stagger people into the laboratory and only have access from 8am to 8pm Monday to Friday."

Working with virologists and scouring literature,

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Raman reveals viral mutation in real time

Fabris and colleagues now know which RNA segments of the coronavirus do not change during replication, and intend to target these sequences with SERS. They have also been testing a SARS-CoV-2-specific nanoprobe and hope to collaborate further with virologists on this.

"We know it works but we need to work collaboratively with virologists and the medical community, and that's going to be tricky right now," says Fabris.

"I hope that as soon as we all get back in the lab together, we'll complete a final demonstration," she adds. "We're doing all the experiments that we can on synthetic versions of the virus, but the next step is to test this in real samples for complete validation."

Clinical potential

Fabris is confident that the potential for SERS nanoprobes to monitor a virus, be it SARS-CoV-2, Influenza A or another infectious agent, in a clinical setting is huge. Her research has shown that SERS is cheaper, faster and easier to perform than widely used methods such as the reverse transcriptase-polymerase chain reaction (RT-PCR). And given these advantages, Fabris is collaborating with Japan-based Hamamatsu Photonics on a low-cost portable Raman spectrometers to enable SERS analyses to be carried out easily in hospitals and other settings.

Credit Don Hamerman.

Going viral: Professor Fabris working in her lab at Rutgers University.

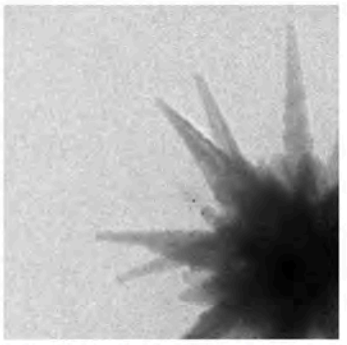
"I'm really interested in developing portable equipment – we've seen a lot of progress in the portable Raman instrumentation industry over the years," she says. "Having equipment with a small footprint is good news for future virus analysis as we'll be able to take the instrument to the virus, rather than the virus to the lab."

Post-Covid-19, Fabris is hopeful that researchers will collaborate more with doctors and clinicians, and students are provided with training to facilitate this. "We cannot influence clinicians but we can talk to them more," she asserts.

And she can't wait to get back to 'real-life' conferences. "Virtual seminars are great – I can be in Canada today and Spain tomorrow," she points out. "But whilst doing this, you still tend to teach or attend other meetings, and this reduces your ability to benefit from that conference."

"SPIE conferences are one of my favourite – you can attend talks, the exhibition and there's just so much information to gather by interacting with other attendees that you can't get if you're not there," she adds. "My colleagues and friends are all saying, 'this has got to end soon'."

Rebecca Pool is a freelance writer based in Lincoln, UK.



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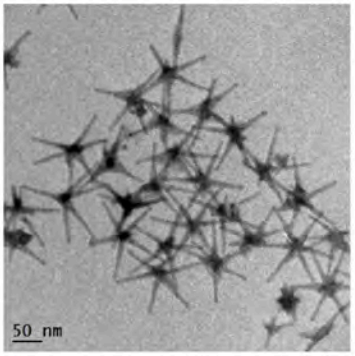

Atta, S.; Beetz, M.; Fabris, L. Nanoscale **2019,** 11, 2946.

Atta, S.; Beetz, M.; Fabris, L. Nanoscale **2019,** 11, 2946.

All images courtesy of Laura Fabris / Nanoscale (Royal Society of Chemistry).

Three images of nanoparticles. Citation below each image references the journal article in which it was published. The yellow image is a 3D reconstruction of a real nanoparticle (not a drawing).

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Electro Optical Industries, Inc.
Electro Optics
Electro Optics Magazine
Element Six Technologies U.S. Corp.
ElFys Oy
Elite Optoelectronics Co., Ltd.
EMF, a Dynasil Company
Energetiq Technology
EPIC-European Photonics Industry Consortium
EPIX, Inc.
Evatec NA Inc.
EVERIX, Inc.
EXALOS AG
Fiber Optic Ctr., Inc.
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Hamamatsu Corp.
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Insaco Inc.
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IPG Photonics Corp.
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ISS, Inc.
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Laser Components USA, Inc.
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Novanta, Inc.
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Teledyne Photometrics - Teledyne Imaging
Teledyne Princeton Instruments - Teledyne Imaging
TeraXion Inc.
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The Optronics Co., Ltd.
ThinFilms, Inc.
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TOPTICA Photonics, Inc.
ULTRA TEC Mfg., Inc.
Universal Photonics Inc.
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Vision Components GmbH
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Wasatch Photonics, Inc.
Wavelength Electronics, Inc.
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Xinxin Gem Technology Group LLC
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Zeus Industrial Products, Inc.
Zhongshan Meisu Technology Co., Ltd.
Zurich Instruments USA, Inc.
Zygo Corporation

Discover how AR, VR, MR community has benefited from global response to pandemic

Running between 28-30 March 2021, the SPIE AR|VR|MR Digital Forum will explore the important next steps after big investments in headset and smart glasses technologies.

By Andy Extance

Credit: Microsoft Holoportation.

Just five years ago, Microsoft Holoportation required a room with $100,000 worth of sensors around it to scan your body (top). Now this functionality is contained in a head mounted display (above).

While the Covid-19 pandemic is bad news for everyone, it has actually accelerated development of some of today's most exciting technologies. The beneficiaries are Augmented, Virtual, and Mixed Reality (AR, VR, MR, together referred to as XR), which will be the topic of a standalone SPIE digital forum from 28-30 March 2021.

Christophe Peroz, Chief Display Researcher at Sony in Tokyo, Japan, noted that the pandemic has meant that there's never been a bigger call for VR. "Imagine if this technology was available," said Peroz, who is the SPIE AR|VR|MR Digital forum 2021's co-chair. "It would be much better for all of us." Therefore the field has not been slowed down when much of the world has. Instead, more companies have invested in research into such displays.

Delivering products will be a huge technological challenge, but one that promises worthwhile rewards, Peroz continued. "There is not yet an ideal solution, which means there is a huge opportunity," he said. "If you want a quick update on what's happening in the field, then the SPIE AR|VR|MR event is the place to be."

The forum has graduated quickly from being just an element of Photonics West to a standalone event, adds Bernard Kress, Partner Optical Architect at Microsoft in Redmond, Washington.

Over four years, Kress has built up the event with Pamela Robertson, Program Manager at SPIE. "It's one of the fastest growing sectors, so it made it to its own conference in record time," said Kress, who is the other co-chair for this year's event.

"Usually it takes many years, but this happened within less than two years." AR|VR|MR is now the world's largest conference dedicated to the technology's hardware, Kress asserted. It seeks to enable smaller form factors, better displays, with wider fields of view, better contrast, better brightness, and longer battery lifetime.

Major company executives will present their latest advances at AR|VR|MR's industry invited talks, Kress highlighted. "This year, especially with companies like Facebook, you will see consumer smart glasses, eight years after the introduction of Google Glass," he said. "The previous years' emphasis was always on enterprise. This year you will see the consumer products going up exponentially."

The hardware focus at AR|VR|MR spans display, imaging, and sensing. Displays comprise both display engines and optical combiners. "The display engine is usually located on the temple side of the headset, or on the nasal side, but not in front of your eye," Kress explained. Display engines form images using technologies such as MEMS laser scanners, microLEDs, LCOS, or DLP. "This year there's a lot of focus on laser MEMS scanners and microLEDs, bringing the promise of small form factor glasses," Kress noted. Meanwhile, optical combiners integrate the image formed by the display engine in MR applications and reside in front of viewers' eyes, and must therefore be transparent.

Face and emotion tracking

In 2021, AR, VR, MR sensors newly include face and emotion tracking to enable realistic avatars in MR systems like Microsoft Holoportation. "If I want to talk to Christophe in Japan, the system has to sense his mouth and eyes, because a human being is really described by how the mouth and eyes move," Kress said. "But people don't want to have sensors all around. Five years ago, when we used avatars at Microsoft Research, we were in a room with $100,000 worth of sensors around it that scan your body. Right now, these cameras are on the head mounted display. And with artificial intelligence, they recreate the entire body in real time. What is important is the sensor fusion. All these sensors have to be talking to each other, to enable a seamless experience."

Credit: SPIE

Bernard Kress, Partner Optical Architect at Microsoft and co-chair of this year's AR|VR|MR event.

New frontiers

More new topics at AR|VR|MR in 2021 are brainwave sensors including electroencephalograms and electrooculograms. "That goes into uncharted waters," commented Maria Pace, technology leader for Hololens at Microsoft, who is an invited industry speaker at the digital forum. "We never had anything sitting so close to your brain. Where are the privacy limits there? The headset will know you better than you know yourself, because it can track emotions before you are aware of them."

The AR|VR|MR forum serves many different attendee types, with many coming from academic research labs. Some come from government labs, such as the US National Institute of Standards and Technology (NIST). This year NIST will participate in a panel concerning standardization in AR, VR, MR technologies. "In the hardware field, many people have different definitions for the same type of hardware or functionality or specification," Kress observed. "There have to be standards in hardware, so that headsets can evolve and be compared with the same definitions."

Meanwhile, attendance from industry "is growing year after year", Peroz added. "You have more or less all the big players in the industry, who come and listen," he said. "You have two days of industry invited speakers. It's one place where you have the academic and the industry worlds presenting the latest data."

This year's online format offers programme flexibility, so that talks were still being added at the time of writing. Currently AR|VR|MR has 2,000 registrants, which would be a larger audience than normal, Peroz said. He expected around 50 technical papers. There will be two other panels,

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Discover how AR, VR, MR community has benefited from global response to pandemic

one on laser beam scanner systems, moderated by Geneva, Switzerland-headquartered STMicroelectronics, and one on optical engines for AR, moderated by Plantation, Florida-based Magic Leap. AR|VR|MR will also feature an online course, entitled Optical Architectures for Displays and Sensing in Augmented, Virtual, and Mixed Reality. It will cover design, modelling and fabrication techniques for micro-optics, including optical alignment.

Peroz is especially looking forward to hearing from Stefan Alexander from Mountain View, California's internet giants Google and Ying "Melissa" Geng from Facebook Reality Labs Research in nearby Menlo Park. Alexander was previously the Chief Executive Officer of Canadian AR glasses maker North, which Google bought in June 2020. "I'm curious to know what their strategy is with this acquisition," Peroz said. "And of course, Facebook is investing massively."

Kress highlights the significance of the attendance of Om Nalamasu, Chief Technology Officer of Santa Clara, California-headquartered Applied Materials, to scaling up the industry. "If you cannot mass manufacture optics, you're stuck with a few prototypes," Kress said. "It's very exciting to see Applied Materials coming in to allow these complex optics to be fabricated in volumes at low costs. This is something that we didn't see in the previous meetings."

Applied Materials is part of a growing ecosystem,

Credit: Sony.

XR workflow expert Hiroshi Mukawa, Corporate Distinguish Engineer at Sony.

Kress added. "We have companies that are developing the entire smart glasses or VR system, and companies that are developing just one particular optical building block," he said. "You have companies designing these waveguides and companies helping to fabricate these elements, and providing high refractive index glass." As they scale up, a better sense of what customers will pay for AR, VR, MR technologies will emerge, something that hasn't yet been clear.

Accelerating the business

An interesting industry speaker that Pace highlights is Stan Larroque, Chief Executive Officer of Paris, France-headquartered Lynx. He won the AR|VR|MR Student Optical Design Challenge in 2018, which is not happening in 2021 due to the pandemic. Lynx has now raised $20 million to produce its video see-through MR headset, which it launched at AR|VR|MR in 2020, and has 30 employees. Pace is also excited to see Peggy Johnson, the new chief executive office Magic Leap, talk about the future of virtual meeting apps and MR for enterprise.

Credit: Sony.

Sony's MR HMD SmartEyeglass prototype, launched in 2018.

Hiroshi Mukawa, Corporate Distinguish Engineer at Sony, will give an invited talk during AR|VR|MR. "Sony has lots of technologies relating to the XR field," Mukawa explained. "I'm going to talk about XR workflow and technologies. The XR business cannot exist only with hardware like head mounted displays. We need content and content creation tools. Distribution is also a big issue. We need data compression as well as security technologies. I'm going to talk about everything from content capturing to content output, including audio and display technologies related to head mounted displays."

Mukawa is looking forward to hearing from companies developing optical technologies. "The optics is very important for realism," he said. "We need very compact systems, high image quality, wide field of view, low power consumption and low cost display, but that is very difficult and at this moment, nobody can realise it."

The AR, MR, VR field breaks down into two segments in Mukawa's view. The first involves everyday wearable AR smart glasses with very compact form factors and small fields of view. "This is already very close to the final form factor," he said. "So, the next question is: what are the good applications for those smart glasses? This is also yet to be determined."

The second sector comprises MR/VR headset products with larger fields of view that deliver high resolution, immersive experiences. "Optical technology for this I think is promising," Mukawa said. "Many companies are trying to develop waveguide combiner technologies. I think there are still challenges, like image quality, optical efficiency, projector size and scalability. But because more companies jumped into this field, we are getting new materials, new processes and also new ideas. Getting together all those new tools, we will be able to achieve consumer applicable technologies in the near future. It will take a few more years, but we are getting closer."

Currently Sony believes a waveguide-based combiner technology will prevail, but otherwise hasn't decided on a final overall approach, Mukawa said. "There are many challenges still," he said. "But, we will continue parallel development, picking up the potential two, three best optical approaches. In one, we are developing retinal scan displays by using laser light together with a MEMS scanner, and a holographic combiner. Of course, we cannot take a very long time, and we have to decide in a certain timeframe. We hope we'll be able to find to say this is the right way to go in a few years." Getting details about the latest designs is part of AR|VR|MR's appeal to Mukawa. "With this technical information and these industry insights, this conference will help us to accelerate technology and business development," he said.

Andy Extance is a freelance writer based in Exeter, UK.

Frequency microcombs to unify the spectrum at the chip scale

OPTO plenary speaker Kerry Vahala is a pioneer in whispering gallery microresonator frequency combs. He sees these devices "opening the floodgates" to the full potential of frequency comb technology.

By Andy Extance

Kerry Vahala from the California Institute of Technology (Caltech) in Pasadena, US, has a "miracle" to share at the 2021 SPIE Photonics West Digital Forum, in the form of frequency combs. Vahala will give a talk during the OPTO plenary session entitled Unifying the optoelectronic spectrum at the chip scale. In that talk, which will be available for replay afterwards, he'll explain the "revolutionary capability" coming through their miniaturization.

"Frequency comb technology has made possible amazing new tools based upon a coherent unification of photonics and electronics," Vahala said. "It's a miracle, what frequency combs do." That includes transforming time keeping, frequency metrology, precision spectroscopy, microwave generation and distance ranging.

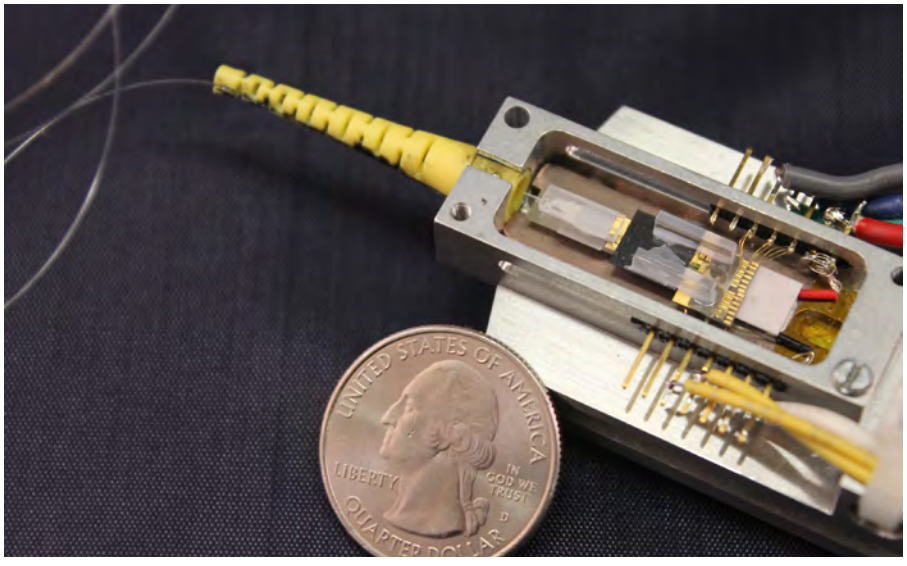
For two decades Vahala's team has studied chip-scale resonators using whispering gallery modes, waves circling around a cavity, supported by continuous total internal reflection off the cavity surface, to make new microcombs. Throughout that time, Vahala has been attending Photonics West to discuss the advances being made.

"There has been so much progress in understanding how high-performance combs can be microfabricated," he said. "In considering their widespread use and commercialization, most people working in this area now recognise it's a matter of when it's going to happen, not if." And at this year's Photonics West, Vahala is set to discuss a transition that will make frequency microcombs accessible to more people than ever before.

Credit: Caltech

OPTO plenary speaker Kerry Vahala.

Frequency conversion today is commonplace within electronic or optical regimes, Vahala explains, but not between the two. Commercial devices divide gigahertz frequency microwave signals down to create audio frequencies. "Conversely, an audio or radio frequency rate signal can be multiplied up so long as I do not hit the frequency limit of electronics," Vahala said. "In optics, nonlinear processes allow signals to be converted both up and down in frequency."



Credit: Boqiang Shen, et. al., Nature, Vol 582, (2020).

Butterfly packaged soliton microcomb and III-V pumping laser from Bowers (UCSB), Kippenberg (EPFL) and Vahala (Caltech) groups.

Also, detectors and modulators couple optical and electrical signals in a relative frequency sense. "However, what frequency combs achieve is quite different," he said. "Electrical and optical signals are coherently linked in an absolute sense, and this link is bidirectional."

One type of traditional frequency comb is based on a femtosecond mode-locked laser that creates a series of discrete, equally-spaced emission frequency 'teeth'. The comb can have up to a million optical frequencies, spanning hundreds of terahertz in the optical domain. But only two parameters – the pulse repetition rates and laser offset frequencies, both of which are in the microwave range – are needed to define the frequency of each individual optical mode. This enables engineers to use the pulse repetition rate for self-referencing, which links comb teeth optical frequencies to the microwave or radio-frequency range where electronics can operate, and vice versa.

"At the electrical end, one could count optical cycles of an atomic transition," Vahala said. "Or, in the other direction, one could control comb frequencies using an ultra-stable radio-frequency oscillator." These functions have enabled many new technologies, including the best clocks, the most stable microwave signal sources, and the most powerful spectroscopic methods.

In 2005, researchers won half of the Nobel Prize in Physics for frequency combs. Around that time Vahala's group, and separately researchers at the NASA Jet Propulsion Laboratory in Pasadena, California, made a key step towards miniature versions. They demonstrated a nonlinear effect called parametric oscillation and cascaded four-wave mixing in whispering gallery optical resonators. The devices used the nonlinear optical Kerr effect, Vahala explained. "While it normally takes a lot of optical power to use the Kerr effect, the devices turned-on at a remarkably low power, less than 1 mW," he adds.

A few years later, Tobias Kippenberg, now at EPFL, the Swiss Federal Institute of Technology in Lausanne, used parametric-induced cascade effects to demonstrate the first miniature comb. "It took quite a while to fully understand these new microcombs, but years of hard work is now paying off in a major way," Vahala said.

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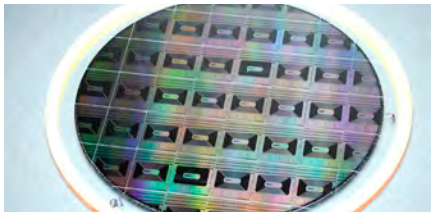

Credit: Warren Jin, Qi-Fan Yang, and Anello Photonics.

200 mm silicon wafer containing ultra-high-Q resonators from Bowers' group at UCSB. "Hertz-linewidth semiconductor lasers using CMOS-ready ultra-high-Q microresonators," Warren Jin, et. al., To appear in Nature Photonics (2021).

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Frequency microcombs to unify the spectrum at the chip scale

The Caltech researchers have continued studying ring microresonators, increasing their optical Q factor. This equates to minimising optical losses, and dramatically lowers power consumption and noise. "Q is a basically a dimensionless way of characterizing the amount of time that a photon will stay inside these devices," Vahala explained. "High Q factor is an essential prerequisite to produce the new frequency microcombs, because it lowers the input power required to tap into the Kerr nonlinearity. On a chip, the Q factors that we can achieve are now over a billion. The key thing is to make the ring resonator perfect enough so that the photon stays in there a long time. 20 years ago, this was very difficult and only one device platform existed. But over the last 10 years there has been an explosion of new devices and materials that can do this."

Vahala explains that a low Q factor microresonator is like a highly damped pendulum, which only has a small amplitude of motion when tapped. "Suppose that damping is nearly zero, so that pendulum has a high mechanical Q factor," he said. "Then so long as I'm willing to stay with it long enough, the amplitude of motion can be huge, even with very weak tapping." High optical Q allows the Caltech team to emulate this using light at the sympathetic resonant frequency of photons within the ring resonators. "The input light power can be extremely weak, but the light power inside the resonator will still be huge," Vahala said. "The power needed is so low that the comb can be driven with a normal semiconductor laser that itself is integrated."

Chip-scale technology

This capability can now be combined with chip-scale technology, heralding future architectures and miniature systems that Vahala will explore in his Photonics West plenary talk. One such area is high-precision optical frequency synthesis. "Commercial electrical synthesizers provide signals to many digits of precision in the electrical frequency domain", Vahala said. "However, we do not have ready-access to the same capability at light frequencies." In a 2018 Nature paper a team of researchers that included Vahala's group used microcomb technology to demonstrate an optical synthesizer delivering laser signals on demand to 15 digits of precision. "Many researchers would love to have that instrument in their laboratory, right now," Vahala said.

As another example, frequency combs are central to the best clocks. "It's accepted that in the near future an optical time standard will emerge based on these optical clocks," Vahala underlined. "Precision clocks are already essential for navigation, including the GPS system. If the new clocks were miniaturized to the chip-scale, optical clock technology might quickly move into space or become field-deployable." Another group including Vahala's team published optical clock architecture suited to such miniaturization in a paper in Optica in 2019. This won the 2020 OSA Paul Foreman Award for Excellence in engineering.

Combining pumping lasers with chip-based combs has been a challenge to integration.

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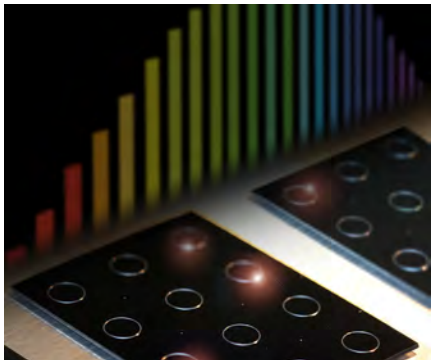

Credit: Ki Youl Yang

Microcombs on a silicon chip. Each ring is a whispering gallery resonator. A soliton pulse is depicted as the bright point in some of the rings. And a comb spectrum is illustrated in the background.

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Frequency microcombs to unify the spectrum at the chip scale

However, there has been rapid progress with butterfly-package-style systems. Although these are not quite fully-fledged combs, Vahala nonetheless asserted they can already be used as spectroscopic tools.

Before becoming commonplace, microcomb integration technology needs some time to further mature and for market pull to develop, Vahala said. "And the latter is out of the hands of science," Vahala warns. However, he speculates that the first phase will be implementation in lab instrumentation and perhaps applications like airborne or space-based systems where size, weight and power are more important than cost. In the second, slower, phase high volume manufacturing of microcomb systems might emerge. Then systems-on-chips could be directed towards known applications of frequency combs.

Ultimately, the availability of such low-cost comb systems on-a-chip could have a profound impact on new technology areas, Vahala believes. "Circuit engineers today do not design with the idea that the entire optoelectronic spectrum is accessible and convertible in an absolute sense," he said. Chips that pass coherent signals between electronic and optical domains would give such engineers "the potential for whole new applications", Vahala adds.

Interest in III-V materials

Currently, about 14 groups worldwide can make frequency microcombs, specializing in different material systems. Vahala said that "besides silica and silicon nitride, there's interest in III-V materials, tantala, and lithium niobate." Vahala's team's lab looks much like those of other groups studying fiber optics or sensing. "A lot of the tools are the same, like spectrometers and tunable laser sources," he said. "The technological hurdle is making the microcombs yourself. That involves a cleanroom facility and significant work to develop processing steps needed to fabricate the high-Q resonators." But that hurdle is about to be lowered. In Vahala's plenary talk he will describe "the first example of a foundry-based, ultra-high Q resonator system that can produce a microcomb". "That transition is a marker point that I think is going to open the floodgates," Vahala said.

During the Covid-19 pandemic, such cleanroom facilities are relatively safe thanks to their air filtration, Vahala suggested. However his team has still been affected. "Social distancing in a cleanroom means that throughput is limited," Vahala revealed. "It's not an absolute shutdown of clean rooms, but it's a speed brake. Southern California shut down in March, there was a full lock down. It was lifted in July. By the end of August, we had figured out a safe way of operating, and even more recently have added weekly COVID testing for everyone that's on campus, so that it's possible to contact trace cases. The primary impact on our work has been less felt in measurement and characterization, but more in the microfabrication side."

Pivoting to hold conferences like Photonics West online in the pandemic world has been a mixed experience, but generally surprisingly positive, Vahala added. "It's been a marvellous thing to see how quickly technology and organizations have responded to the pandemic," he said. "I think everybody realizes that the in-person event offers an extra something in that human contact is very important. We're probably going to see a hybrid model going forward, as the ability to see talks is another barrier that can be broken by the internet." Vahala also noted that in teaching at Caltech his students like recorded lectures as they can replay hard-to-understand parts. Also, their friends and families can take the opportunity to attend online PhD defenses in great numbers. "Despite all the pain and suffering, there will be some long term benefit."

Andy Extance is a freelance writer based in Exeter, UK.

Stick-on skin patches close in on coronavirus

A Band-Aid-like sensor from Professor John A Rogers can detect the faintest of Covid-19 symptoms and is set to reach the world within weeks.

By Rebecca Pool

Throughout the pandemic, Professor John A Rogers, and many of his team at Northwestern University, have been wearing Band-Aid-like patches on their throats to detect the early symptoms of Covid-19. Classed as essential personnel, the researchers have worked during lock-downs, eager to take their wireless, wearable sensors from the laboratory into the field.

"I've been wearing a sensor and a good fraction of my students also volunteered to use a device to monitor symptoms whilst working," highlights Rogers. "We've also been using hospital-grade instrumentation to track the heart rate and temperature of everyone as they arrive to the lab. I don't want to press my luck, but so far we haven't been impacted by the disease."

The bio-integrated patches are adapted from a platform originally developed to track swallowing and speech behaviour in stroke patients. Rogers and colleagues had been working closely with clinicians on this application, but come March 2020, collaborators asked if they could adapt the sensor to track key Covid-19 symptoms. So, partnering with the US Department of Health and Human Service's Biomedical Advanced Research and Development (BARDA) and also launching the start-up, Sonica Health, they did just this.

Sensing temperature and respiration

The latest devices comprise a high-bandwidth accelerometer and clinical-grade precision temperature sensor connected via a network of springy wires, all nestling within a silicone rubber enclosure. Thanks to its soft and skin-compliant design, the sensor mounts easily, and comfortably, onto the suprasternal, or jugular, notch of your neck, to monitor skin temperature as well as the subtle heart and respiration vibrations that lie within.

"There's a lot of airflow here and you're close enough to the carotid artery to capture heart sounds," highlights Rogers. "We monitor heart rate and its variability, cough frequency, intensity and duration, chest wall movements and respiration activity including features related to wheezing and sneezing."

"The accelerometer is also responsive to low frequency motion so we can detect body orientation and activity level which is important contextual information when you're interpreting patient status," he adds.

Critically for Covid-19, pilot-trials are well underway. Hundreds of subjects, including volunteers that presented with symptoms as well as frontline workers from the Shirley Ryan AbilityLab and Northwestern Memorial Hospital in Chicago, have been monitored, generating terabyte after terabyte of raw data that is transmitted to a cloud server, ready for analysis.

"We've been deploying devices at drive-through testing clinics in several locations across the Chicagoland area, and monitor subjects for up to ten minutes," explains Rogers. "We've found that fatigue ability is a key symptom of Covid-19 so we ask people to walk a certain number of paces, sit up and down - then we can pull out the more subtle indications of an infection, beyond, say, exhibiting a fever."

Symptom-driven algorithms

Rogers and collaborators have also been developing a set of symptom-driven algorithms to pinpoint and analyse the faint, almost indistinct, signs of disease present in mildly symptomatic, and nominally asymptomatic individuals. Custom signal processing and machine-learning algorithms are extracting more and more detail from the data deluge being generated.

"We're relying on the machine learning to look for subtle nuances, but you could imagine, that changes in respiratory depth and frequency after exercise might be detected, or there could be subtle variations in parameters associated with gait or walking speed," says Rogers. "It's been illuminating to see how much individual variability there is in all of the data – we're really not getting a cookie-cutter set of parameters that you can apply to every individual – it depends on gender, age and so on."

Once analysed, data is presented to a clinician in an easily-interpretable dashboard, and importantly for the fight against the virus, Rogers is expecting FDA approval of the devices for Covid-19 monitoring within weeks. He also intends to deliver around 100,000 devices to the field by Summer this year.

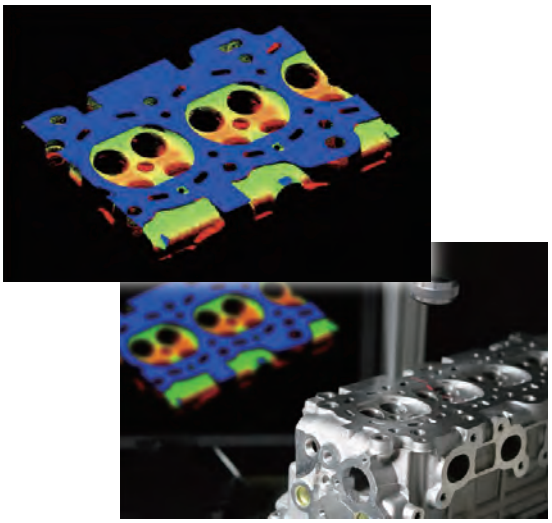
Small-scale manufacturing has been taking place at Northwestern University – Rogers' laboratory has enough manufacturing tooling to produce around fifty devices a week. And platforms have been designed to be compatible with commercial

continued page 33

Credit Northwestern University

Early warning: the flexible wireless sensor sits on your suprasternal notch to detect Covid-19 symptoms.

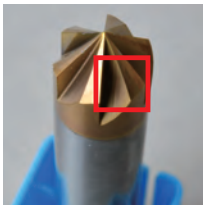
Revolutionizing Optical 3D Profiling



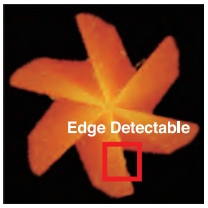
Santec introduces a new **3D Optical Profiler.** Designed to support R&D and production environments, the **OPS-1000** delivers fast, accurate and wide 3D object scans with high sensitivity.

Capture surfaces that other profilers miss.

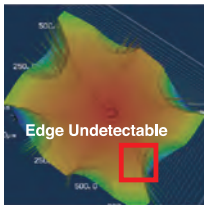
High Measurement Sensitivity (Up to 100dB)



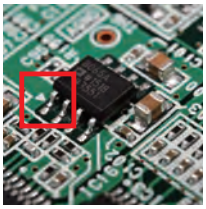
Drill Bit



OPS-1000

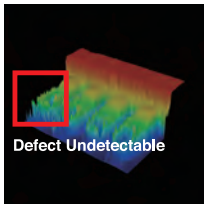


Confocal Microscope



Solder Fillet

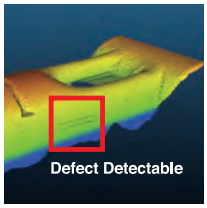
OPS-1000



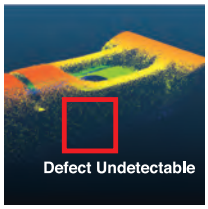
Confocal Microscope

Any Material & Surface (Single Beam Geometry)

Metal Parts



OPS-1000



Optical Frequency Comb

A wide system dynamic range of >**70dB** enables non-contact, high-speed measurements with high accuracy, regardless of shape, material, color or surface condition.

OPS-1000, 3D Optical Profiler

Join us at the:

Photonics West Digital Forum

santec **Beyond Imaging**

https://www.santec.com/en/products/oct/3DOpticalProfiler/

continued from page 30

Stick-on skin patches close in on coronavirus

manufacturing infrastructure for when mass production comes – which should be soon.

Outsourced manufacturing partners and a solid supply chain are in place, and Department of Defence funds are supplying around a thousand devices to military personnel. "We're engaging with a large medical insurance company and are quickly moving from academic pilot to a more extensive set-up that has real potential to impact Covid-19," says Rogers.

Clearly the upcoming weeks are going to be a hive of activity for Rogers and his team. He is looking forward to 'attending' the forthcoming 2021 SPIE Photonics West, and is pleased the conference can proceed virtually. "It's not a substitute for going to the conference in person, but it works very well at the moment," he says.

Rogers is also confident that his super-sensitive wireless sensors will find success in the field. Thanks to their intimate interface to the body, through the skin, the devices will detect the finer Covid-19 signatures that a wrist-mounted Fitbit or Apple Watch simply cannot. And given this, the Northwestern University researcher is confident that the devices will nicely complement such smart devices, while providing an easy alternative, where needed, to molecular diagnostics.

Credit: Northwestern University

"Our devices have real potential to make a difference": Professor John A Rogers and colleagues in his laboratory.

"I believe our devices have real potential to make a difference to this virus," he says. "Vaccines are now rolling out and everyone's hoping that Covid-19 will go away, but this is probably not going to be the only pandemic we see in the future."

"Having this kind of device could really be powerful – that's our hope," he adds.

Rebecca Pool is a freelance writer based in Lincoln, UK.

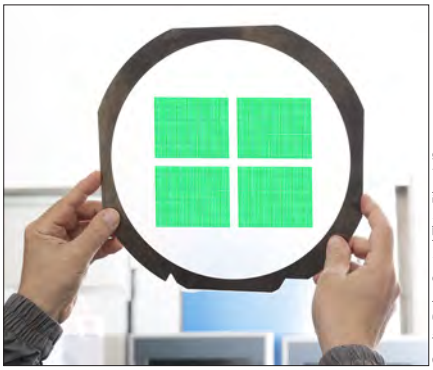
Digital Marketplace exhibitors showcase new launches and innovations

In the following pages we present some recent launches and applications by companies appearing at this year's Photoics West 2021. Visit spie.org for access.

By Matthew Peach, Editor in Chief, optics.org.

Delta develops and manufactures optical filters for PoC instruments

Delta Optical Thin Film A/S can supply small custom optical filters for PoC instruments, which come with specialized designs to reduce the effects of large angles found in PoC instruments and polarization splitting. Our ultra-hard coated filters are suitable for applications in varied environments, as they do not alter in performance over time or in different conditions. Using latest dicing equipment, the filters can be as small as 1.5x1.5 mm^2 with edge chips well below 50 µm. The filters are typically delivered diced to the final size on adhesive tape or in Gel-Paks that



Credit: Delta Optical Thin Film A/S

Optical Filters for PoC Instruments.

can be handled by pick-and-place machines. Our optical filters are all designed for the next generation of PoC instruments and they have been used in clinical applications in the biotech, biomedical, and drug discovery sectors.

www.deltaopticalthinfilm.com

Trumpf's 5-axis laser system supports car panel manufacture

Trumpf's TruLaser Cell 5030 is an entry-level solution for flexible 2D and 3D laser cutting. With its low machine-hour rate, the laser materials processing system is suited to small and medium batch sizes, and for applications where components are frequently changed.

QFS Technologies, Birmingham, UK, a specialist supplier of body-in-white parts to the automotive industry has invested in a new Trumpf TruLaser Cell 5030 five-axis 3D laser cutter.

"As we supply panels in batch quantities of 25-150 through various prototype build phases, we already have some of the tooling in place, we're increasingly being asked to support OEM customers with production volumes – often running into thousands of parts," said Managing Director Neil Holloway.

Credit: Trumpf.

TruLaser Cell 5030 for flexible laser cutting.

The TruLaser Cell 5030 is a suitable entry-level solution for flexible 2D and 3D laser cutting. With its low machine-hour rate, the 5030 is suited to small and medium batch sizes, and for applications where components are frequently changed.

www.trumpf.com

Cognex introduces 3D inspection system

Cognex has introduced the In-Sight 3D-L4000 embedded vision system. Featuring 3D laser displacement technology, this first-of-its-kind smart camera allows engineers to quickly, accurately, and cost-effectively solve a range of inspections on automated production lines.

Credit: Cognex

In-Sight 3D-L4000 embedded vision system.

"Until now, 3D has been too expensive and complicated to solve inspection applications for most customers," said John Keating, 3D Business Unit Manager. "The In-Sight 3D-L4000 breaks previous barriers by providing a massive suite of true 3D vision tools and making them as easy to use as the industry leading In-Sight 2D vision tools."

The 3D-L4000 combines patented speckle-free blue laser optics and the broadest range of true 3D vision tools with the flexibility of the In-Sight spreadsheet. This all-in-one solution quickly captures and processes 3D images with spectacular quality during inline inspection, guidance, and gauging applications.

www.cognex.com

Diamond specialist Element Six reports advances with its optical solutions

In 2020 Element Six launched DNV-B1, the first in its DNV Series of materials purpose-built for quantum applications. The DNV-B1 has been selected as a finalist for the 2021 Prism Awards Quantum category.

DNV-B1, Element Six's first commercially available, general-purpose CVD quantum grade diamond, has a carefully controlled nitrogen-vacancy doping that enables a range of experimental setups. NV delivers spin states that are extremely long-lived at room temperature, and can be controlled and read out using simply optical systems.

Credit Element Six

DNV Series of materials is designed for quantum applications.

DNV-B1 is an ideal starting material for those interested in researching NV ensembles for quantum demonstrations, masers, detecting of RF radiation, gyroscopes, sensing and further projects.

In 2021, the company plans to introduce new engineered grades in its DNV Series, with the aim of unlocking an even wider range of quantum-related applications.

There is also progress with the Raman diamond range. This ultrapure grade of diamond is an exceptional solution to shift frequencies and clean up laser beam quality through the Raman processes. Its outstanding thermal conductivity, combined with high gain and large shift, make this a suitable material for accessing hard-to-reach parts of the optical spectrum.

www.e6.com

Camera range expanded with 20MP USB3 models

Teledyne Lumenera, a Teledyne Technologies company, and developer of digital cameras for industrial and scientific imaging applications, has released new 20 megapixel models of its Lt Series USB3 cameras. Like all of the Lt Series cameras, these new models have a robust compact enclosure, fully-locking USB3 connectors, and are built for rugged 24/7 use.

Equipped with Sony's IMX183 rolling shutter CMOS

continued page 38

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SPIE. PHOTONICS WEST

Digital Forum
6 - 11 March 2021

Photonics West Marketplace
6 - 11 March 2021

BiOS Marketplace
6 - 11 March 2021

Attend the Photonics West Digital Forum, the premier laser, photonics, biomedical optics event. SPIE Photonics West covers a wide range of topics: biomedical optics, biophotonics, industrial lasers, optoelectronics, microfabrication, MOEMS-MEMS, displays, and more.

The digital forum will offer live plenary talks, on-demand technical presentations and discussions, online networking and special events, and a digital marketplace with product demonstrations and the ability to make business connections.

We hope to see you online in March.

You'll find many more news articles, products and market analysis on line at the **optics.org** website. Why not sign up to our weekly **eNewsletter** and get the latest photonics news directly to your in box.

If you want to keep up to date with optics.org you can do so via the website or you'll find us on LinkedIn and twitter.

www.optics.org

To register for the **Photonics West Digital Forum** go to **www.spie.org**

HOLOEYE Photonics AG

New Compact Phase Only Spatial Light Modulator - LUNA

The compact phase only Spatial Light Modulator LUNA is based on an 0.39" LCOS-microdisplay with a resolution of 1920x1080 pixels and 4.5µm pixel pitch. The SLM provides 8-bit phase levels (@ 60 Hz input frame rate).

The driver ASIC is embedded in the LCOS-microdisplay itself. This saves board space and the display can even accept data input via 4-lane MIPI DSI. This novel approach brings phase SLM technology to a new level of potential for industrial implementations.

Contact Details
HOLOEYE Photonics AG
Vomerstr. 1
12489 Berlin, Germany
www.holoeye.com
slm@holoeye.com
Tel: +49 30 4036 9380

DIAMOND USA Inc.

A Compact and Versatile Fiber Optic Connector

Diamond introduces a modular DM4 Multipurpose Insert that allows for configuration of each termini and can be assembled to meet your specifications.

The Compact DM4 can be used as a standalone product or as an insert in our Harsh Environment connectors.

It incorporates four termini, either optical or electrical, making it ideal for hybrid applications.

The optical termini are also available with our new Expanded Beam (XB) lensed technology ensuring easy maintenance and a high rate of mating cycles with a low risk for damage.

Contact Details
DIAMOND USA Inc.
85 Rangeway Road, Bldg. 3
North Billerica, MA 01862
USA
www.diausa.com
sales@diausa.com
Tel: +1 (978) 256-6544

EKSMA Optics, UAB

Quick Turnaround Manufacturing of Precision Spherical Lenses with IBS Coatings

Combining the capabilities of EKSMA Optics in-house CNC polishing and thin-film coating facilities allows us to offer great flexibility in the production of custom optical lenses. We can manufacture precision-polished lenses as single piece prototypes or in batches of up to 200 pieces. ø12.7 – 50.8 mm plano-convex and plano-concave UV fused silica lenses with custom focal length or radius of curvature can be delivered within 3 weeks ARO. Our optical engineers are also ready to design high-performance anti-reflection coatings optimized for your laser application. Challenge EKSMA Optics with your requirements for high-precision and on-time production of custom spherical lenses.

Contact Details
EKSMA Optics, UAB
Mokslininkų str. 11, LT-08412
Vilnius, Lithuania
www.eksmaoptics.com
info@eksmaoptics.com
Tel: +370 5 272 99 00
Fax: +370 5 272 92 99

Photonis

The Cricket™ by Photonis – A Lens Coupling Camera Attachment

The Photonis Cricket enables your camera to capture images across a broad spectral range, from 200 to 900 nm, supported by our Hi-QE Photocades. Connecting the Cricket is simple, using a universal C-mount interface. Simply adjust the fine focus and begin. Also it converts UV and NIR photons into green photons with emission characteristics that perfectly match the spectral response of a solid state camera. It has a high 3 ns temporal resolution that is made possible with an optional gating module. The Cricket supports 1 µlx sensitivity or single photon counting.

Contact Details
Photonis
www.photonis.com

FISBA AG

The READYBeam™, combines three lasers in one housing

The READYBeam™ is an extremely compact multi-color laser module including driver electronics and temperature control. Different diode combinations are available which cover a range of applications from microscopy and flow cytometry to display and projection techniques. The module comes with a single mode fiber, the individual channels can be modulated independently. As a true turn key solution and as an OEM product the READYBeam™ facilitates the integration into existing instrumentation as well as their technological development and evolution.

Contact Details
FISBA AG
Rorschacher Strasse 268
9016 St. Gallen, Switzerland
www.fisba.com

Optikos Corporation

Introducing the newest LensCheck™ Thermal Module for testing lenses subject to temperature extremes

The TM-1010 is the latest addition to the family of LensCheck™ and OpTest® Thermal Modules developed to enable lens testing over temperature, typically from -30° to +100°C. Specifically designed for small lenses with fields of view up to 160°, the TM-1010 adds to the range of automotive lenses that may now be characterized over a range of temperatures on a LensCheck instrument. Besides the thermal chamber, thermal modules also include a recirculating thermal controller, a Skyhook™ hose carrier, and a dry air control manifold.

Contact Details
Optikos Corporation
107 Audubon Road, Bldg. 3
Wakefield, MA 01880 USA
www.optikos.com
sales@optikos.com
Tel: +1 617 354-7557

HOLOEYE Photonics AG

Off-the-shelf standard glass Diffractive Optical Elements

HOLOEYE's new stock elements are made of fused silica glass by etching, or by replication using acrylate polymers on soda lime glass substrates. They feature anti-reflective coatings, for most of the fused silica DOEs both on plain and microstructured substrate surfaces.

Compared to polymer DOEs, the glass DOEs - in particular the fused silica ones - withstand significantly higher laser powers and higher temperatures, are more scratch resistant, have lower thermal extension coefficients and withstand exposure to UV-radiation without degradation.

Contact Details
HOLOEYE Photonics AG
Vomerstr. 1
12489 Berlin, Germany
www.holoeye.com
doe@holoeye.com
Tel: +49 30 4036 9380

OZ Optics Ltd

Low Cost Universal Optical DNA Rapid Detection System for Pathogens Including COVID-19

- Use to detect viral and bacterial DNA/RNA including Covid-19, SARS, Ebola, Cholera, Salmonella, etc.
- Rapid DNA/RNA detection *(as little as 20 minutes)*
- Highly sensitive and specific detection of low viral levels
- Intuitive software displays real time data during testing
- Compact modular design allows easy cleaning and maintenance
- Test up to 8 samples simultaneously *(higher count systems with up to 96 samples available soon)*
- Wireless communication to computers and smartphones *(coming soon)*
- A fraction of the cost of qPCR based systems

Contact Details
OZ Optics Ltd
219 Westbrook Road, Ottawa,
Ontario, K0A 1L0
www.ozoptics.com/ALLNEW_PDF/DTS0177.pdf
sales@ozoptics.com
Tel: +1 613-831-0981
Fax: +1 613-836-5089

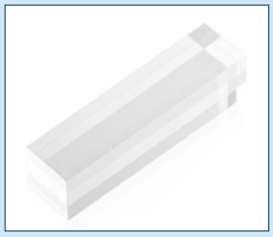
elementsix

High gain Raman crystal for tuned laser optics across the spectrum

Diamond Raman crystals combine a broad transmission window, large frequency shift and high gain with the extreme thermal properties of diamond to make them ideal for tuning laser light across the spectrum.

E6 CVD synthesis and processing enables diamond crystals optimised for intra-cavity laser optics, including Raman frequency converters.

In comparison with other high gain Raman crystals, E6 diamond offers a larger frequency shift combined with significantly higher powers.



Contact Details
elementsix
www.e6.com

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Digital Marketplace exhibitors showcase new launches and innovations

sensor, a resolution of 20 megapixels, and using back illumination technology, these new cameras perform in a wide variety of imaging applications with low

Credit Teledyne

Teledyne's new 20 MP Lt Series USB3 cameras.

or changing light conditions such as aerial imaging, Intelligent Traffic Systems (ITS), robotic inspection solutions, and life sciences.

The cameras offer 32 and 64-bit operating system compatibility for, Windows, Linux, Linux for embedded system platforms, and single board computers (SBCs). They are designed to deliver high dynamic range, high speed, with low read noise for both industrial and scientific imaging applications.

www.teledyne.com

Palomar 3880 die bonder expands EPIC's packaging research

Palomar Technologies, a global leader in delivering total process solutions for advanced photonics and microelectronic device packaging, announced today that Electronics and Photonics Innovation Center (EPIC), Torbay, UK, has purchased a fully loaded 3880 Die Bonder. The purchase strengthens the continued cooperation between the two entities in the area of photonics and microelectronics packaging research, which began in 2019.

Credit Palomar

Palomar 3880 die bonder.

Josef Schmidl, Managing Director EMEA for Palomar Technologies commented, "By acquiring the Palomar 3880 die bonder, EPIC has put their confidence in Palomar and that our equipment provides the highest quality, flexible electronic packaging solutions to support their growing photonics and microelectronics cluster."

EPIC, founded in 2019, is a center of excellence to support technological innovation and promoting collaborative activity between businesses and research institutions in the area of microelectronics and photonics development.

www.palomartechnologies.com

Ophir Helios Plus industrial laser power meter enhanced

MKS Instruments has announced the Ophir Helios Plus, an expanded version of the Ophir Helios industrial laser power meter. The Helios Plus has all the features of the Helios for measuring a wide range of high power lasers in production operations, as well as the ability to measure additional wavelengths, such as blue and green lasers used in copper welding in the automotive industry.

Credit MKS Instruments

Ophir's Helios Plus industrial laser power meter.

The Helios Plus power meter measures high power industrial lasers of up to 12kW and, for increased flexibility, provides an expanded choice of wavelengths: 450-550nm (blue/green) and 900-1100nm (infrared). This is especially important in the automotive industry where heat conduction welding with blue and green lasers is becoming the first choice for battery welding and connecting small copper parts in electrical components.

The power meter is compact, requires no water cooling, and provides a high damage threshold. PROFINET, Ethernet/IP, and RS232 communication options make it easy to integrate into manufacturing networks. Once integrated into the production control system, fully automated measurements can be made.

The Helios Plus industrial power meter measures high power solid state lasers – such as diode, fiber, and Nd:YAG lasers – with powers from 100W to 12kW and energies from 10J to 10kJ.

www.ophiropt.com

Suss MicroTec launches mask aligner for imprint

Suss MicroTec, a supplier of equipment and process solutions for the semiconductor industry and related markets, has launched its latest generation mask aligner, the MA8 Gen5. The semi-automated tool is specifically aimed at imprint lithography, a key enabling technology for many trending applications such as face or fingerprint recognition, light carpets or augmented reality.

Credit Suss MicroTec

Suss MicroTec's new mask aligner.

The new platform introduces improved imprint processing features for standard, advanced and high-end processes and provides additional improved functionalities, including the further enhanced Suss leveling system. The leveling system in particular offers an effective means to achieve an even more precise parallelism between stamp and substrate.

Configured for handling wafers up to 200 mm, the MA8 Gen5 is a highly attractive solution that meets the requirements of a large variety of imprint applications in the field of LED, MEMS/NEMS, micro-optics, augmented reality and opto-electronic sensors, using the Suss Smile imprint technology.

www.suss.com

Schott presents static phosphor ceramic converters

Designed for laser-pumped phosphor light sources, Schott has developed phosphor ceramic converter assemblies, which offer high irradiance and superior luminance. The company is presenting at Photonics West Digital Exhibition its advanced static ceramic converters product line. Integrated on a heat spreader, static ceramic converters enable innovative, compact light sources without moving parts.

Credit Schott

High irradiance and superior luminance.

The completely inorganic ceramic converter material is positioned on the heat spreader to allow high power use. This approach provides excellent and sustainable heat management to conduct the heat away from the ceramic.

Schott says its solution "offers the highest luminance as well as reliability and a high irradiance limit. With the static ceramic converter, our customers can realize many different product designs and address applications with extremely high brightness."

The company is also making a presentation at the OPTO 2021 conference; paper 11706-40 "Design rules for laser pumped phosphor light engines with static ceramic luminescent converters". Authors are Volker Hagemann and Albrecht Seidl (SCHOTT AG).

www.schott.com

SPIE. PHOTONICS WEST

TOP 10 THINGS
you don't want to miss

In addition to the on-demand technical presentations, make time for live presentations, networking, and other opportunities at the 2021 Photonics West Digital Forum.

BiOS Hot Topics + plenary sessions
Live sessions with world-class speakers addressing the hottest topics
6 - 9 March

Quantum West
Sessions focused on the quantum industry
8 – 11 March

Digital Marketplace
Top companies, product demonstrations, and more
6 – 11 March

Join the conversation on Slack
Dialogue with colleagues
Workspace available throughout the event

PRISM Award winners
Watch the virtual awards ceremony from 3 March
Recording available throughout the event

Social and networking opportunities
Online sessions to help you make important connections
6 – 11 March

Photonics 2025: Today's applications and tomorrow's innovations
Hear thought leaders address today's hottest application areas
11 March

SPIE President Welcome
Hear the Digital Forum welcome from 2021 SPIE President David Andrews
Recording available throughout the event

Compensation in Optics and Photonics
Hear highlights from the 2021 SPIE Global Salary Report
10 March

Light-based images
Download images for your Zoom background and social media accounts

Available online throughout the event.
Find these and other opportunities online

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Come find the employees you need or find your dream job—at the world's largest multidisciplinary event focusing on optics and photonics technologies.

Post your CV/resume online, set-up job alerts, access career-related articles and more, all for free.

STAY INFORMED
GAIN EXPOSURE
BUILD YOUR NETWORK

Top Companies are Hiring

VISIT THE
VIRTUAL JOB FAIR
at SPIE Photonics West

Tuesday 9 March
Wednesday 10 March

10:00 AM – 5:00 PM

To recruit in the Virtual Job Fair contact: **Lacey.barnett@spie.org**

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Surround the Workpiece® with Our Full Portfolio of Solutions

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