2025

SPIE. | optics.org

JANUARY 25 — 30, 2025

PHOTONICS WEST PREVIEW

Monitoring stroke recovery
p. 07

Paras Prasad, SUNY Distinguished Professor of the University at Buffalo. Credit: U Buffalo.

Bioimaging and nanophotonics combined for health benefits

Paras Prasad describes how nanomedicine will have a big impact in clinical care, diagnosis, and therapy.

The field of nanophotonics has a long and storied history, as Paras Prasad from the University at Buffalo knows well. Prasad, SUNY Distinguished Professor and recipient of the 2016 SPIE Gold Medal among other awards, wrote the 2004 book *Nanophotonics* that played a part in making the field and its emerging optical technologies into a major sector of research. His subsequent books include *Introduction to Nanomedicine and Nanobioengineering* eight years later, about the interdisciplinary frontiers then taking shape where nanotechnology, engineering, and medicine converge.

Today's research at those frontiers could have major impacts on bioimaging and healthcare, as Prasad will discuss during the SPIE Photonics West Biophotonics Focus: Nanophotonics and Imaging plenary event.

"Nanophotonics is no longer an emerging field, but an expanding technology based on some fundamental questions," he commented. "How can we use both nanoscience and nanochemistry to perform nanomedicine? Can we make new kinds of nanoscale optical materials, in which the light-matter interaction is

continued on page 03

Laser fusion: Are you ready?

Edging ever-closer to commercial power plants, laser fusion energy will bring 'transformative' opportunities for photonics markets far and wide, says Constantin Häfner. Here's how.

On 5 December 2022, an experiment at the National Ignition Facility (NIF) at Lawrence Livermore National Laboratory (LLNL) truly showed the world what laser fusion could do. Intensely powerful laser pulses, fired at peppercorn-sized fuel pellets, sparked a fusion reaction that generated three megajoules (MJ) of energy, equivalent to the power a typical American household consumes for nearly an hour. Critically, this mighty three MJ figure was also 50% more than the laser energy used to trigger the fusion reaction: for the first time, fusion ignition had been reached in a laboratory.

Since this remarkable result, fusion energy yields have continued to rise as have government and private investment funds,

continued on page 06

Igniting fusion: a NIF fusion target contains a 2mm diameter capsule filled with cryogenic hydrogen fuel. In a commercial set-up, these pellets would be fired into the plant at a rate of approximately 600 per minute. Credit: National Ignition Facility & Photon Science.

DON'T MISS THESE EVENTS.

SATURDAY

BIOS EXPO
10am – 5pm Moscone Center, Halls DE (Exhibit Level)

QUANTUM SENSING FOR BIOMEDICAL APPLICATIONS
4:15 – 4:45pm Moscone Center, Expo Stage, Hall DE

BIOS HOT TOPICS
7 – 9 pm Moscone Center, Room 207/215 (Level 2 South)

SUNDAY

BIOS EXPO
10am – 4pm Moscone Center, Halls DE (Exhibit Level)

TRANSLATIONAL RESEARCH FORUM
12:30 – 2pm Moscone Center, Room 153 (Upper Mezz South)

NEUROTECHNOLOGIES PLENARY
3:30 – 5:30pm Moscone Center, Room 207/215 (Level 2 South)

BIOS POSTER SESSION
5:30 – 7:00pm, Moscone West, Room 2003 (Level 2 West)

BIOPHOTONICS FOCUS: Nanophotonics and Imaging Plenary
7:00 – 9:00pm Moscone Center, Room 207/215 (Level 2 South)

For the full schedule and most up-to-date info, download the SPIE Conferences app. Some events require a paid technical registration.

IN THIS ISSUE.

Happy New Year, and welcome to Photonics West 2025!

Dr. Kent Rochford is CEO and Executive Director of SPIE. Credit: SPIE.

It's common to start the year with resolutions to improve, break bad habits, and start new good habits. At SPIE, we strive to improve and resolve every year that Photonics West will be better than the previous year. I'm happy to report that we're accomplishing this resolution for 2025.

I look forward to gathering in San Francisco again to celebrate the remarkable advancements in optics and photonics, share knowledge, and forge new collaborations to further our industry and enable future innovations. Photonics West has always been a showcase of innovation, bringing together the brightest minds from academia, industry, and government. This year is no exception. We have an extraordinary lineup of speakers, exhibitors, and sessions that promise to inspire and challenge us all. From cutting-edge research presentations to exhibits showcasing the latest technologies, the week is designed to start the year with a comprehensive view of our field's current state and future directions.

This year, we are particularly excited to celebrate the International Year of Quantum (IYQ) as a Founding Partner to honor 100 years since the initial development of quantum mechanics.

This year, we are particularly excited to celebrate the International Year of Quantum (IYQ) as a Founding Partner to honor 100 years since the initial development of quantum mechanics. IYQ is intended to raise public awareness of the importance and growing applications of quantum science and technology. Of course, photonics enables many of the quantum technologies that are poised to revolutionize our lives, from computing and secure communication to sensing and imaging.

Kicking off the Year of Quantum, Quantum West will again be bigger than ever before with over 350 technical presentations, three exceptional plenary speakers, including Nobel laureate Eric Cornell, a focused exhibit, and the Quantum Business Summit — highlighting the transition of quantum technologies to industrial applications and solving real business needs.

In addition, we have an exceptional lineup of 25 plenary speakers this year, including two Nobel laureates: Moungi Bawendi from the Massachusetts Institute of Technology and the previously mentioned Eric Cornell from the University of Colorado Boulder and NIST. But the exciting research is not only presented on the plenary stage, the conference rooms are full of innovative uses of light to solve the pressing problems of our time.

This week, we will have 5,000 presentations spanning over 100 distinct technical conferences. While impressive from a conference organization and program perspective, perhaps more impressive is the importance our photonics community has on the global research and innovation infrastructure. This impact will be on full display this week. From lasers for dentistry to lasers for free space communication, there truly is something for everyone at Photonics West.

The exhibition halls are filled with over 1,300 companies showcasing the latest products and solutions. This is a unique opportunity to see firsthand the innovations that are shaping the future of photonics. I encourage you to take the time to visit our exhibitors to engage and explore how their offerings can benefit your work. Tell them about your work, the dialogue of the tradeshow floor should not be one-direction. Use the time to inform the companies how their tools are used and learn from them how to improve your work with new equipment or find solutions to your roadblocks.

Networking is the key component of Photonics West, and we have planned numerous events to facilitate meaningful connections. Whether you are attending the welcome reception, participating in a panel discussion, or simply enjoying a coffee break, I urge you to take advantage of these opportunities to meet new colleagues, share ideas, and build lasting relationships. The true value of attending Photonics West is the people you have access to!

I would like to extend my heartfelt thanks to our sponsors, exhibitors, and presenters. Your support and participation are what make Photonics West such a vibrant and impactful event. I am particularly grateful to our organizing committees and volunteers, whose hard work and dedication are instrumental in bringing Photonics West to life.

As we begin this exciting week of discovery and collaboration, I encourage you to embrace the spirit of innovation that defines Photonics West. If your 2025 New Year's resolutions are to improve your career, grow your network, solve difficult problems, or just have more fun, coming to Photonics West is a great way to start those good habits to reach your goals.

Thank you for being here and for contributing to the success of Photonics West. I look forward to the inspiring conversations, groundbreaking discoveries, and new friendships that will emerge from the week. Together, we are shaping the future of photonics technologies, and I am excited to see what we will achieve.

KENT ROCHFORD

Biomaging continued from page 01

enhanced in controlled ways to produce a novel response? And since multi-photon processes are a big part of nanophotonics technology, providing access to new energy states and enabling the use of deep penetrating IR photons, how can we utilize the excess energy being deposited into nanoscale materials in 2- and 3-photon operations and make excitation dynamics work for us?"

Those queries are being combined with breakthroughs in novel quantum materials and heterostructures to give materials specific nanophotonic behavior that was not previously feasible. Prasad describes the field today as one where evolutionary progress and revolutionary breakthroughs can both play their part.

Optically probing your state of mind

One example of a revolutionary advance is how nanophotonics will be utilized in brain research and the study of cognitive processes, commented Prasad.

"Can we actually assess a patient's cognitive state of mind by using optical techniques? Magneto-optical materials might be the way. Examples of conventional magneto-optical materials are well known, but we are trying new approaches to the design of these materials using novel nanochemistry which can dramatically increase the magneto-optic activity."

This work hinges on the physics of chiral media, and how interactions between optical and magnetic fields can be amplified if materials are first loaded with local chiral centers and then formed into particular helical structures that impart non-local chirality as well. Adding plasmonic nanoparticles to these designer structures enhances the magneto-optical response further, with the ultimate goal being a material sensitive enough to respond to the weak magnetic fields generated by human brainwaves.

"These materials can be conformable polymeric structures, so we can envision a head-worn helmet made with new generation magneto-optical materials where different regions of the brain can be optically probed," said Prasad. "Sensing the brainwaves from a specific area of the brain in this way would be a revolutionary and novel approach to study of cognition."

Past the blood-brain barrier

As nanomedicine picks up pace, it faces challenges placed in its way by nature. The problem of light not penetrating deeply into biological tissues has to be dealt with by all biophotonics techniques, but nanoscale materials have their own additional hurdle, since the human body has evolved ways to keep them out.

In the case of the brain, a layer of cells termed the blood-brain barrier exists specifically to stop extrinsic contaminants from getting deeper into the organ. So particles designed for the kind of nanomedicine envisaged by Prasad will have to find a way to enter the brain in the first place, as well as then be targeted at the areas of interest.

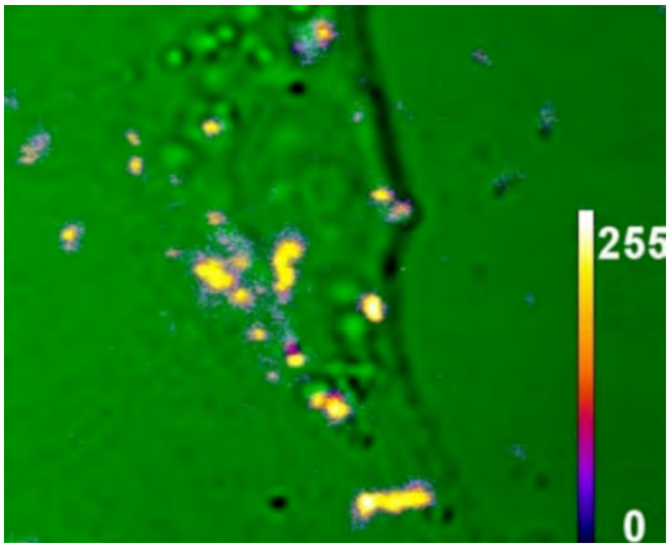
The benefits of success, though, could be substantial. Prasad described three particular areas of brain medicine where nanophotonics can make an impact: diagnosis and treatment of glioblastoma brain cancer; brain dysfunctions such as Alzheimer's disease arising from the aging process; and traumatic brain injuries, or TBI.

In TBIs, whether arising from a specific accident or the cumulative effects of playing sports, it is very difficult for clinicians to assess the true extent of damage. But nanophotonics might allow the injury to be recognized at an early stage, at a time when there is as yet no morphological alteration but nonetheless some underlying change taking place in the brain.

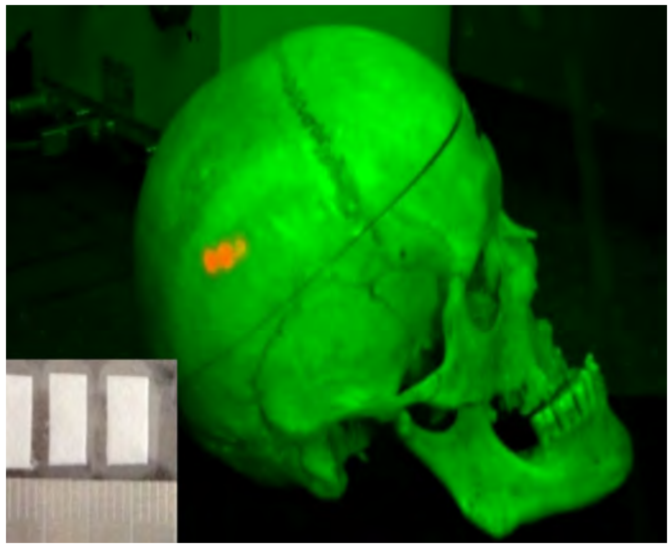
"The first question is how to detect TBI," said Prasad. "What biological changes are taking place that we can image, by using nanoparticles targeted to

continued on page 04

Biomaging continued from page 03



Cancer imaging: Two-photon sum-frequency-generation bioimaging of KB cells with targeted ZnO nanoparticles. Credit: Paras Prasad.


Through-skull imaging: Two-photon bioimaging using IR to IR up-conversion in rare-earth-element doped nanoparticles. Credit: Paras Prasad.

particular biomarkers in different parts of the brain? We ultimately foresee an integrated approach, one combining natural medicine, synthetic medicine, immunotherapy and optogenetics. But first we must get past the blood-brain barrier, something we have achieved in phantom models and which still presents a challenge in human patients."

From science-fantasy to reality

Artificial intelligence (AI) and machine learning (ML) will have a role to play, as the computational workloads and modeling demands of the technology increase. An ability to identify multiple biomarkers and signatures of diseases in a single imaging operation would be hugely significant, but creating nanoscale structures with this kind of multiplexing ability will need machine assistance. So too will identifying the exact parts of individual cells to be targeted by the new technology: should nanomedicine for a particular purpose be delivered to the mitochondria, or the nucleus, or elsewhere? Where should the bullet be aimed?

"In an important development at my institution, SUNY University at Buffalo will house a state-of-the-art AI computing center as part of the Empire AI partnership, which is bringing together leading public and private universities in New York State," said Prasad. "We are trying to educate and prepare ourselves for the ways in which AI and ML will impact this field in the future."

The technology is already making an impact in the present. In 2015 Prasad received the University at Buffalo's Innovation Impact Award for work applying the concepts of magnetic and laser-activated nanoparticles to cancer diagnosis and treatment. This technology was licensed at an early stage to the French company Nanobiotix, which has since been developing an oncology treatment based on functionalized hafnium oxide nanoparticles. In December 2024, Nanobiotix announced completion of a Phase 1 clinical study applying its nanoparticle treatment to pancreatic cancer.

"These nanomedicine technologies are the realization of ideas that were previously science-fiction," said Paras Prasad. "In 1966 injecting a miniaturized targeted medical treatment in this way was something you saw in the film *Fantastic Voyage*. But by realizing a nanomedicine-based nanoclinic, we have turned fiction into reality."

TIM HAYES

Q&A with Fluence Technology

Fluence develops shock- and temperature-resistant femtosecond lasers for applications in various fields from science to industrial micromachining. *Show Daily* conducted a Q&A with Bogusz Stepak, the company's Ultrafast Laser Application Laboratory Director.

Bogusz Stepak, Ultrafast Laser Application Laboratory Director. Credit: Fluence Technology.

Show Daily*: Give us an introduction to your company: recent history and current business activities.*

Bogusz Stepak: Fluence Technology is a laser manufacturer based in Warsaw, Poland, focused on environmentally-stable femtosecond fiber lasers. The mission of the company is to deliver maintenance-free femtosecond lasers with a long lifetime. Years of research have led Fluence to create shock- and temperature-resistant femtosecond lasers for applications in science and industrial micromachining. Founded in 2016, Fluence is a growing company with a team of over 50 employees and an annual revenue exceeding €2.5 million.

Fluence laser-processing example: periodical surface structuring. Credit: Fluence Technology.

Key products, locations, target applications and typical customers:

Our advanced lasers offer ultrashort pulse energy up to 400 μJ, power levels ranging from precision low-power options up to high-power systems up to 50 W, and features such as pulse-on-demand and burst envelope shaping. With options for multiple wavelengths, our lasers are replacing outdated nanosecond and picosecond technologies across various industries.

While our headquarters are in Warsaw, Poland, we showcase the capabilities of femtosecond lasers at Fluence's Ultrafast Laser Application Laboratory in Wrocław, focusing on general ultraprecise laser material processing, including cutting, drilling, dicing, and surface patterning/functionalization.

Beyond the work conducted in our lab, our femtosecond lasers are also designed for a wide range of target applications, such as: ophthalmology; two-photon microscopy; two-photon polymerization; and scientific research and spectroscopy.

Typical Fluence customers come from both industrial and scientific sectors. For industrial customers involved in material processing, we provide a combination of high-quality results enabled by ultrashort pulses and high productivity thanks to our lasers' high average power. Additionally, we address more complex needs with advanced techniques, such as spatial and temporal beam shaping and harmonic generation, delivering tailored solutions to solve specific application challenges.

What are the recent news headlines from the company?

Fluence Technology was recognized in the 22nd edition of the (Polish) Presidential Economic Awards. The awards ceremony took place on 7 November 2024, where President Andrzej Duda honored companies making significant contributions to national economic development and promoting Poland's image globally. Furthermore, in 2024 we were awarded the main prize at the Entrepreneur of the Year UW Competition held by the University of Warsaw.

Fluence's Ultrafast Laser Application Laboratory (ULAL) has a lot of experience in glass processing. For the past four years we have focused on glass cleaving, drilling or welding. We can demonstrate welding glass to glass, multiple layer sandwich, glass to metal or even sapphire to metal. Lately we are working on glass drilling using different approaches that includes HQ and fast percussion drilling and precise rear side ablation drilling. Both techniques enabled record aspect ratios with minimized taper and very low hole to hole spacing.

Recently we have achieved high quality microhole drilling in glass, an important building block for advanced packaging and which includes iterposers for AI chips. Our recent findings at ULAL show strong correlation between pulse duration and drilling speed. By using optimized NA and high-pulse energy exceeding 250uJ, high-quality holes can be obtained with shiny walls and no defects. Productivity can be improved by what we call drilling on-the-fly. Such an approach may be applied to silicon or SiC drilling as well. In particular, the fabrication of polymer microfilters may benefit from this processing strategy as organic substrates are heat-sensitive.

Considering Photonics West, what do you like about this event?

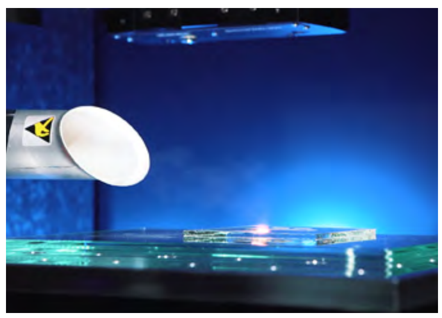
We've been active at Photonics West for several years, and we consistently find the event to be a key opportunity for connecting with industry leaders, researchers, and potential customers. The conference offers a comprehensive view of the latest trends in photonics, which is valuable for us as a company focused on femtosecond lasers and their applications. What we particularly appreciate about Photonics West is the diversity of attendees — from academics to industrial professionals — which allows us to engage with a wide range of perspectives and explore potential collaborations.

What are Fluence's activities during Photonics West 2025?

During this year's Photonics West, I will deliver an oral presentation on 27 January. The presentation, entitled "Single-step fabrication of high-aspect-ratio through-glass vias using an ultrafast fiber laser" (Paper No. 13350-2), will provide insights into advanced laser micromachining techniques.

Are there new markets you are exploring?

Femtosecond lasers are the key tool for fabrication of components for new and future technologies like VR or quantum computing, which are based on transparent materials. With ultrashort pulses, we can cut, cleave multilayer and multimaterial substrates, modify in volume and inscribe microstructures. All this is possible thanks to well-localized nonlinear absorption of ultrashort pulses in transparent media. Moreover, ultrashort pulses will drive the further advancements in chip and sensor packaging which includes glass drilling, welding, and selective laser-induced etching, and cleaving. New optical memory storage is also a promising market. New enabled technologies include medical procedures like cataract surgery.



Fluence has recently focused on ultrafast laser processes for glass cleaving, drilling or welding, including welding glass to glass, multiple layer sandwich, glass to metal and sapphire to metal welding. Credit: Fluence Technology.

What are some of the challenges to your business model?

A major challenge, and a big opportunity at the same time, is the vast diversity of applications possible to tackle with ultrashort lasers, and the majority of them are still in the development stage and not widely implemented. Each application may require a slightly different optimal femtosecond laser configuration. This creates a need to make different products tailored to specific application tacking into account all factors such as size, cost, power and pulse energy, pulse duration of the laser.

Some companies focus on their niche applications, while others compete in big markets applications related to consumer electronics/display/healthcare with the major competitors, sacrificing their margin. So, for our company, the challenge here is to select the right applications that will take a major stake of market share soonest and pioneer that application.

Comment on the state of the market in 2025?

The ultrashort laser market is growing faster than any other laser market. It invites many laser manufacturers and research groups from academia, to step in. However, without extensive knowledge and experience in femtosecond lasers and systems, it might be difficult to be successful here. Femtosecond lasers are complex devices. Simple, robust technology, and easy to manufacture will be the winning factors in this competitive market.

Laser fusion

continued from page 01

and the number of laser-based fusion start-ups racing to build reactors — all of which spells good news for photonics.

Director of Germany's Fraunhofer Institute of Laser Technology, Constantin Häfner, led the development of some of the world's most powerful laser systems at LLNL until 2019 — and on Monday, 27 January, he will deliver the LASE plenary "Global advancements in laser fusion energy and their implications for the photonics market." As he puts it: "Building on the groundbreaking success at NIF, laser inertial fusion energy has attracted considerable attention — I will look at the achievements and profound implications for photonics, along with the very many industry opportunities."

Häfner is adamant that laser fusion energy brings transformative opportunities for organizations strong in optics and laser technologies. However, less obvious opportunities are also waiting to be seized. "The scope of laser fusion extends beyond lasers and optics into areas the industry may not yet fully recognize. Building a fusion reactor requires advanced material processes, such as fabricating components that withstand the extreme conditions," he says. "Laser additive manufacturing, especially for specific alloys, could also be transformative here. Lasers enable the precise production and refinement of these advanced materials."

In his plenary session, Häfner will also explore how the laser fusion industry can build a robust supply chain and tap into "spill over" markets by addressing today's technology gaps. "To construct a first-of-its-kind fusion power plant in the next 10 to 15 years, we need an industry capable of seizing these opportunities," he highlights. "Developing these technologies and bringing the industry along will take considerable time."

Filling in the fusion gaps

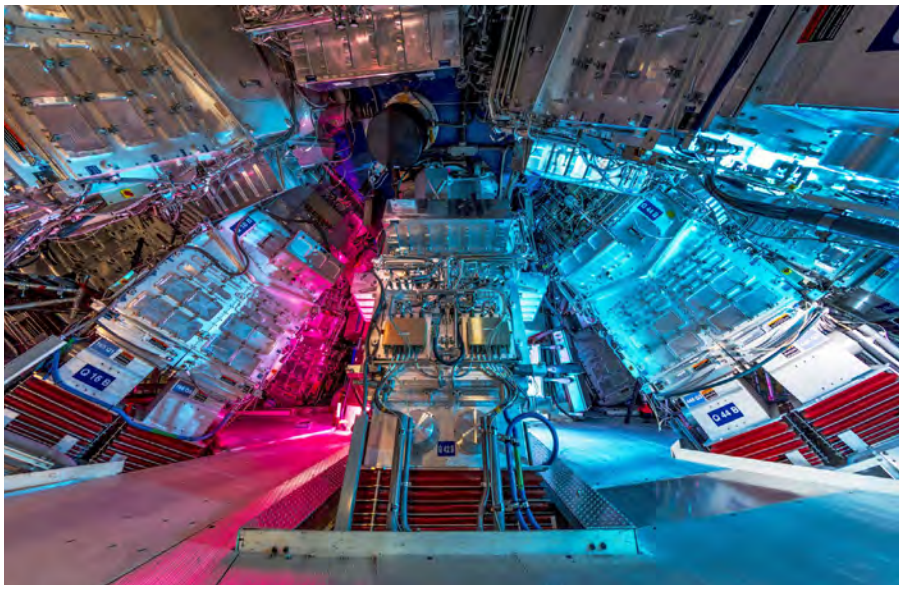
Häfner has also served as Head of the Inertial Fusion Energy Expert Panel for Germany's Federal Ministry of Education and Research (BMBF) — a group that estimates a fusion power plant could be demonstrated by 2045, with strong commitment. But numerous technology gaps need to be closed and a capable supply chain established between now and then.

According to Häfner, the pulsed high-power lasers used to implode the fusion fuel pellet still need more development. To drive a fusion power plant, he says these lasers need to be more robust and reliable, and have wall plug efficiencies around twice as high as current systems. Today's lasers can deliver one to two GigaShots of high-peak-power pulses, but a fusion power plant demands at least 10 GigaShots to meet the necessary reliability requirements.

Looking at a power plant's reactor vessel, materials need to be developed that can sustain the powerful pulses of neutrons, other particles, and X-ray radiation. And the cost of manufacturing components including lasers, photonics, and the fusion target needs to be streamlined.

"If we were to construct the fusion drive lasers for a power plant with today's technology, the cost would not be economically competitive," says Häfner. "To reduce costs, we need innovations in laser systems and optical components production alongside a high level of standardization. The assembly of lasers must also be highly automated — akin to modern car manufacturing."

Clearly the pace of fusion plant production is some way off that of a car manufacturing line, but Häfner is certain industry momentum will help to meet the need for speed. He points to several inertial fusion energy projects with industry partners that are already tackling laser-based fusion's pain-points.



Chamber: A view from NIF's target bay of some of the final optics assemblies surrounding the target chamber. Credit: Jason Laurea.

For example, LLNL's $16 million STARFIRE Hub project is driving commercialization forward by developing supply chains. Meanwhile, the Fraunhofer-led €18 million ($18.5 million) PriFUSIO network brings together myriad start-ups and established firms to develop key laser architectures and components. And BMBF-funded DioHELIOS unites Germany-based photonics players ams-Osram, Jenoptik, Laserline, and Trumpf with Ferdinand-Braun-Institut, Leibniz-Institut für Höchstfrequenztechnik and the Fraunhofer Institute for Laser Technology, to raise the power and efficiency of laser diodes used in laser inertial confinement fusion. "We're witnessing a strong commitment from industry — every project call in Germany has been oversubscribed which I view as a very positive sign that the sector is gaining momentum," says Häfner.

The Fraunhofer Director also believes that statements made by numerous nations during the inaugural World Fusion Energy Group meeting at the Italian Ministry of Foreign Affairs and International Cooperation in Rome in November 2024 signify a clear commitment to moving fusion towards commercialization. Bringing together stakeholders from public and private sectors, industry, academia, and national labs, the meeting highlighted how technical breakthroughs have generated industry momentum, making the deployment of fusion plants in the near future increasingly plausible. At the time, International Atomic Energy Agency (IAEA) Director General Rafael Mariano Grossi, who co-chaired the meeting with Italian Prime Minister Giorgia Meloni, said: "Until recently, fusion energy was a distant dream, but now with burgeoning private sector involvement and major technical breakthroughs, it seems fusion's realization is within reach."

Professor Constantin Häfner is Director of the Fraunhofer Institute of Laser Technology, and led the Advanced Photon Technologies program at Lawrence Livermore National Laboratory in California, where he helped to develop some of the world's most powerful laser systems. Credit: Fraunhofer ILT.

For his part, Häfner anticipates the transition of fusion towards market will present "unique opportunities" for countries worldwide to lead in new energy markets and boost economic growth. He is also certain that accompanying risks can be managed through strategic investments and innovative policy-making.

"The most transformative applications from the fusion energy supply chain may not even be known yet — but these will emerge as we address the challenges," he says. "To capitalize on these opportunities, future investment decisions will need to consider market dynamics, technology potential, scalability, regulatory frameworks, and intellectual property management."

And in a word of caution he adds: "Maintaining momentum is crucial — our challenges and eventual setbacks will all need sustained commitment and resilience to ensure success."

REBECCA POOL

NIF power plant: Concept art showing an inertial fusion energy power plant of the future. Fusion power plants could be similar in size to today's large baseload power plants. Credit: Eric Smith.

Connecting the DOT

2025 SPIE-Franz Hillenkamp Postdoctoral Fellowship recipient Morgan Fogarty's translational research applies diffuse optical tomography to monitor recovery of post-stroke patients.

When Morgan Fogarty was in eighth grade, her parents offered to send her to any kind of summer camp she chose. "I think they expected me to pick a more traditional summer camp of horseback riding or something like that," says Fogarty. Instead, she chose science camp, spending a week at the University of Illinois immersed in a bioengineering summer camp for girls. "That really sparked my interest in optics," she says. "We did some fluorescence imaging, and I just thought it was so cool. I've always been interested in biology, but I never thought of research as a career path until then; it just drew my interest very quickly. There are so many things we don't know about the human body and especially the brain, which is why I was drawn to imaging the brain. It's so fascinating to me, what we can learn about how our bodies actually work, and the diseases we can treat in the future."

Her pursuit of that interest has brought Fogarty high-level recognition this year. Fogarty, who is expected to receive her PhD in Imaging Science from Washington University in St. Louis (WashU) in February, was recently named the recipient of the 2025 SPIE-Franz Hillenkamp Postdoctoral Fellowship in Problem-Driven Biomedical Optics and Analytics. The annual award of $75,000 supports interdisciplinary problem-driven research and provides opportunities for translating new technologies into clinical practice for improving human health. Fogarty will be recognized at the Sunday evening plenary session during SPIE Photonics West, scheduled for 26 January.

Fogarty's research — conducted in conjunction with Sherwood Moore Professor of Radiology Joseph Culver at the Culver Lab and Biophotonics Research Center at WashU — will build on her doctoral work, exploring the potential of using diffuse optical tomography for monitoring language function and recovery in post-stroke patients. Applying the same technology, she also hopes to establish the feasibility of brain-computer interfaces to restore inter-personal communication for post-stroke patients.

Fogarty adjusts the very high-density diffuse optical tomography (VHD-DOT) cap on labmate Wiete Fehner, ensuring optimal optode coupling and participant comfort as a critical step before data collection. Credit: Morgan Fogarty.

The technique of diffuse optical tomography (DOT) is considered a more accessible and flexible alternative to MRI. "As you can imagine, an MRI scanner is not portable, it's very expensive, and it's not something that can really be used for daily usage in a clinical setting," says Fogarty. "My PhD work developed our very high-density DOT system, the purpose of that system being to capture image quality that's comparable to that of an MRI." Now, Fogarty's proposed post-doctoral research will use that fiber-based DOT imaging system — "it's essentially a cap that's got a bunch of wires coming out of it with a chair underneath it" — for semantic brain-mapping studies: "We want to look at the way language is mapped onto the brain, and then be able to use that in the clinical setting for people with post-stroke aphasia. We'd like to map their language recovery over time with a wearable neuroimaging approach." As Fogarty points out, lying down in the bore of an MRI magnet can feel very unnatural; there's also a lot of additional acoustic noise in MRI scanners. "It's not the best imaging modality for capturing neuroimaging in a naturalistic way. Our idea with this imaging cap is that you're able to sit in a room and watch a movie or listen to a podcast as naturally as you would normally in your spare time." In the meantime, the DOT system captures neural activity, process, and development.

Fogarty would love to see DOT technology become as commonplace as fitness watches. "What we really need to understand is our brain health — and that's where this technology with semantic mapping comes in. We believe it could help in catching early-stage dementia and other declines in cognitive abilities. If we are able to track these conditions as early as possible, that understanding could potentially be applied to managing the condition. That would be better for people."

But wait, there's more: her labmates, under the direction of Culver, developed a mobile, portable, high-density DOT system that consists of a helmet and backpack. "I think that's really one of the most interesting things that's coming out of the lab right now," says Fogarty who plans to use the wearable imaging system as part of her research. "We see it as a more natural imaging technique and can use it for naturalistic imaging tasks: You're not confined to a specific location; you can get up and walk around with the cap on; you can talk to your friends and family; you can do anything that you would do in your natural life. That's the imaging system working with you."

DANEET STEFFENS

SPIE Fellow brings optics torch to the Olympics

In 2024, alongside the buzz of athletic achievements, medals, and Parisian flair, the Olympic Games offered a less visible but no less exciting opportunity: a chance for SPIE Fellow Babak Shadgan to experiment with optics

Babak Shadgan, an assistant professor at the University of British Columbia's Department of Orthopaedics, has had a long-standing relationship with SPIE, including presenting his work and research at SPIE conferences since 2008. In 2010, he was the recipient of that year's D.J. Lovell Scholarship. Two year later, he placed second in the SPIE Startup Challenge's biophotonics division for his use of near-infrared spectroscopy to noninvasively diagnosis bladder dysfunction. And in 2021, he contributed to a special guest-editorial section for the Society's *Journal of Biomedical Optics*, Wearable, Implantable, Mobile, and Remote Biomedical Optics and Photonics. "SPIE had a very primary impact on my career," he says. "I initially discovered optics through my early engagement with SPIE as a PhD student, attending Photonics West every year. There, I had the opportunity to dive into lots of interesting ideas, talking to knowledgeable people; it was always a good time for me to engage in discussion with the best optics and photonics scientists in the world."

Shadgan also recognized a niche area that needed filling, founding the *Biophotonics in Exercise Science, Sports Medicine, Health Monitoring Technologies, and Wearables* conference at Photonics West's BiOS in 2019. This year, the conference, co-chaired by Shadgan and the National Institute of Health's Amir H. Gandjbakhche, includes 31 presentations and runs on Saturday and Sunday.

Early in his career, Shadgan realized that he could use optics and photonics for better, less invasive methods of diagnosis and monitoring of organ and tissue function — "like the implantable sensor that I designed for monitoring spinal cord oxygenation, hemodynamics, and spinal cord injuries" — or the near-infrared spectroscopy (NIRS) sensor he's developed for monitoring reconstructive surgical grafts: "I was able to get involved in all these areas after getting introduced to SPIE." And, for the past two decades, the SPIE Fellow has been taking his expertise in the areas of clinical biophotonics, optical diagnostics, implantable biosensors, musculoskeletal medicine, and muscle biophysics to the Olympics. In 2024, Shadgan, who has been the medical director of Olympic wrestling competitions since the 2004 Athens Olympic Games, celebrated his sixth Olympics in that role, using his extensive knowledge to minimize athletic injuries. At the same time, he has leveraged his Olympic presence to test new technologies, using optics to explore and assess the physical abilities of Olympic wrestlers.

Shadgan tested his first wearable wireless NIRS sensor on a group of athletes at the Beijing Olympic Games in 2008, used advanced IR imaging to evaluate Achilles tendinitis in an Olympic wrestler at the 2012 London Games, and applied a non-contact IR thermometer to screen athletes for the Zika virus at the 2016 Rio Games. This year, at the Paris Olympics, Shadgan tested a novel NIRS-EMG (electromyography) wearable sensor developed in his research lab — International Collaboration on Repair Discoveries' Implantable Biosensing Laboratory — to evaluate muscle and metabolic activity.

Shadgan, sixth from left, with his 2024 Olympic wrestling medical team. Credit: Babak Shadgan.

"The fields of sports and exercise sciences are ripe for innovative applications of optics and biophotonic techniques — they offer us exciting opportunities for research and development," says Shadgan. "Right now, in our lab, we are working on a wearable sensor that is basically a combination of NIRS and EMG sensors. It's a compact wireless device, very wearable, that allows you to observe the electrical activity of the exercising muscle while recording the metabolic fitness of the muscle." In these tests, Shadgan was particularly interested in discerning the difference between muscle activity and metabolism. "Integrating NIRS and EMG sensors can provide this information for you as an observer or reviewer of the data. We are working on a calculating method, trying to use this information, this device, to find lactate threshold points during exercise — like the point where the body starts to change its metabolism from aerobic to anaerobic."

SPIE Fellow Babak Shadgan at the Paris Games in 2024. Credit: Babak Shadgan.

For an athlete, he says, if you have the predictive ability to be able to tell when you are getting to that point in advance, you could strategize your training and your exercise to get your best performance: "When you pass that threshold point, the metabolic activity is different, and you have a limited time before the lactic threshold hits, starts to accumulate, and reduces your performance."

Shadgan first proposed using optics technology on a wrestler's physique 20 years ago, when an athlete at the Athens Games had to drop out due to progressive leg pain resulting from chronic exertional compartment syndrome (CECS). Shadgan discovered that CECS could be diagnosed noninvasively using a NIRS sensor, and he's applied optics solutions to his wrestling-focused work ever since, improving his devices alongside developments in optics and photonics technology.

"We've seen very good progress in the technology, especially in the electro-optical components that we use in our NIRS devices," says Shadgan. "The first NIRS system that I worked with was wired, and many still are. But by improving the components, especially the chips that we use, we have made sensors wireless as well as shrinking their size. Now they are truly wearable devices that can send data to a computer or a smartphone or a smartwatch. Developing the NIRS-EMG miniaturized, wireless, multimodal system, that's been a major progression. We simply didn't have that platform, those technology opportunities, ten years ago."

Shadgan, who's been in the sports-medicine business for 25 years, sees plenty of potential in optics and photonics still to be fulfilled in exercise and in sports monitoring. "With NIRS, you can get noninvasive, real-time information of all areas critical in exercise science. Look at the Apple Watch, Fitbit, Garmin — they are all using optical components and sensors to provide lots of information for both recreational and professional athletes." Ultimately, says Shadgan, if we can integrate that optics and photonics technology, collecting data from the exercising muscle and the cardiovascular and cardio-respiratory system, with AI-based software that can provide predictive information during activity, "it would change the whole field of exercise science."

Based on that information, he explains, athletes could improve their athletic performance while preventing injury: "When you pass specific thresholds during exercise, especially from aerobic to anaerobic, you gradually get susceptible to injuries. And if you understand that you are getting close to that point, then you can reduce the risk."

That same approach could be a boon for non-athletes as well — post-trauma and post-treatment patients, for example: someone recovering from a cardiac attack and trying to get back to normal life would need to improve their body fitness. "To manage the best way to progress or how much intensity of exercise they can tolerate and gradually increase, you need a measurement, the relevant data, right?" says Shadgan. "The data from optics techniques like near-infrared spectroscopy can be the safest real physiological information that you can get."

And with his firm grasp on gathering that optics-generated data, once SPIE Photonics West has drawn to a close, Shadgan can look ahead to Los Angeles in 2028 and plan his next application of optics at the Olympics.

DANEET STEFFENS

Smart glasses and headset sales to grow again in 2025

At SPIE AR|VR|MR 2025, attendees will see how the industry is coming together to push the limits of XR technology in order to accommodate different and demanding consumer requirements.

Despite shipments for augmented, virtual, and mixed reality (AR, VR, MR, together referred to as XR) headsets seeing a slight decline in 2024, a host of different factors are expected to come together to drive a 25% compound annual growth rate over 2025, with more affordable products integrating AI in consumer-friendly designs.

A large part of why the XR industry is expected to return to growth in 2025 is clarity on the products consumers really want and how to simply convey what those products are. "AR, VR, MR are early acronyms that are not used much anymore," says Bernard Kress, Director of Google AR. "Today, two main product segments are emerging: smart glasses that you can buy at an eyewear shop, and XR headsets that you can buy at a consumer electronics shop."

This distinction is important. An XR headset is a consumer electronic device whose aesthetics are relatively unimportant and that is used for a limited amount of time for gaming, fitness, or entertainment, and then taken off. A pair of smart glasses are worn for prolonged periods, often all day, and are first and foremost a fashion item, then actual glasses that correct your vision, and finally a digital device, perhaps in the form of a personal assistant to help with everyday activities.

Attendees are all smiles at AR|VR|MR.
Credit:SPIE.

"When you buy a pair of glasses, you spend most of your time on choosing its design and a little bit of time deciding which lenses you want," emphasizes Google Program Development Lead Christophe Peroz. "Smart glasses have to be fashionable to be successful." Both XR headsets and smart glasses present unique challenges that the industry is making significant progress on solving.

Another important factor in the buoyant mood coming from the XR industry is the maturity of the AR hardware ecosystem. Even two years ago, the likes of Microsoft, Magic Leap, Google, Meta, and others had to develop their hardware internally, especially the key building

continued on page 10

AR|VR|MR 2025 continued from page 09

blocks for displays, imaging, and sensing; the three key functional system in any AR device.

Today, the global AR hardware ecosystem is at a point where companies looking to develop new products can leverage waveguides from one supplier, display engines from another, sensors from yet another, etc, and build their AR hardware through multiple service providers without investing hundreds of millions of dollars in internal clean rooms and research.

Of course, decent hardware is worth little if the platform running on it is not up to scratch. "Previously, people took parts of Android and tried to fit it in a pair of smart glasses — we didn't have a generic platform," reveals Kress. "Today, Apple provides VisionOS, a closed platform just for Apple products; Meta came up with the MetaHorizon OS platform, which is for Meta products but maybe beyond; Snap with SnapOS; and now Google has just announced Android XR, which is aimed at becoming the main platform for all smart glasses and XR headsets on the planet."

Running parallel, in the year when AI went mainstream, these tech behemoths have developed their own personal AI assistants that can be used in smart glasses. Personal AI assistants unlock a host of applications, says Kress, and developers are going to tap into the amazing potential of Google's Gemini Astra, Apple Intelligence, and Meta AI.

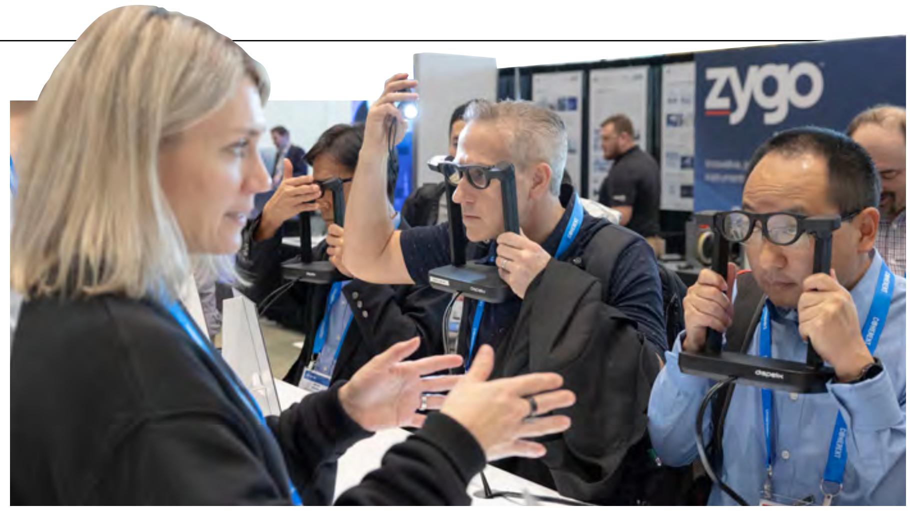
"I think we are having so many breakthroughs coming along, for example in quality AR displays and AI platforms, and the ecosystem is getting more and more mature," agrees Grace Lee, Mojo Vision VP of Display Product Management. "So, next year will be a very exciting year, and also a critical year in terms of launching new consumer products."

Given 2025's potential to be the breakout year for XR in the consumer market, attending this year's AR|VR|MR is essential for anyone interested in how we might all be living our lives 10, five, or even fewer years from now. Co-organized by Kress, Lee, and Peroz, and running parallel to SPIE Photonics West, AR|VR|MR is the largest AR hardware industry event on the planet.

The first day, 27 January, is dedicated to technical presentations predominantly from academia focused on advancing XR technologies. Chaired by prominent academics Hong Hua and Daniel Nikolov, and Meta's Naamah Argaman, these sessions are not to be missed — with many of the presentations showcasing new scientific breakthroughs that will be incorporated in future XR hardware, and many of the presenters likely to be the CEOs and trailblazers of tomorrow.

Flexibility: Today's AR hardware evolution allows developers to leverage waveguides from one supplier, display engines from another, and sensors from yet another. Credit SPIE.

To encourage this type of entrepreneurial spirit, AR|VR|MR hosts the Optical Design Challenge, a competition exclusively open to students and intended to stretch them to solve real-world design challenges in the XR industry. "We don't ask them to write a paper like regular SPIE authors; they pitch an idea in front of a jury of industrialists," explains Kress.



Out of sight: In Moscone West, attendees can try out cutting-edge headsets and smart glasses. Credit: SPIE.

"We want to take them a little bit out of their very cushy academic world, so they have three minutes to pitch, much like you would pitch an idea in front of a VC." Previous winners include Stan Larroque who founded successful French XR company Lynx, and appeared in Forbes Europe Technology 30 under 30 last year. "This competition gave him the self-confidence to actually go and build his own company, raise his own money, and develop his own product in the field of AR," adds Kress.

The other two-thirds of the conference on 28-29 January brings the major players in XR center stage, and focuses on the breakthroughs, challenges, and opportunities for today's industry. A particular highlight will be the four keynote presentations. Google's Hugo Swart, Head of AR Partnerships, will talk about Google Android XR. Jason Hartlove, VP and Head of AR Hardware from Meta, will describe developments in the company's Ray-Ban Stories smart glasses and Orion smart glasses, and the roadmap to smaller, lighter, and cheaper display smart glasses. The third keynote is from Snap's Kenny Kubala, Head of AR Hardware, outlining the capabilities of their Snap Spectacles. And finally, XREAL CEO Chi Xu will talk about how they were able to gain the largest market share in display smart glasses.

Also important are presentations and networking events focusing on women in optics in both the AR|VR|MR program and the larger Photonics West event. "We have been working to build the women in optics network, with women from all different kinds of industry, big companies, small companies, from universities, etc," explains Lee. With panel discussion and various events organized, it is hoped that the global network of women making waves in XR will be bolstered at AR|VR|MR and Photonics West 2025. By facilitating connections, education, and support for women and allies in XR and optics generally, these events will amplify the voices of the women playing a crucial role in shaping a more inclusive and diverse future for XR technology.

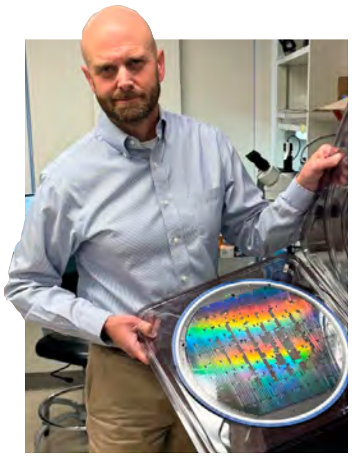
As ever, complementing the talks and networking opportunities will be a host of other events and features. This includes stalwarts such as the dedicated AR|VR|MR headset museum, as well as the ever-busy Job Fair. This year's conference will host the largest exhibition to date — increasing from ~60 exhibitors last year to around 80 exhibitors this year. Attendees can sample for themselves the most cutting-edge headsets, smart glasses, and components from companies around the world.

BEN SKUSE

Winners of the 2024 Optical Design Challenge pose with event sponsors. Credit: SPIE.

BiOS Hot Topics Panel charts the diverse futures of photonics

Show Daily interviews co-chairs and some of the key presenters speaking at this year's sessions on their specializations, achievements, and future plans.



Left: Vivek Srinivasan. Credit: NYU Grossman School of Medicine.

Below: Ben Miller. Credit: University of Rochester Medical Center.

The BiOS Hot Topics session provides a snapshot of the state-of-the-art of the field of biomedical optics, and highlights significant recent developments, says co-chair Sergio Fantini. The session features a mix of technology development, in vivo and in vitro applications, studies at microscopic, mesoscopic, and macroscopic scales, and a variety of targeted biological information, all with the goal of advancing biomedical research and procedures. The speakers of the 2025 BiOS Hot Topics sessions will cover a broad range of techniques and applications of biophotonics.

Show Daily also asked for comments on each Hot Topics talk from the two co-chairs of the Hot Topics session, Paola Taroni an engineer and physicist at the Politecnico di Milano in Italy; and Sergio Fantini, professor of biomedical engineering at Tufts University in Massachusetts.

Vivek Srinivasan, NYU Grossman School of Medicine: Monitoring brain blood flow, in real time

New technology for monitoring functions of the normal brain and brain diseases is the focus of Srinivasan's talk. "In a neuro-ICU, the doctor wants to know and maintain the optimum brain blood flow for patients, and there is no way of monitoring that in real time," said Srinivasan, an associate professor in ophthalmology and radiology at the NYU Grossman School of Medicine. Working at the neuro-ICU of NYU Langone Hospital, located on NYU's campus in Brooklyn, he has developed a novel light-based brain monitoring technology that can also be applied to brain imaging.

"It can work to monitor the brain locally, or give a larger image of a part of the head. We have built the technology in our lab, and the validation has gone as expected." His team is looking to commercialize this approach over the next year or two. Currently the only prototypes are for lab research at NYU and cooperating institutions including the University of Pennsylvania and the University of California Davis.

Instead of a costly single photon system, Srinivasan's technology can make use of a standard CMOS array detector. "It lets us get even better measurements, with many pixels," he added. Interest at Photonics West should be high, he said, since a number of other institutions have adopted this approach to measuring brain blood flow, and that will be a topic in some dozen talks at Photonics West.

Taroni said of Vivek Srinivasan's topic: "Over the years, the field of diffuse optics has provided a rich set of tools to investigate the human brain non-invasively. Interferometric detection is a recent methodological development in this field. The approach benefits from the use of inexpensive detectors and is especially promising for the measurement of signals related to blood flow.

Fantini commented, "Diffuse optical methods allow non-invasive measurements of tissue to depths of the order of

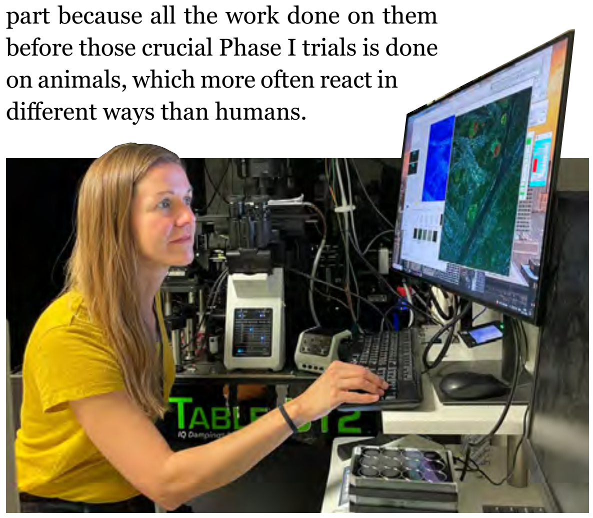
continued on page 12

BiOS Hot Topics continued from page 11

centimeters. Srinivasan's research has led to the development of an interferometric approach to diffuse optics that can significantly advance some key aspects of this technique. Srinivasan's talk will present a major recent development in the field of diffuse optics.

Ben Miller, University of Rochester Medical Center: See the whole movie — continuous real-time monitoring of microphysiological systems with photonic sensors

Tissue chips, a platform, sometimes described as an "organ on a chip" or "microphysiological systems," are microfluidic cell-culture devices designed to mimic the complex structure and multiple cell types of a human organ system. It is a field that is growing rapidly, for several reasons. A big part of the motivation here is to incorporate tissue chips into the drug development process as an alternative to animal testing. Currently, around 85-90% of candidate drugs fail on entering Phase I human clinical trials. This is at least in part because all the work done on them before those crucial Phase I trials is done on animals, which more often react in different ways than humans.



Kate Grieve. Credit: Vision Institute, Paris.

Governments have recognized the need for and promise of these systems: in late 2022, the U. S. Congress passed the "FDA Modernization Act 2.0", which allows the FDA to consider data from tissue chips in place of animal testing.

How does it work? Says Miller, "The key thing that we've been doing that's unique is integrating photonic sensors into tissue chips. This allows us to monitor molecules produced by the chip continuously and in real time over a period of hours to days — and eventually weeks. This is something you can't do in an animal, let alone a human, with any reasonable time resolution.

Among those who will find this talk most interesting for their work would be anyone interested in photonic sensors, spectroscopy, drug development, tissue engineering, or microscopy. As for applications for labs or industry circles, drug development is certainly the most widely recognized application for these devices, but there are other possibilities in basic biology and personalized medicine.

Taroni's take on Miller's talk: "Tissue chips aim at mimicking human physiology, improving upon animal models in terms of reproducibility at a lower cost. They are typically analyzed at an endpoint, with no information provided on the processes that have led to that endpoint. Adding photonic sensors to the chips allows monitoring the chip evolution in real time."

Fantini added, "Miller's research adds a new dimension to the value of tissue chip systems by incorporating photonic biosensors for real-time and label-free monitoring of target analytes. This presentation demonstrates the wide range of contributions of biophotonics techniques to biomedical research and their value in advancing it.

Kate Grieve, Vision Institute, Paris: How OCT can track retinal disease

The development of label-free live imaging techniques goes hand in hand with advances in personalized medicine, says Kate Grieve, the research director at the Vision Institute in Paris. "With the increasing use of organoids, which are miniaturized versions of human organs grown in the lab, used to test treatments directly on samples derived from the patient's own stem cells, new imaging tools are required to follow these 3-D structures in 3-D in a non-invasive way," she said.

In standard OCT imaging, the contrast in the image is related to the static scattering properties of tissue structures. "In dynamic OCT, on the other hand, we use microscopic fluctuations of organelles such as mitochondria within cells to create contrast which is related to the dynamic scattering within the tissue," Grieve explained.

"These dynamic fluctuations are linked to the cell metabolism and therefore our images carry a contrast which quantifies the cell behavior. We represent our images in a color scale where hot, bright colors show high, fast cell activity, and cold, dull colors show weak, slow activity. We can also probe the sample and witness the effects, for example by stimulating retinal samples with light, or by applying drugs to cell cultures, while recording their response."

"Research labs are using our technology for live follow up of their in vitro samples in applications such as organoid growth, drug testing, and disease modeling," Grieve said. "The pharmaceutical industry has shown interest in our

Daniel Elson. Credit: Imperial College London.

technology, particularly for cell and gene therapy development where our imaging could provide quality control to check that cell therapy products are alive and healthy prior to graft in a patient's body."

Grieve added, "To make our technology available to others, members of my team specialized in optics, biology, and data science have recently founded a startup named Lutèce Dynamics with the support of the Paris Vision Institute. Thanks to funding from the European Research Council, we have designed a module that can be attached to any commercial microscope, as well as software enabling automatic data analysis via AI to extract metrics for interpretation. We hope to launch a first product in 2025."

Taroni commented, "Dynamic full-field optical coherence tomography is applied to investigate the retinal pigment epithelium at the cell level. This layer is affected in degenerative diseases, such as age-related macular degeneration, one of the leading causes of blindness in developed countries, affecting 170 million people worldwide. The proposed technique can help clarify the mechanisms underlying the late stage of dry AMD and open the way for new treatments.

Fantini said, "Grieve, who is an expert in both OCT and adaptive optics technology for retinal imaging, will discuss her research in high resolution ocular imaging. In particular, dynamic full-field OCT is a powerful tool for label-free optical imaging of cellular and subcellular features of retinal tissue."

Daniel Elson, Imperial College London: Sensing the surgical field, enabled by vision and robotics

Surgical sensing and imaging techniques bring biophotonics concepts into the operating theatre to help to guide surgeons to make better decisions, says Daniel Elson, who is a Professor of Surgical Imaging and Biophotonics in the Hamlyn Centre for Robotic Surgery, Institute of Global Health Innovation and Department of Surgery and Cancer at St. Mary's Hospital, London. While operating theatres adapt to more advanced surgical techniques, such as less invasive surgeries, the use of robotics, and the integration of additional data sources, it is important to ensure that optical methods are compatible with these approaches.

"Therefore my laboratory is applying optical spectroscopy methods alongside imaging, computer vision and robotics to help to improve the ergonomics and usability of these devices," Elson said. This includes the use of multispectral and polarization-resolved imaging and diffuse and fluorescence spectroscopy to contrast healthy and cancerous tissues.

Taroni on Elson's talk: "Sensing of the surgical field, enabled by vision and robotics accurate tracking of tissues and instruments, is crucial for robotic-assisted surgery, as it enables the robot to better interpret the surgical scene, identifying precise locations and interactions of tissues and tools. Extensive work was done to achieve improved surgical tracking, which in turn can lead to safer and more efficient surgery in many real conditions."

Fantini added, "One of the broad objectives of biophotonics is to make a difference in the clinical practice and help improve human health. Elson's talk demonstrates the variety of roles that photonic technologies can have in the context of surgery, endoscopy and theranostics.

Michalina Gora, Wyss Center for Bio and Neuroengineering, Geneva: Shining light on gut feelings

The digestive tract is controlled by an

continued on page 16

Michalina Gora. Credit: Wyss Center, Geneva.


CoolLED
OEM Illumination
LED Illumination
Custom solid-state illumination for automated applications
Need Something Different?
Proven CoolLED technology, customised to suit your application
Automated Fluorescence
Semiconductor / Metrology
Machine Vision
Spatial Biology / Profiling
Spectroscopy
Quality Control & Inspection
High Content Screening
Visit us at SPIE BiOS - Booth #8208
Visit us at SPIE Photonics West - Kiosk #415
www.oemillumination.com


CHROMA®
89 NORTH®
Optical Filters from UV to MWIR
Employee-Owned with Offices Worldwide
Expert Engineering and Application support
Build-to-Print, Prototype to Volume, and Catalog Filters
Filter Sub-Assemblies in Collaboration with 89 North
Visit us at:
Photonics West - Booth #3425
AR | VR | MR - Booth #6402
chroma.com


elementsix™
DE BEERS GROUP
Advanced semiconductor and thermal management solutions for key stages of the semiconductor and consumer electronics value chains
Cu-diamond - a high-performance copper-diamond composite for demanding thermal management applications
Optics solutions for photonics and next-generation technologies
DNV™ Series - perfectly imperfect diamonds, uniquely designed for quantum applications, and ELSC™ Series - electronic grade diamond for detector and quantum technologies
e6.com | e6cvd.com

When a femtosecond just isn't fast enough

Paul Corkum's plasma physics lights up electrons in attoseconds. It's handy in terahertz science too.

If another sign were needed of the quality of Photonics West plenary speakers, just a month before this week's presentation by Prof. Paul Corkum, the University of Ottawa attosecond science pioneer was awarded the American Physical Society's 2025 APS Medal for Exceptional Achievement in Research.

The theories he postulated over a quarter of a century ago about how to reveal unimaginably quick "attoseconds" in action by using laser pulses would eventually help three scientists share the Nobel Prize in Physics 2023 for their experimental work. An attosecond, in case you need reminding, is the fastest pulse ever observed by humankind. It makes a femtosecond look turtle-like.

"An attosecond is so short that the number of them in one second is the same as the number of seconds that have elapsed since the universe came into existence, 13.8 billion years ago," the Nobel Foundation explained.

The raw numbers: an attosecond is a billionth of a billionth of a second, leaving the femtosecond's millionth of a billionth of a second in the dust. That's life in the fast lane for Corkum, for whom speed is also of great consequence in the comparatively slower business of terahertz science, in which Corkum imagines applying terahertz speeds to applications that today operate nowhere near that quickly, such as computer memory. Speed is relative.

First things first though. As Corkum will highlight in Monday's plenary *A plasma perspective on attosecond and terahertz science*, none of his speed work, including his Nobel-inducing attosecond insights, would be possible without his fondness for plasma physics.

Generally speaking, plasma physics works in the realm of ionized gases — otherwise known as plasma. By comparison, atomic physics works with atoms. The two are related, but different. It was Corkum's decision back in the late 1980s to hone in on a plasma approach that underpinned his theory on how to pulse light at the rate of attoseconds — a mind blowing fast rate that had never been achieved but which would eventually break the femtosecond barrier.

"I ventured into this long history of atomic physics, but I had a different way of looking at it," Corkum recalls. "I began thinking of it not as an atomic physicist, but as a plasma physicist. From that different way of looking at it I developed my perspective on how to make attosecond pulses, how to measure attosecond pulses, what you can do with the attosecond pulses — all of that."

Corkum was at the time working at the National Research Council of Canada, the national government's Ottawa-based science and technology group, to which he is still strongly affiliated while now working as Full Professor of Physics and Distinguished Research Chair of Attosecond Science at the University of Ottawa.

Professor Paul Corkum in the Joint Attosecond Science Laboratory. Credit: © National Research Council Canada / Conseil National de Recherches Canada.

By 1994, he, along with co-authors, penned his seminal paper, *Plasma perspective on strong field multiphoton ionization*, published in the American Physical Society's Physical Review Letters. Simply put, the paper advanced the notion that laser light in a plasma affects electrons, causing them to exit and then return to their atom, and thus creating bursts of radiation. This all happens in the realm of what would become detectable, measurable attoseconds.

"I began understanding the characteristics of the bursts of radiation, and in fact how to measure it," Corkum says. "All of these things I proposed."

Over the next seven years or so, at least two physicists would indeed apply Corkum's theory, capturing attoseconds in action, in different experiments. By 2023, the Royal Swedish Academy of Sciences honored those physicists by jointly awarding the Nobel Prize in Physics to them and to a third physicist "for experimental methods that generate attosecond pulses of light for the study of electron dynamics in matter."

One recipient, Pierre Agostini of The Ohio State University in Columbus, Ohio, in 2001 "succeeded in producing and investigating a series of consecutive light pulses, in which each pulse lasted just 250 attoseconds," the Royal Swedish Academy stated. At around the same time, Ferenc Krausz of the Max Planck Institute of Quantum Optics in Garching, Germany and of the Ludwig-Maximilians-Universität in Munich, "was working with another type of experiment, one that made it possible to isolate a single light pulse that lasted 650 attoseconds," it noted.

Earlier, in 1987, Anne L'Huillier, now of Lund University in Sweden, had "discovered that many different overtones of light arose when she transmitted infrared laser light through a noble gas," the Nobel bestowers said. "Each overtone is a light wave with a given number of cycles for each cycle in the laser light. They are caused by the laser light interacting with atoms in the gas; it gives some electrons extra energy that is then emitted as light."

L'Huillier's work pre-dated Corkum's paper, but the work of all three of the Nobel scientists over the years has been influenced by the plasma approach long advocated by Corkum. The state of the art has now advanced to around 40 attoseconds.

The applications could be profound, with the Royal Swedish Academy seeing great potential in material science and in medical diagnostics.

"We can now open the door to the world of electrons," said Eva Olsson, chair of the Nobel Committee for Physics.

"Now that the attosecond world has become accessible, these short bursts of light can be used to study the movements of electrons," the Academy wrote in announcing the winners. "Attosecond pulses make it possible to measure the time it takes for an electron to be tugged away from an atom, and to examine how the time this takes depends on how tightly the electron is bound to the atom's nucleus."

Corkum sees possibilities for using attoseconds to study how materials fail, and thus to make tremendous advances in material science. "I think this will be a powerful diagnostic for materials," he notes, adding that it could also reveal how an atom's inner electrons behave — something that is not a nearly well understood as outer "valence" electrons.

Meanwhile, in another main area of interest for him, terahertz science, the main application in his vision could be to get magnets to switch on and off at terahertz speed, which could then lead to huge increases in computer memory speed.

Again, for the numbers-minded: terahertz is a measure of frequency that, when converted to seconds, is a picosecond. A picosecond is a millionth of a millionth of a second. It's a far cry from an attosecond or even from a femtosecond, but it would be a dizzying result when it comes to switching magnets on and off.

"Memory is one of the slower things in computers, and it's hard to speed it up right now," says Corkum. Lasers and plasma might help reveal how to solve that problem.

In exploring this potential, Corkum is, as with attoseconds, taking a plasma approach. His plenary will thus serve as a paean to plasma physics. And to plasma's interaction with lasers.

"The unifying theme is that we control electrons with ordinary lasers, and those electrons then create either the attosecond pulse or the terahertz radiation," Corkum says. "I hope to unify them by saying we can control matter with strong laser fields or with laser fields we can control. We can therefore create these pulses under our control."

Like with any job, good preparation is extremely helpful. Top tip: before attempting any attosecond or terahertz experiment with lasers, be sure to have plenty of plasma on hand.

MARK HALPER

BiOS Hot Topics continued from page 13

extensive network of neurons known as the enteric nervous system (ENS) comprising more than half a billion neurons. Nerve fibers transmit physiological signals from the gut to the brain thus forming the gut-brain axis pathway. This communication is known to affect mood, appetite, and memory.

Taroni commented, "Michalina Gora is exploring the frontiers of the gut-brain connection toward novel approaches for the diagnosis and treatment of brain disorders that are becoming increasingly widespread with increases in life expectancy, Parkinson's disease, dementia and depression."

Fantini's take on Gora's talk: "An exciting application of optical coherence tomography to develop an optogenetic endomicroscope for investigating the connection between the gut and the brain certainly qualifies as a Hot Topics talk. Gora's research explores the close link between the gut microbiota and the brain, which accounts for an important connection between brain function and gut health. This research can have significant implications toward advancing our understanding of neurodegenerative disorders."

Seemantini Nadkarni, Wellman Center for Photomedicine, Harvard Medical School: Investigating tissue mechanopathology with speckle techniques

Nadkarni is an Associate Professor of Dermatology at Harvard Medical School, and directs her laboratory at the Wellman Center for Photomedicine at Massachusetts General Hospital. She received her PhD in Medical Biophysics from the University of Western Ontario, Canada. Her talk will address optical techniques for the characterization of mechanical properties of tissue provide insight into pathological transformation of tissue. Fantini commented, "Nadkarni will present a novel optical technique based on wideband speckle spectroscopy for measurements of the dynamic viscoelastic behavior of tissue to characterize its mechanical properties associated with intracellular processes at microstructural levels. This contribution to the session is another example of biophotonics technologies that advance research capabilities and have diagnostic and prognostic potential for a variety of diseases."

Taroni's take on Nadkarni's talk: "Mechanical factors are key elements in disease pathogenesis. There is an important frequency range, between kilohertz and megahertz, where the mechanical behavior of whole tissue remains largely unknown. The proposed technique, recently published in *Science Advances*, works in that range and has the potential to reveal previously unidentified sources of micromechanical contrast leading to improved disease prognostication."

Prof. Frédéric Leblond of Polytechnique Montréal. Credit: PMTU.

Frédéric Leblond, Polytechnique Montréal: Saliva to surgery: diagnostics for viruses and cancer

Frédéric Leblond is a full professor in the Department of Engineering Physics at Polytechnique Montréal, where he heads the LumedLab. He works mainly in biophotonics (including diffuse optical tomography), designing new surgical methods, enhancing medical imaging, and studying light propagation in biological tissues. A major part of Prof. Leblond's work is in perfecting of powerful optical needle biopsy instruments. A prototype that relies on interstitial optical tomography can guide surgeons by detecting blood vessels during procedures. The primary goal is to improve safety and effectiveness when examining tumours in the brain. The better physicians can understand a tumour by collecting as superior sample, the greater the odds of successful treatment.

Fantini's take on Leblond's talk: Every year, the Hot Topics session includes a "*Journal of Biomedical Optics (JBO)* talk" that is delivered by the senior author of the most cited original science JBO article in the previous two years. This speaker is nominated by the Editor-in-Chief of JBO, Brian Pogue. This year's JBO talk will be given by Frédéric Leblond, who will report on his work on the development of a Raman spectroscopy probe for real-time discrimination of cancerous and healthy cells, and an open-source software package for the analysis of Raman spectroscopy data.

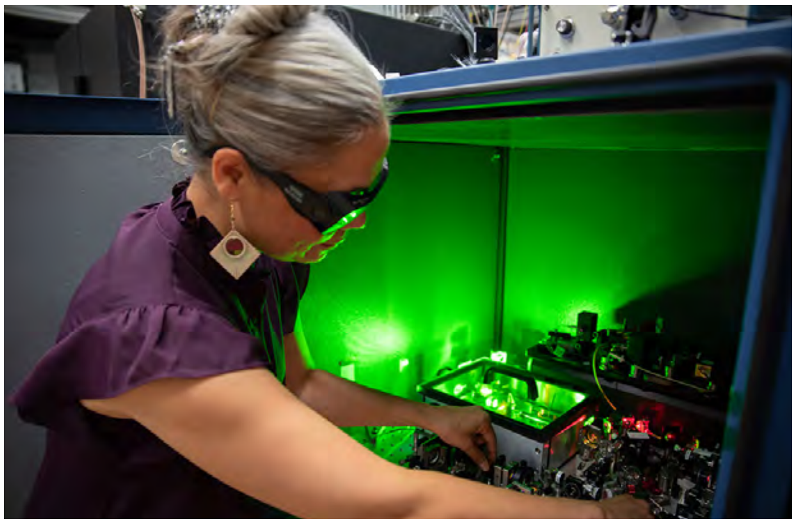
FORD BURKHART

Ticking with atomic accuracy

NIST researcher Tara Fortier discusses the science and impact of atomic clocks.

“Atomic clocks are at the heart of global timing, keeping the world synchronized and on time,” explains Tara Fortier of NIST. “Beyond timing, the exceptional performance of today’s best atomic clocks has relied on well-established techniques in AMO [Atomic, Molecular and Optical Physics] such as magneto-optical traps, laser cooling, and high-stability laser systems. At the same time, the drive to further improve clock performance is advancing new technologies, including optical frequency combs, waveguide-based wavelength conversion, compact high-performance optical references, and quantum logic.”

Fortier adds that the transition frequencies in atomic clocks are rooted in physical laws, making atomic clocks highly sensitive to external physical fields. This sensitivity enables their use as high-resolution quantum field sensors. Furthermore, enhanced measurement techniques for comparing frequencies across different atomic transitions open the door to testing and expand our current understanding of physics. Such tests include searching for dark matter, looking for violations of Local Position Invariance and testing General Relativity.



NIST researcher Tara Fortier aligns optics to maximize the signal coming from an optical clock. The signal is measured by a frequency comb. Credit: R. Wilson/NIST.

Fortier is project leader in the Time and Frequency Division at NIST, where she leads a research group focused on developing optical frequency combs for precision measurement of atomic clocks. “Our lab sits at the intersection of fundamental and applied research,” says Fortier. “We’re advancing the optical infrastructure needed for the future redefinition of the SI second in terms of optical atomic time.”

On 27 January, at SPIE Photonics West, Fortier will offer a forward-facing perspective on the evolution of atomic clocks, their enabling technologies, and developing applications. Her presentation, “Optical atomic clocks: Refining the definition of time and advancing the future of metrology,” will explore the optical technology at the heart of atomic clocks and how these enabling technologies will help serve to advance the field of precision metrology.

Still ticking after 75+ years

Many of us learned to count “one, 1,000” or “two, Mississippi” in school as a way to mark time, but defining the second with atoms is much more complex. For centuries, the best timekeepers were pendulum clocks, which kept time with a weight attached to a rod or string that swung back and forth in a regular, predictable motion. The time it took for the pendulum to complete one full swing back and forth was called a “period.” This period depended on the length of the pendulum and the force of gravity. First developed in the late 1600s by Christiaan Huygens, most pendulum clocks lost about 15 seconds per day.

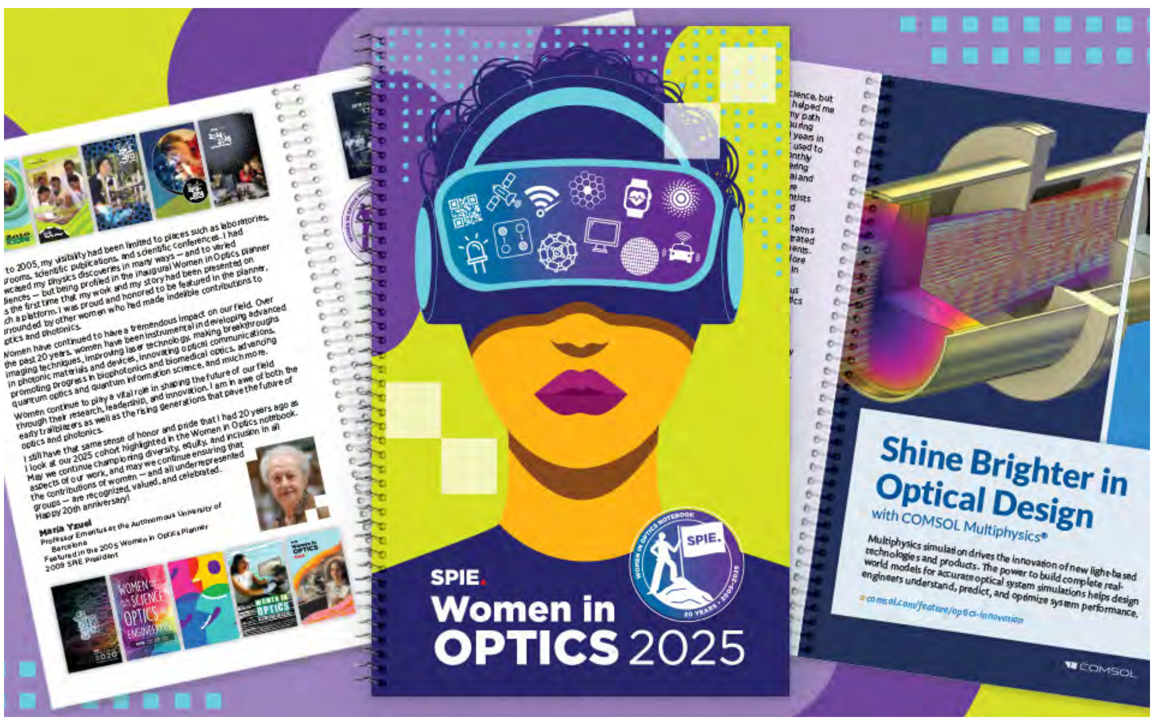
In 1949, the first working cesium-beam atomic clock was developed by NIST’s predecessor, the National Bureau of Standards (NBS), which allowed for unprecedented accuracy. Cesium-based clocks became

continued on page 19

SPIE celebrates 20 years of its Women in Optics notebook

A special one-day event, held during SPIE Photonics West 2025, will mark two decades of the Society's empowering publication.

Since 2005, SPIE has showcased more than 500 researchers, academics, engineers, and industry leaders through its SPIE Women in Optics planner and notebook. In this annual publication, an extensive range of professional women's career arcs and personal stories have shone a focused and inspiring light on the myriad number of optics and photonics opportunities as well as raising the visibility of the featured individuals. Since its inception and its highlighting of female scientists who are making a difference through their work and other contributions to the fields of science, optics, and engineering, the SPIE Women in Optics notebook has proved to be valuable resource for young women and other underrepresented individuals interested in entering STEM-related fields.



Now, on the occasion of the publication's 20th anniversary, SPIE will celebrate the two-decade milestone with a one-day event held on 26 January during Photonics West. The gathering will feature panels and presentations from optics and photonics luminaries who have all been showcased in the notebook, from Nu Quantum's Simone Eizagirre Barker and Johns Hopkins University's Muyinatu Bell, to Castor Optics' Caroline Boudoux and Monroe Community College's Alexis Vogt.

"We've had 20 years of celebrating women in optics, and diversity in optics more broadly across SPIE," notes Jess Wade, a Royal Society University Research Fellow and lecturer in functional materials at Imperial College London, chair of the SPIE Equity, Diversity, and Inclusion Committee, and organizer of the event. "We've recently re-visited the way we celebrate them, through recognizing people's science, thinking about how we can transform research culture, and thinking what we can do to better support students from historically underrepresented groups. Through the online activity during the pandemic, through the fantastic conference offerings that SPIE has come up with — like the lunch-and-learn sessions and our new and extended networking opportunities — we've got some fantastic leaders with great visions that we really want to share with the wider optics and photonics and STEM community. I think this is just a beautiful opportunity to bring all of those people together to say thank you for everything that you've done and to learn from their professional insights."

It's also an opportunity, she adds, to ask: *What do we do next to really shift the needle on the representation of women in optics?*

This particular event should offer some answers: Its participants are steeped in both technological success stories as well as their impactful work in mentorship and outreach; while all of them represent instrumental pioneering aspects of their respective fields, they are also known for their support of other women and their work in proactively incorporating diversity and inclusivity into the optics and photonics ecosystem.

Speaker topics and panels will cover a diverse slate of discussion topics including Career Path from Bench to the C-Suite, Imposter Phenomenon and Resilience, Creating Inclusive Work Environments, Too Few Women Authors, and Establishing a Personal Brand. It's a robust range of career-related advice, from how to build a company and hire people, to the challenges and rewards of navigating a STEM-focused ecosystem, whether that might be in academia, government, or industry.

"These topics all came from discussions with our community's scientists and suggestions we'd have from audience members during conference sessions," Wade points out. "So it's a program built by the community and built by the speakers, with a strong representation across academia, industry, and policy. It's fantastic to see this kind of energy from people, from lecturers and early-career professionals up through to senior-ranking policymakers and civil servants."

This focused event, she affirms, will offer something for everyone: "It's a celebration of all of the fantastic people who work in this great community, and we want everyone to come to learn from them and to be part of it. It's open to everyone, and we'd love to welcome early-career people so that they can learn from their peers as well as from these living legends."

"The SPIE Women in Optics notebook has spotlighted many outstanding women in optics and photonics, showcasing their achievements and contributions while also providing invaluable role models for future generations," says Ursula Keller, ETH Zurich professor of physics, who was featured in the 2011 edition. "As we celebrate two decades of recognizing these inspiring women and welcoming early-career professionals, I look forward to a day of rich discussions and honoring the ongoing impact of women in science."

"I discovered the Women in Optics planner in 2010 at my first SPIE meeting in San Francisco, and I loved it instantly," says Sona Hosseini, a research and instrument scientist in the Planetary Science Section of the California Institute of Technology's Jet Propulsion Laboratory, who was included in the 2017 version. "The size and design were ideal for my busy schedule, keeping all my tasks and events organized, and even having space for jotting down ideas and reflections on the side. I'd look forward to reading about successful women scientists featured in it, imagining the challenges they must have faced and the persistence they needed to break through. I'd remind myself of the untold efforts behind their achievements, the grit it took to accomplish that one remarkable thing that earned them a spot on these pages. Their journeys inspired me to empower my own: Their brilliance and resilience fueled my ambitions and reminded me that there's no limit to what I could achieve. When I meet them at SPIE events, I always ask what they thought about their profile, and almost always get to hear more untold stories!"

The full-day program in January should provide plenty of opportunities for even more stories, a great reason to hold it during the week of Photonics West. "This is probably the biggest meeting of optics and photonics specialists in the world," notes Wade. "Holding this celebration at the beginning of the year — and at the beginning of the International Year of Quantum, no less — heralds the fact that there are lots of things about the coming year that are exciting and full of promise. Bringing together a sensational team of women, it's just too good an opportunity to miss. Yes, 20 years of the planner is obviously great, but, beyond that, we've actually got so much expertise and enthusiasm and energy! I say, let's unite it and see what we can accomplish together."

"Over the past two decades, our Women in Optics planner and notebook has been a wonderful way to highlight many of the amazing women in our field," says SPIE Chief Inclusion Officer and original creator of the publication Allison Romanyshyn. "Now we want to bring some of these pioneering women together to celebrate the continuing advancement of women in optics and photonics. We hope to inspire the next generation of leaders with an engaging and exciting day full of insights and dynamic interaction, a day built to enhance their future in this ever-evolving field."

DANEET STEFFENS

Atomic clock continued from page 17

the foundation for modern timekeeping systems, where one second is defined by the vibration frequency of cesium atoms.

As a result of NIST's success with atomic clock research and other developments in the field, the definition of the second was redefined in 1967 by the International System of Units to be based on the radiation frequency of the cesium-133 atom, solidifying atomic timekeeping's role in both science and daily life. Today's atomic clocks are so accurate that they can lose or gain less than one second in millions of years.

Living in exciting times

Considered a pioneer in the development of frequency combs, Fortier's work with ultrafast laser systems and techniques has broadly impacted optical science, laser physics, atomic physics, and related technologies. She began her research on the time domain side of ultrafast laser and science at JILA/University of Colorado, where she first connected with collaborators in the Time and Frequency Division at NIST. "Through those collaborations, I was drawn to the precision and order of metrology, which inspired me to pursue postdoctoral research focused on the frequency aspects of ultrafast physics," says Fortier. "Over my 20+ year career at NIST, I've worked closely with atomic physicists and precision metrologies, and I find great satisfaction in pushing the performance of optical systems to advance clock measurements and expand their applications and versatility."

For Fortier, recipient of the 2023 SPIE Harold E. Edgerton Award in High-Speed Optics, the most exciting aspects of time and frequency lie in pushing the state-of-the-art in atomic clock performance and their supporting optical technologies. Like high-energy physics experiments, atomic clock measurements enable researchers to broaden their observational scope of natural phenomena. "With advanced clock technology, we can subdivide optical cycles, allowing us to examine the laws of nature at the finest frequency scales," says Fortier. "In the near term, the most impactful advances will likely come from developing highly robust, engineered, and compact clock systems designed for deployment beyond the lab."

More recently, Fortier's group has been exploring the use of time and frequency techniques in quantum networking. Quantum networks rely on single photons for distributing entanglement and enabling quantum protocols. These protocols involve the detection and interaction of single photons events that require precise synchronization at the femtosecond level. Additionally, due to the high fidelity required in maintaining quantum states, factors like frequency and phase stability become critical, depending on the network architecture. Researchers at NIST have developed strong skills in disseminating optical time and frequency references with high fidelity.

Future of time technology and humanity

"Atomic clocks will continue advancing the frontier of timing precision, pushing timing resolution beyond the attosecond level," says Fortier. "These improvements will likely benefit fundamental research that demands the highest measurement accuracy."

As they evolve, atomic clocks will integrate quantum techniques for remote networking, enhanced noise reduction, and shorter measurement times to enable the highest performance. There have been several advances over the past few years: the first measurements using clocks based on nuclear transitions and clocks based on highly charged ions. Looking further ahead, atomic clocks could enable groundbreaking research in cosmology and fundamental physics by measuring time dilation across varying gravitational fields, deepening the understanding of space-time. This research could also pave the way for clocks to serve as highly sensitive sensors for dark matter and other exotic phenomena.

Not only is this research important to Fortier, but also important is who gets to do the research. "As we push the boundaries of technology, we must ensure that a diverse range of voices contributes to decisions about how these innovations will be used and shaped for the future," says Fortier.

At NIST, alongside dedicated colleagues, Fortier helped develop the institute's DEIA strategic plan and lead workshops on advocacy communication and conflict resolution. To strengthen the workforce, she works to highlight the importance of broadening participation in quantum technologies by drawing on all available talent. This effort involves expanding educational resources and opportunities, increasing internships, building a robust base of technicians, and creating an accessible brand around quantum technology and related career pathways.

"It's time to intensify our efforts in diversity, equity, and inclusion in STEM," says Fortier. "In 2016, I made a New Year's resolution to support women and minorities in physics and photonics, a commitment I continue to uphold. In light of the complex challenges facing society, we should ask not only how our work advances our field or solves technical problems, but also how it serves humanity and the planet as a whole."

KAREN THOMAS

Ophthalmic Technologies conference celebrates 35 years bringing together clinicians and engineers

Left: Arthur Ho. Credit: University of New South Wales.

Below: Daniel Hammer. Credit: University of New South Wales.

This year marks the 35th anniversary of the Ophthalmic Technologies Conference to be held 25 to 26 January at SPIE Photonics West. To celebrate, Chair Daniel X. Hammer of the U.S. Food and Drug Administration and Co-Chairs Yuankai (Kenny) Tao of Vanderbilt University and Derek Nankivil of Johnson & Johnson Vision Care, Inc. have included a special session, entitled "35th Anniversary of Ophthalmic Technologies" on 26th January.

Why celebrate the 35th Anniversary of the Ophthalmic Technologies Conference? "It felt like we have seen enough changes over the years to take a pause this year and sort of celebrate our conference," says Hammer. "I don't know if Ophthalmic Technologies was one of the first conferences at Photonics West, but it was close one of the first ones. We're one of the core clinical sessions that was introduced, and we've been going strong for 35 years."

Hammer points out that 2025 is also the 35th anniversary of the first paper published describing medical imaging technology, optical coherence tomography (OCT). The technology "has made its way into almost every field of medicine," he says, "but it started off in ophthalmology."

"I wanted to have a session that celebrated our conferences' involvement in the discovery and development of [a variety of] technologies like OCT, and then translating them to the clinic for the benefit of patients" Hammer continues. "So, we've invited a number of luminaries in our field to come talk at the session, including David Huang of the Casey Eye Institute, one of the primary inventors of OCT (with James Fujimoto of Massachusetts Institute of Technology).

Other presentations at the anniversary session will include a perspective on 35 years of technological innovations in ophthalmology led by Fabrice Manns of the University of Miami and a long-time Chair in previous years; adaptive optics for the eye, by Austin Roorda of the University of California, Berkeley; prosthetic vision in patients blinded by retinal degeneration by Daniel V. Palanker of Stanford University; and laser corneal surgery by Theo Seiler of IROC AG in Switzerland.

"We're looking at some of the history in terms of technologies that were developed," says Manns, in describing the decision to mark this particular anniversary. "I think 35 is a good number for that."

He notes that the first SPIE Ophthalmic Technologies conference was held in Los Angeles in 1991, chaired by Jean-Marie Parel of the Bascom Palmer Eye Institute at the University of Miami. It covered exciting emerging technologies including excimer laser beam delivery systems for corneal refractive surgery, laser Doppler interferometry to measure axial eye length and retinal thickness and the concept of electrode array for artificial vision. Each year since, Manns says, the conference has continued to showcase advances and new emerging ophthalmic technologies that had a transformative impact on clinical ophthalmology.

Manns says that many of the major technologies now commonly used in clinical ophthalmology including OCT, LASIK, wavefront technology, and more, were first

continued on page 22

SPARKing innovation and scientific joy

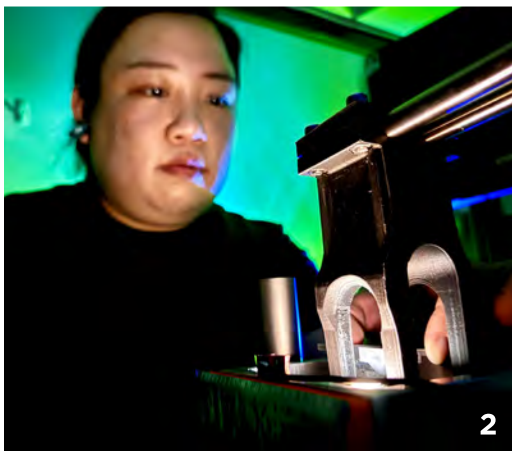
Four Berns-SPIE SPARK Grants, offered in partnership between SPIE and the Beckman Laser Institute, aim to have lasting impact in healthcare.

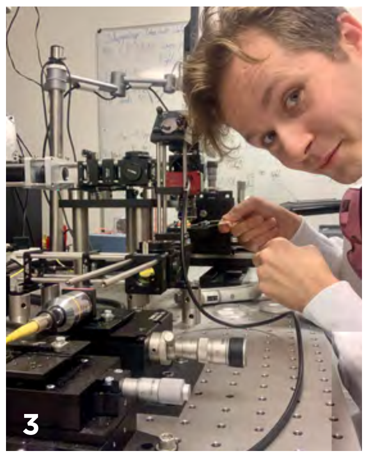
Thanks to the Berns-SPIE SPARK Grants, four research scientists — selected from a field of 65 applicants — will each receive a transformative $100,000 in order to further their innovative biomedical projects. In 2024, SPIE, the international society for optics and photonics, partnered with the Beckman Laser Institute (BLI) to generate and award these grants in order to provide support to young research scientists — either postdocs or faculty — who are using lasers and other optically based systems to study basic cell process or to develop technologies to diagnose and/or treat diseases in an innovative way that could have a major impact on the field of biophotonics.

These Berns-SPIE SPARK Grants represent geographical diversity, honoring recipients from four countries; they also reflect technical diversity, with distinct medical applications being targeted The grants will support the development and implementation of a novel platform for early-stage Alzheimer's diagnosis; an innovation to enhance success within the IVF cycle; a tool for early prediction and prevention of pelvic organ prolapse; and an improved method for diagnosing and monitoring Acute Respiratory Distress Syndrome.

Roman Zakoldaev, of the University of Tromsø-The Arctic University of Norway, is developing the ProMis platform. The project aims to develop a photonics biosensing platform for misfolded protein analysis, based on waveguide-enhanced Raman spectroscopy, to detect early biomarkers of Alzheimer's disease. Through its waveguide design, single-step fabrication, validation of nanomolar sensitivity, and time-resolved monitoring of protein aggregation, this work promises to result in a novel platform for early-stage Alzheimer's diagnosis.

"When, in the course of my research, I found that mesoporous materials make spectroscopic signals clear, I thought, 'Wow! Let's integrate photonics elements to improve their sensitivity,'" says Zakoldaev. "I want to push the boundaries of on-chip Raman spectroscopy and develop a relatively simple tool to study proteins. This tool, the ProMis platform, is the core of my project. The Berns-SPIE SPARK Grant provides crucial support, enabling me to develop this novel photonics biosensing platform for time-resolved analysis of proteins. Ultimately, this technology could revolutionize how we monitor protein misfolding, paving the way for earlier and more reliable Alzheimer's diagnoses."





Left to right, from top: (1) Eno Hysi working with a laser source for a previous project; (2) Cheow Yuen Tan placing a specialized chamber that holds embryo samples onto the light sheet microscope for imaging; (3) Roman Zakoldaev working on a custom-made Raman spectroscopy setup in his lab; (4) Isaac Pence in his lab, explaining his research and technology during an outreach tour for members of the community. Credits: Hysi: University of Toronto; Tan: Univesity of Adelaide; Zakoldaev: University of Tromsø-The Arctic University of Norway; Pence: University of Texas Southwestern Medical Center at Dallas.

At the University of Toronto in Canada, Eno Hysi is working on developing a project that focuses on photoacoustic imaging of lung injuries. His research addresses the critical challenge of diagnosing and monitoring Acute Respiratory Distress Syndrome (ARDS) in intensive care, a challenge to which Photoacoustic Imaging of Lung Injury (PILI) may offer a solution by offering real-time, non-invasive, and radiation-free assessment of lung injuries and providing insights into the structural and functional changes in ARDS. The project aims to establish PILI as a crucial tool for ICU diagnostics, potentially transforming the management of ARDS by enhancing early detection, treatment monitoring, and patient outcomes. "I am very grateful for the opportunity provided by the Berns-SPIE SPARK Grant," says Hysi. "Investigating photoacoustic imaging of lung injuries is a completely new area of research for my laboratory and the field in general, and seed funding such as this is extremely valuable for building a research program that can potentially have significant clinical impact." Hysi will be presenting on various aspects of his research at SPIE Photonics West on January 26 and 27.

At the University of Texas Southwestern Medical Center at Dallas in the United States, Isaac Pence and his team are developing a depth-sensitive side-viewing fiber optic probe for *in vivo* clinical assessment of pelvic organ prolapse (POP). Their research seeks to use a non-invasive optical tool based on Raman spectroscopy to track and treat POP. The goal of the project is to develop an optimized depth-sensitive side-viewing Raman spectroscopy probe that can examine the make-up and quality of pelvic floor tissue quickly and painlessly. This tool could be used during annual well-woman exams to help predict which women will develop POP and to help guide doctors on the best treatment for each patient, a process that, ideally, will also avoid having to perform costly, invasive, and often ineffective surgery.

"I am honored to have been selected as one of the recipients of the Berns-SPIE SPARK grant," says Pence, who will be presenting an invited paper at SPIE Photonics West. "This award will directly support the design and development of new optical-sensing hardware to improve measurement capabilities that can be directly translated to study patients in a medical setting. The support is exceptionally important for our collaborative investigation of pelvic organ prolapse which has long been understudied despite its enormous prevalence, healthcare burden, and impact to the quality of life for millions of women worldwide. The SPARK grant will help us to develop new, optimized tools to better understand this condition and evaluate new treatments with the goal to ultimately improve patient care for those affected and at risk."

Cheow Yuen (Tiffany) Tan, at University of Adelaide in Australia, is working on a novel multimodal system that will improve the success of clinical in vitro fertilization (IVF). Her research focuses on improving the chance of a baby being born following IVF by accurately and objectively diagnosing embryo quality with the first-ever multimodal microscope capable of simultaneously capturing both molecular and morphological information in a single instrument. This safe diagnostic process of embryo quality will ultimately improve IVF success, and utilization of this new instrument could have implications that extend beyond IVF to other fields of research and medicine.

"The Berns-SPARK grant will significantly accelerate the development of our cutting-edge optical imaging technology, allowing us to push the boundaries of reproductive biology," notes Tan. "With the support from this unique funding, we can refine our multimodal microscope system to distinguish embryo quality and move one step closer to practical applications in IVF clinics. As a recipient of this prestigious grant, I am excited about the potential for our work to create a legacy in the field of biophotonics, paving the way towards developing a safe and accurate diagnostic for embryo quality, and ultimately improving IVF success."

"The variety of projects and proposals we saw across the Berns-SPIE SPARK

continued on page 22

Ophthalmic continued from page 20

presented in their early stages at the SPIE Ophthalmic Technologies conference.

This year's keynote address, "Structural and functional biomarkers for glaucoma neuroprotection trials," will be presented by Jeffrey L. Goldbert of Stanford U. Glaucoma is a common neurodegenerative disease associated with progressive axon degeneration and cell death of retinal ganglion cells (RGCs). Goldberg will review recent work revealing the pathophysiology of RGC degeneration, and the therapeutic targets to promote RGC neuroprotection and regeneration. Translating these advances from lab-based research with animals into human clinical trials, has begun in earnest. He will discuss recent data from his lab on advances in measuring RGC function in animal models in vivo, and in noninvasively measuring RGC structure, function, and metabolism in people.

Manns and Hammer note that this year's keynote presentation is named in honor of the late Pascal Rol, a former conference co-chair. The address was established to promote the exchange of ideas between clinicians with a technological need and engineers interested in solving problems in ophthalmology.

It's part of the appeal that the conference has always included many sessions relevant to clinicians, says one longtime chair, Arthur Ho, a professor in the School of Optometry and Vision Science at the University of New South Wales in Sydney, Australia. He mentions laser refractive eye surgery as one of the clinical developments tracked by the Ophthalmic Technologies Conference. "It's now a push-button technique [more commonly known as LASIK] in the clinic."

In fact, Manns notes, the conference is always scheduled on weekends so that clinicians can come outside of their busy schedules. It's one of the few places where engineers and clinicians can sit together at a conference and exchange ideas that range the spectrum from more clinical kind of applications to very fundamental technology development. "That really opens your eyes, both for engineers to see the clinical side of things, to see how a technology is used, and for clinicians to potentially have ideas of how technology can be applied. We've seen that a lot over the years."

Over the decades, the conference has tracked progress in many technologies important to clinical practice, Ho says. This year's conference "still includes papers on improving eye tracking during the surgical process. There's been a constant pipeline of ideas and innovations coming through."

Ho also notes the value of in-person gatherings like Photonics West. He says you might know all the technical details of a given technology just by reading the literature, "but when you go and have a chat with your colleagues, you know the full in and out of all the developments. There's also the networking aspect that's a bit hard to define—you get to know people and you understand where they're coming from in terms of motivation for doing their work, and where they are likely to be going next. That insight to me is very useful."

Of this year's special anniversary session, Hammer says, "the invited speakers by themselves would command a lot of attention. I think it's going to be a great session and will be really informative for people. And it's something that maybe we don't do enough of—where we take a pause and look backward. Sometimes you have to take a pause and. say, that's where we were, and here's where we are today. That's really exciting to me."

WILLIAM G. SCHULZ

SPARK continued from page 21

Grant applications — as well as those submitted by the successful recipients — shows the profound and critical role that photonics and lasers can play in the biomedical field," says SPIE Director of Membership and Community Development Nelufar Mohajeri. "We are delighted to support these four projects in partnership with the Beckman Laser Institute, and look forward to seeing the wide-ranging impact that each of these researchers will have in the future."

The Berns-SPIE SPARK Grants program honors former Beckman Laser Institute founder, chairman and CEO Michael W. Berns who passed away in 2022. Berns, the 2022 winner of the SPIE Gold Medal, the Society's highest honor, was a professor of surgery and cell biology at the University of California, Irvine, as well as a founder of the first Laser Microbeam Program, the Beckman Laser Institute, the UCI Center for Biomedical Engineering, and the UCI Photonics Incubator. A pioneer in the use of laser technology for medical and biological research, Berns applied his research across a variety of illnesses including skin disorders, vascular and eye diseases, and cancer.

DANEET STEFFENS

EXOSENS

REVEAL THE INVISIBLE

BiOS BOOTH **8359**

PW BOOTH **1827**

- Advanced Image Intensifier Adapters
- State-of-the-Art Photon Counting and Imaging Solutions
- Exceptional Collection Efficiency for Enhanced Detection

SCIENTIFIC SINGLE PHOTON DETECTION & IMAGING SOLUTIONS

- High-speed performance and High-temperature accuracy
- Enhanced Power grid Safety with UV Solar-Blind Technology
- Advanced SWIR capabilities to ensure production quality in Semiconductor

ADVANCED IMAGING SOLUTIONS

- Cooled and uncooled detector technologies
- Reveal IR scientific acquisition and control software
- Accessible scientific thermal cameras

RADIA FAMILY ACCESSIBLE SCIENTIFIC IR IMAGING

PHOTONIS Xenics TELOPS