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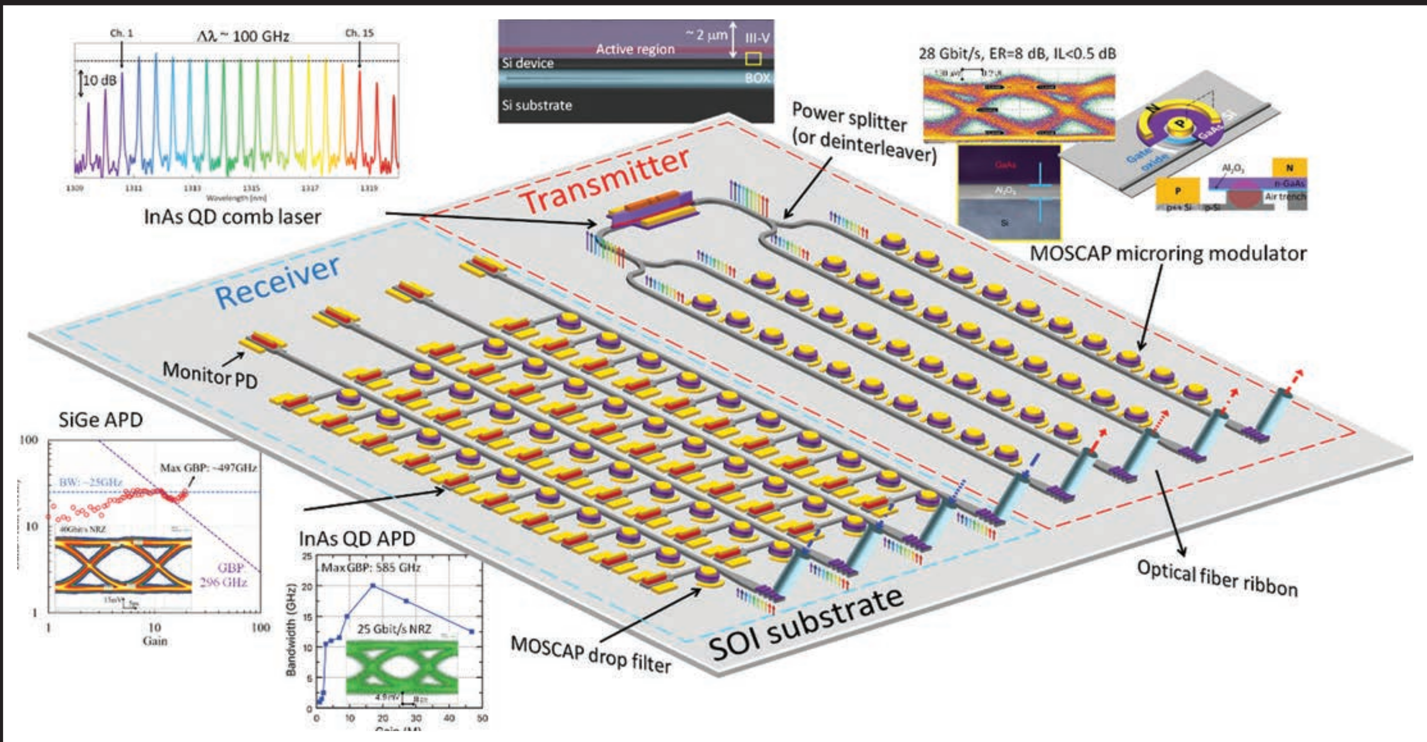
IEEE Photonics Society NEWS

Integrated Photonics for Energy-Efficient Communication and Computing



Also Inside:

- Early Days in a Venture-Backed High-Growth Photonics Startup (or: I'd Like Money for Lasers, Please!)
- OFC 2021 Highlights, and IEEE Women in Photonics Outreach

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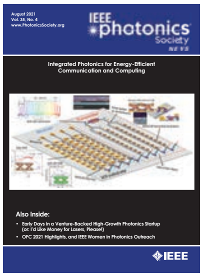

IEEE photonics Society NEWS

August 2021 Volume 35, Number 4

FEATURE

20 EPIC European Photonics Industry Consortium

21

40

COLUMNS

Editor's Column

DOMINIC SIRIANI

Welcome to August! The longest/shortest day of 2021 (depending on your geography) is behind us as we've entered the second half of the year. In my life, I'm seeing a little bit more "hybrid" activity - I'm still home a lot, but getting out to see people face-to-face is starting to become more regular. This is really encouraging, and we can see this trend emerging in our Society's upcoming conferences and events. In fact, to me, this emerging hybrid trend is looking very positive: many people can start returning to the traditional way of doing things, but many others who didn't have the means or opportunity can now participate more directly like they never could before. It's logistically very challenging for our conference and event organizers (kudos to them for all their hard work and sacrifices), but it provides an immense benefit to our community!

In this month's issue, we have a great mixture of technical content, personal stories, individual achievements, and community activity. On the technical side, the Research Highlight focuses on using silicon photonics and heterogeneous III-V/Si integration to create high-efficiency solutions for data center links and high performance computing. The melding of the best of all worlds for silicon photonics and III-Vs continues to be a hot topic, and this research article by Dr. Di Liang and colleagues at HPE Labs is a great summary of some of the state of the art.

In Industry Engagement, Dr. Cibby Pulikkaseril provides a captivating personal story of his journey in getting a photonics startup off the ground. Compellingly written and inspirational in its content, this is a must-read for anyone who wants to vicariously experience how an idea on paper becomes a physical reality. And for further inspiration, check out the personal stories in the regular series of "Get to Know Your IEEE Photonics Society Leadership," "This Is My Lab," and the WaveJobs Interview, as well as all the Membership articles on Diversity initiatives, the inspirational stories and contributions of Women in Photonics, and the activities of our Young Professionals.

To conclude but not be comprehensive (there's a lot more great content to read in this issue!), I'd like to direct you to our continuing coverage of select conferences. In this issue, the chairs of OFC provide a summary of the highlights of this year's conference held in June. Additionally, one of our enthusiastic volunteers and chapter chairs, Kithinji Muriungi, reviews his participation in the Special Session "Photonics Vision 2030 in Africa". It's great to have this conference back this year, and it was a great success!

Thanks so much for reading the *Newsletter*. As always, please reach out to us with your feedback and contributions!

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President's Column

CARMEN S. MENONI

Every June when my university, Colorado State, launches the United States National Science Foundation (NSF) Research Experience for Undergraduate (REU) Program, jointly offered with the University California at Berkeley, an infusion of energy occurs. The eager student participants are motivated to work on exciting research projects, which in our case span from high energy and ultrashort pulse lasers and their applications to the generation of coherent extreme ultraviolet sources, and spectroscopies. Everyone gets involved, graduate students, and senior personnel, mentoring the newly arrived students by introducing them to experiments that will train them in fundamental optics and photonics concepts, facilitating laboratory visits, and seminars that showcase the most recent advances in our field. This is a cycle that in a university environment repeats with the arrival of every student that joins a research program. We, the faculty, pride ourselves with training a cohort of student experts in photonics who will then lead challenging projects in industry, research labs and universities. The impact of these efforts is enormous, from the perspective of human resources and economic development.

It is for the impact of our education, mentoring and training activities that it is critical we make every possible effort to increase the participation of women within such programs and our profession. Women are 49.584% of the world population according to World Bank data. Within Engineering in the United States, statistics from the NSF show that in 2018 women received 22.2% of Bachelors' degrees, 25.78% of Masters' degrees and 24.53% of doctorate degrees. Nevertheless, we all know that in Electrical Engineering, in which many photonics research activities reside, these numbers are lower. It is evident in the classroom, in our research groups, in our conferences, which in spite of all of the efforts of organizing committees, the number of plenary, keynote and invited talks given by women is at best equal to the number of doctorates given in Engineering above.

There is a lot of room for improvements to impact the recruitment and retention of women in photonics, and it takes a multifaceted approach. Outreach activities to students at an early age, including preuniversity methods, are important to bring awareness of what we do. The IEEE Photonics Society is involved in these types of activities through networking opportunities, regional events, and educational resources, as well as through access to funding and volunteer opportunities. However, at the undergraduate level, I find that the most effective way to mentor women is by inviting them to participate in a research project, as in this way students get a full scope of how I work and handle relationships. At the graduate level and beyond, it becomes easier to retain women if they are offered the opportunity to develop their technical and leadership skills and are given the support to accommodate their personal needs.

An example of a successful regional event that recently took place at the Compound Semiconductor Week (CSW 2021) was organized by Dr. Ayodeji Coker, Science Director from USA Office of Naval Research Global, and Qin Wang, Senior Expert Research Institutes of Sweden (RISE) and IEEE Women in Photonics Affinity Group Representative for the IEEE Photonics Sweden Chapter. Women speakers were invited to present their scientific results aimed to inspire young professionals and graduate students to embrace new technology leaps in the field. The talk topics included: Nanotechnology; Infrared Detection; RF Applications; Laser Interferometer Space Communications; Bandgap Semiconductors; and Nanoscale Engineered Silicon Imaging.

Our Associate Vice-President of Women in Photonics, Deepa Venkitesh from Indian Institute of Technology Madras, is also strategically leading a "Re-Ignite: Back to Career" program, proposed to roll-out this Fall. The program is designed to assist women and gender minorities returning or transitioning in the field. It will include mentorship pairings, soft-skills trainings, and grants to support individualized project goals and onboard learning. More information on this program can be found on the Society's IEEE Women in Photonics webpage in the coming months.

Many of our professionals are involved in similar efforts to attract and retain women, and certainly as a Society we will continue expanding our efforts. We are all very conscious that drop by drop a bucket fills up, so impacting our immediate environment is critical. In turn, efforts in increasing the participation of women in leadership positions at conferences, publications and membership are extensive. Nevertheless, I question whether further transformational change may be possible. At this stage in which we heavily rely on many of the photonics technologies that connect us, that are instrumental in advancing medical diagnostics and are key in many other technologies that impact humanity, we cannot afford losing talent!

In this issue of the Newsletter we celebrate 'International Women Day' by recognizing the many achievements of women in the profession. This yearly celebration also brings awareness of the challenges that remain to make the environment in which we work more inclusive.

At the IEEE Photonics Society, we are committed to expanding the participation of women, through our dedicated IEEE Women in Photonics program. We would like to inclusively invite our members to bring their ideas and enthusiasm forward to further diversify the range of individuals and perspectives building the technology and information of tomorrow. We encourage mentors and others who want to help advance the future of women in photonics to get involved. The stories of successful women in leadership roles and supportive global, educational programs can serve as inspiration and a model for others to follow.

With warm regards.
Carmen S. Menoni
President (2020–2021)
IEEE Photonics Society
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Enabling Advanced Integrated Photonics for Energy-Efficient Communication and Computing

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Large-Scale Integrated Photonics Lab, Hewlett Packard Labs, Hewlett Packard Enterprise

1. Introduction

The push to build bigger, better, and faster computers has accelerated in recent times thanks to the advent of technologies like Big Data and Machine learning. In high-performance computing (HPC) the push to exascale performance (i.e. building a computer with 10^{18} floating-point operations per second) has put a strain on existing technologies. Systems with up to 100,000 sockets are now being built as the avenues to improve socket performance are being limited by other factors. To achieve such scales HPC systems will require affordable interconnects. Photonics networks are already widely deployed because they provide the bandwidth and reach that is required to build modern HPC systems. However, in its current implementation HPC photonics relies on expensive active optical cables (AOCs) and therefore its reach is limited by overall system cost considerations. In addition to lowering the system costs, low-cost photonic links can enable new, high-performance architectures. Silicon photonics (SiPh) is considered one of the most promising technologies to enable low-cost optical links. In the past few years, SiPh has demonstrated a significant market penetration in datacenters and HPC. This penetration has been driven by companies that deployed a vertically integrated business model where they exclusively own much of the intellectual property involved in the design and assembly of SiPh components. The current business model for SiPh is different to the foundry and OSAT (outsourced assembly and test) model that has been common in the semiconductor industry. With its steep entrance barrier, the vertical model stifles innovation and tends to favor established players in the space. Leveraging over a decade of research expertise in SiPh (both CMOS compatible and heterogeneous III-V-on-Si platforms), we are aiming to develop a more open SiPh industrial ecosystem targeted at computer-com applications in datacenters and HPCs. The open SiPh ecosystem would make available to the design community a new way to design, build, test, and assemble SiPh PICs (Photonics Integrated Circuits) using verified IP, industry standard tools, and verified fabrication and assembly processes. Whereas initial applications target optical interconnects in datacom and HPC applications, the same platform can also be used for optical information processing.

2. CMOS Silicon Photonics

One of the key advantages of SiPh is that the fabrication process is compatible with standard CMOS processes and therefore can use the same tools and leverage years of innovation that happened to support the large-volume CMOS market. For example, several foundries have developed 300- mm SiPh lines that leverage existing processes, especially in the back end of the line (BEOL). More recently several foundries have started combining SiPh and through-silicon vias to build SiPh interposers. The comparison of the two packaging strategies is shown in Figure 1. Through Si via (TSV) packaging opens the way to a close 3D integration of the photonic and logic chips.

2.1. Development status

Our group has been focusing on using CMOS SiPh to implement dense wavelength division multiplexing (DWDM) links. A schematic of the transmitter and receiver for high-radix switch application is shown in Figure 2. Rather than bundling up several single-wavelength lasers together, a comb laser is a better choice here to generate tens of high-quality continuous-wave (cw) wavelengths with inherently fixed channel spacing. This stream of multi-wavelength laser output can be split or deinterleaved to feed multiple arrays of microring resonators which provide energy-efficient data modulation and WDM function simultaneously. Modulated signals are coupled to fiber ribbon through low loss grating couplers (GCs). In the receiver side a similar array of microrings drops the signal to corresponding photodetector to finish O/E conversion. Significant reduction in the link power consumption is possible when

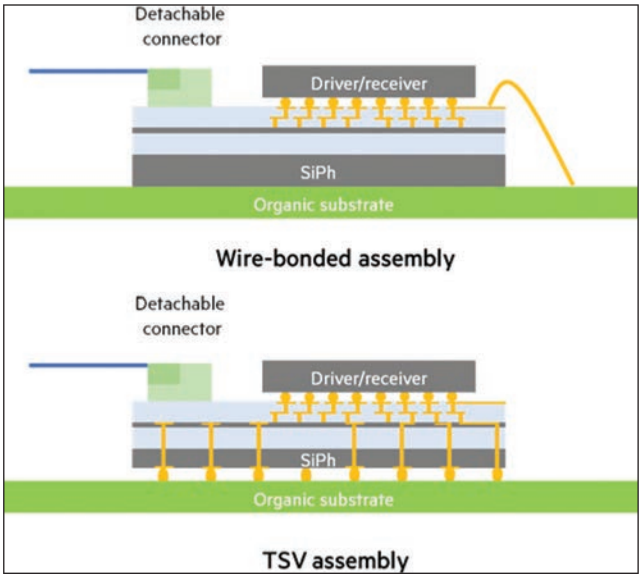

Figure 1. SiPh packaging options, wire bonded (2.5D) and TSV (3D).

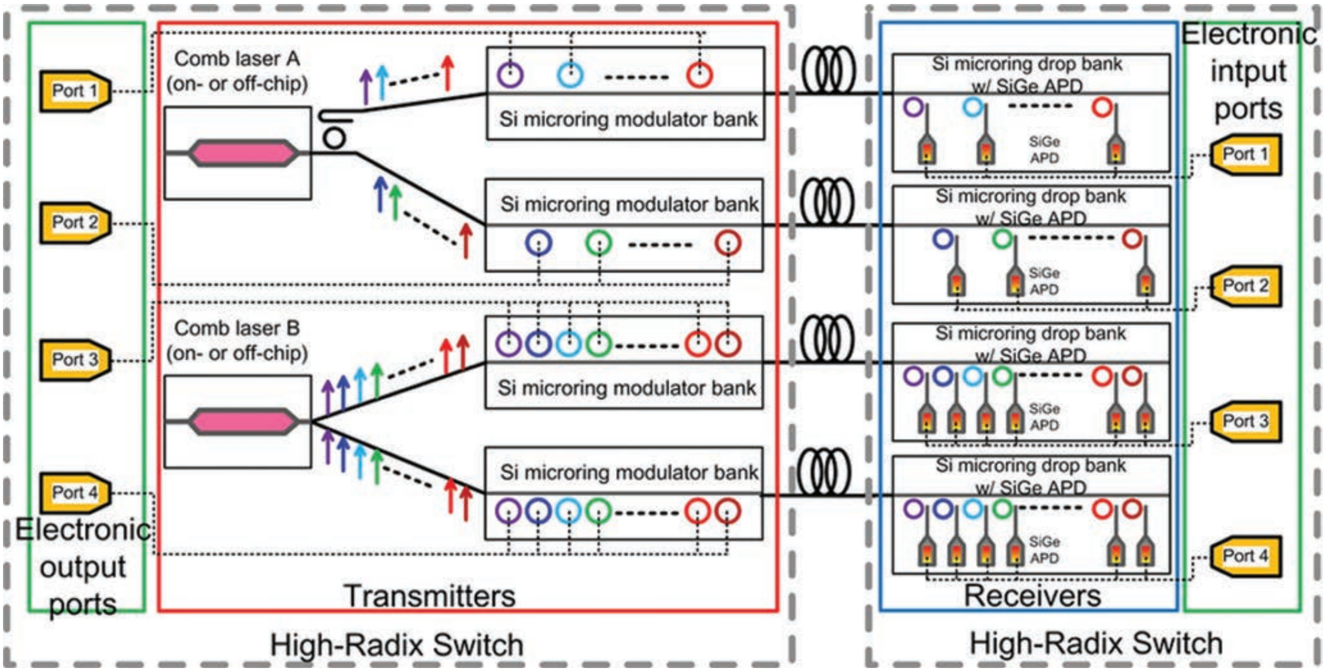

Figure 2. Schematic diagram of the DWDM transmitter and receiver.

employing highly sensitive detectors, such as avalanche photodetectors (APDs).

We recently demonstrated a 24-channel version of the DWDM transceiver [1]. A picture of the wire bonded assembly is shown in Figure 3. The CMOS driver/receiver chip (code named Iceman) channels implemented in a 28-nm process. The SiPh interposer (code named Halla), fabricated in a 65-nm process, consists of a transmitter waveguide with two grating couplers and 24 modulator rings and a receiver waveguide with a single grating coupler and a bus waveguide with 24 silicon microring filters and 24 photodetectors (PDs). The receiver chip and SiPh interposer are flip chip packaged using state-of-the-art 3D packaging technology.

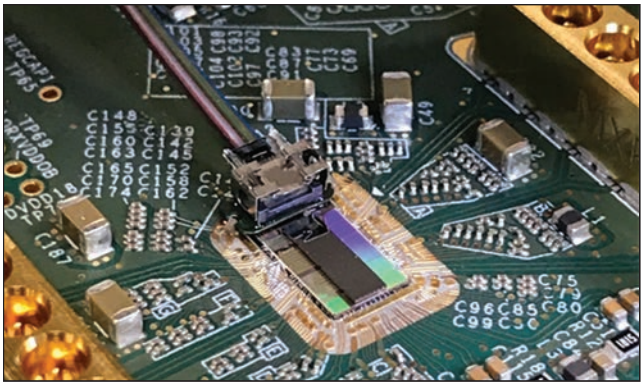

Figure 3. Picture of a silicon photonics circuit with flip-chip integrated drivers and removable connector.

The Iceman chip consists of three parts: 1) digital logic with industry-standard interface, 2) high-speed front-end circuits, and 3) wavelength monitoring and tuning circuits. The digital logic block in Iceman, which is compatible with the Peripheral Component Interconnect express (PCIe) standard, provides the data pattern to the transmitter and checks bit-error from the received data for 24 channels through the serializer and de-serializer. Inter-integrated circuit (I2C) block is also included to send and receive the control commands using an externally connected field-programmable gate-array (FPGA). The transmitter front-end circuits drive the Si p-i-n microring modulators at the data-rate of 16 Gb/s/wavelength and includes 1-tap pre-emphasis equalizer that compensates sub-GHz bandwidth of the carrier-injection to achieve the target data-rate. An on-chip AC-coupling is implemented at the transmitter to employ pseudo-differential signaling scheme so that the microring modulators are biased correctly and have sufficient modulation amplitude. The receiver front-end circuits consist of trans-impedance amplifier (TIA), automatic gain control (AGC) circuit and a linear equalizer. The TIA converts current signal from the photodetector to a voltage signal with a large gain using two feedback resistors. The linear equalizer compensates the bandwidth limit from the transmitter as well as packaging parasitics by employing source degeneration and negative capacitance techniques. The AGC circuit allows a wide input current dynamic range to accommodate potential signal fluctuation from highly sensitive microring devices. The wavelength monitoring circuit uses an analog-to-digital converter with successive approximation resistor logic (SAR-ADC) to capture how far the resonance wavelength of each microring is from the target wavelength by monitoring the amplitude and DC value of transmitted or received optical signal. The digitized output of the SAR-ADC controls the tuning circuits that inject current into the silicon photonic heaters located in the proximity of the microrings using a current-steering digital digital-to-analog converter (DAC). The assembly is driven by an external laser and on-chip drivers and receivers able to sustain speeds up to 16 Gbps. The aggregate bandwidth per fiber is 384 Gbps.

2.2. Tool Development

A robust set of design tools is a key ingredient for a successful SiPh ecosystem. Design tools enable technologists to access the underlying technologies easily and transparently. There are several different tools that are required for a complete ecosystem

1) **Device design tools**. These tools are used by device designers to optimize device performance and create the models that can be used in the design of complex circuits. In the past few years there has been an explosion of tools that allow the simulation and optimization of photonic devices. Some tools are suited for a particular type of device or analysis. Others are integrated and help streamlining the device designer workflow from device conception and layout to the initial simulation and finally to test, verification, and model build. A compact model library (CML) is the outcome of the workflow and can be widely distributed to circuit designers and used in a system simulation tool to ensure end-to-end performance.
2) System design. Design automation is one of the key requirements for the system design tools. We strive to reproduce the electronic design workflow for SiPh. This workflow starts with a schematic of the circuit, progresses to a verification stage using the compact models, and then moves to the circuit layout using an automated layout tool. Once the layout is complete a layout-versus-schematic tool verifies that the final layout reflects the original design intent. The final step before tape out is the verification that the layout complies with the process design rules. This workflow has been at least partially realized thanks to tools from several EDA companies.
3) **Packaging and co-design.** Soon 2.5D and 3D co-packaging of PICs and drivers will become more prevalent in the industry. This creates the need to co-simulate the thermal and power performance of the chips. Heating from power grids and through-silicon vias can affect the performance and reliability of the photonic components and these effects must be considered at the design stage. Our group has partnered with industry-leading EDA companies to develop tools in this space [2].
4) **Device optimization and models**. Recently, the performance of SiPh devices has progressed, much thanks to the use of a variety of optimization techniques. These techniques couple electromagnetic simulation tools with optimization techniques inspired by other areas of science and engineering such as machine learning and genetic optimization algorithms. Our group has been active in the design and optimization of individual devices. For example, we have used adjoint methods [3] as an effective and powerful tool for optimizing photonic devices such as grating couplers that comprise many parameters. The adjoint method simplifies the exploration of large parameter spaces by calculating the gradients of the Figure-of-Merit (FoM) in an efficient manner.

3. Heterogeneous III-V-on-Si Photonic Integration

Heterogeneous III-V-on-Si integration is a novel technology with proven volume manufacturability. It marries the merits of III-V direct-bandgap materials with SiPh to overcome their respective limits of small III-V wafer size and integration density for PIC production, and lack of efficient optical gain or other useful electro-optic properties on silicon. As shown in a cross-sectional scanning electronic microscopy (SEM) in Figure 4, ~2 micronm-thick III-V epitaxial structure on the SOI substrate enables high-performance lasers, amplifiers, phase or absorption modulators and photodetectors [5]. These are great complementary building blocks to CMOS SiPh components for full PIC enablement and versatile applications.

3.1. Transceiver Architecture and Key Building Blocks

We are on the way to demonstrate a fully integrated DWDM transceiver on our heterogeneous III-V-on-Si platform. A possible implementations schematically shown in Figure 4. Like the DWDM architecture realized in the CMOS SiPh transceiver chip we use a high-performance InAs quantum-dot (QD) comb laser with optional integrated QD semiconductor optical amplifier (SOA) as the multi-wavelength source. In this architecture the laser is on chip and generates tens of evenly spaced wavelengths. One multi-wavelength stream is either split by power splitters or deinterleaved in the spectral domain into two or more streams to feed parallel compact microring modulator arrays to complete the transmitter function. On the same chip similar microring resonators are used as demultiplexer (DEMUX) to drop each channel of optical data into the corresponding high-sensitivity avalanche photodetector (APD) to complete the receiver function. Low loss grating couplers serve as I/O ports to fiber ribbons. The project is targeting 25 Gb/s/channel with 40 channels in total to reach an aggregate bandwidth of >1 Tb/s with <1.5 pJ/bit energy efficiency.

3.2. Development Status

Compared with standalone monolithic modelocked comb lasers, our heterogeneous platform offers a critical advantage of design flexibility in channel spacing without compromising output power and a single saturable absorber for simple control [6]. By designing a compound laser cavity with low-loss Si waveguide and taking advantage of the Vernier effect between the two coupled cavities channel spacing and device length are decoupled from each other. Laser efficiency and output power can be optimized independently of channel spacing. The intrinsic properties of quantum dot materials favor robust low-noise comb line generation, as shown by a 100 GHz-spaced flat comb spectrum with 15 useable channels in Figure 4 [6]. A record 220 comb lines with 15.5 GHz channel spacing from a single comb laser was also demonstrated recently [7]. Our group is also working on heterogeneous SOAs and preliminary test data is very encouraging.

We also developed a III-V/oxide/Si MOS capacitor (MOSCAP) (Figure 4 inset, TEM image) to provide athermal, ultra-low power consumption phase shift for deinterleaver, modulators and microring drop filters in DC condition, as well

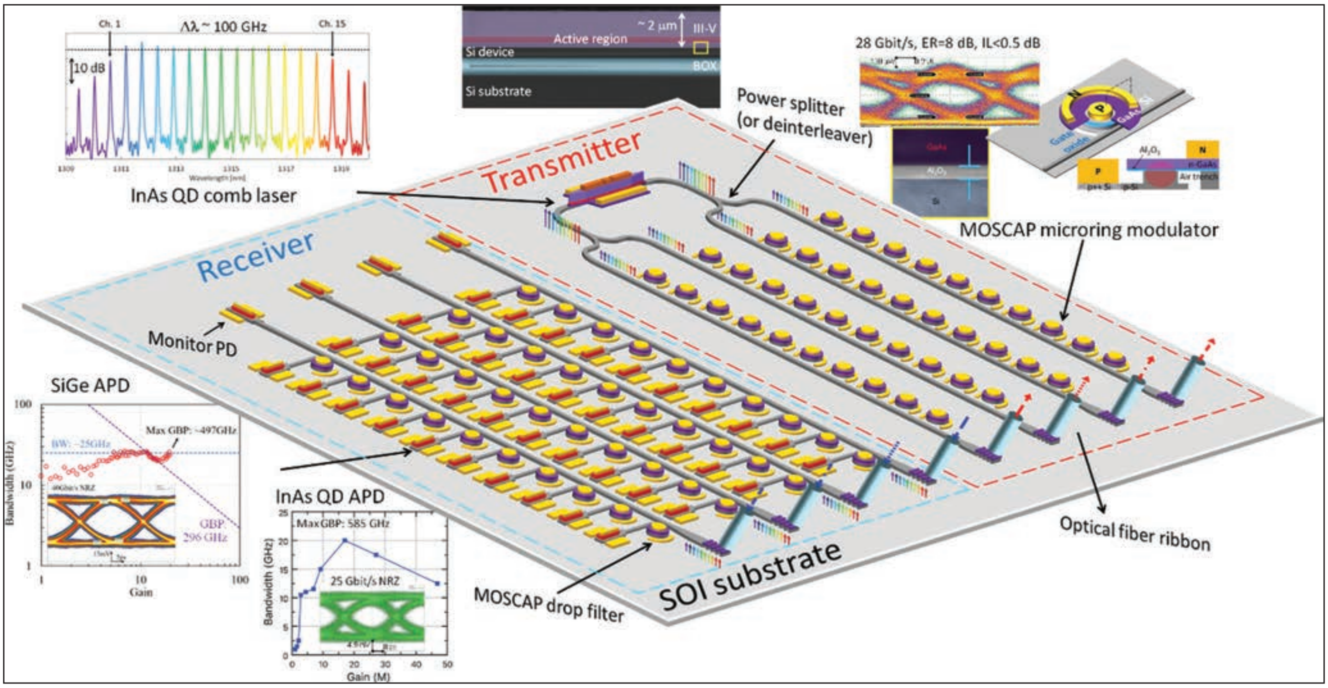

Figure 4. Schematic of a 40-channel heterogeneous DWDM transceiver chip, and experimental highlights of key building blocks as insets.

as high-speed, low-loss data modulation [8]. We observed a wavelength shift over 1 nm in a 40 µm-diameter heterogeneous microring resonator with 4 V bias on the MOSCAP. We measured ~50 fA leakage current that translates into a power consumption over 1 billion times lower than the widely used thermal tuning [9]. The same MOSCAP will also be integrated in the heterogeneous comb laser to help locking the comb lines with MOSCAP microring modulators and drop filters with negligible power consumption. The MOSCAP concept has been employed in pure Si modulators by other research groups, however in our case, the lower effective mass and larger mobility for electrons in the III-V material, result in more effective plasma dispersion effect and other favorable electro-optic effects [8]. Such a MOSCAP microring modulator is illustrated in the inset of Figure 4. An eye diagram of 28 Gb/s non-return-to-zero (NRZ) signal without any equalization was measured recently [10]. The modulator has a good extinction (8 dB here) and low insertion loss (<0.5 dB here) comparable to those of carrier-injection p-i-n modulators. These properties are critical for good signal integrity and low laser/SOA power consumption in this cascaded microring-based DWDM architecture. On-going improvement in design and fabrication is expected to extend the current RC time constant-limited bandwidth to enable >40 Gb/s modulation, and 1.6 Tb/s aggregate bandwidth from this ~mm^2 chip.

On the receiver side, there are two flavors of Si-based APDs in our roadmap, viz. SiGe APDs and bonded InAs QD APDs. Internal gain in the APD enables the detection of weak optical signals, and consequently good sensitivity can be achieved. The strong optical absorption in Ge and the small impact ionization coefficient ratio of Si (~0.02) make a separate absorption carrier multiplication (SACM) SiGe APD structure ideal for high responsivity and low excess noise [11]. Reflector-assisted designs allow further improvements of the responsivity without sacrificing the overall bandwidth to reach a gain-bandwidth product (GBP) of 497 GHz and 40 Gb/s NRZ and 80 Gb/s PAM4 operation [12]. A receiver sensitivity, for BER of 10^{-12}, of -13.5 dBm was achieved at 32 Gb/s NRZ operation (limited by our Bit Error Rate Tester). Calculations indicate an 8X reduction in total link power consumption when receiver sensitivity is improved to -20 dBm at 25 Gb/s, facilitating our goal to reach sub-pJ/bit link energy efficiency. SiGe APDs also have the advantage of being CMOS-compatible in the fabrication process. However, a process integration challenge will arise when attempting to integrate the SiGe and heterogeneous III-V processes together.

For this reason, we were thrilled to discover that the InAs QD laser epitaxial material can be used as an APD as well if enough reverse bias was provided [13]. In addition to ultra-low dark current density ~ 1 µA/cm^2, most recent measurement showed 20 GHz bandwidth and 585 GHz GBP, both records for QD APDs [14]. Open eye diagram for 25 Gb/s NRZ data rate shows these APDs will suffice for the project target pending sensitivity characterization which is under way. As QD APDs were fabricated on the same chip with heterogeneous comb lasers and MOSCAP modulators, there is no roadblock to accomplish full transceiver integration in near future.

Progress in all these individual building blocks endows great flexibility and confidence for us to march towards the ultimate project goal of a fully integrated 1 Tb/s DWDM transceiver chip. A proof-of-concept DWDM transmitter link with aggregated bandwidth of 200 Gb/s (8×25 Gb/s) will be reported at the OSA advanced photonics congress in July 2021 [15].

4. Optical Information Processing

In addition to reaping the benefits of having cheaper, faster, higher bandwidth and more energy-efficient SiPh-based optical interconnects inside HPC systems, our group has also explored the possibility to leverage the same scalable CMOS-compatible platform to offload certain computations from digital electronic chips to specialized photonic accelerators. In 2014 we published a theoretical study, proving that **optical nonlinearities in ring resonators** are sufficient to obtain a cascadable universal set of logical gates [16]. To obtain ultimate energy efficiency, optical nonlinearities can be engineered in a scalable way such that switching energies with ~10s of aJ inside the ring resonators become feasible, allowing these photonic logic system to operate at the few-photon limit. Further lowering the photon number in the cavities would result in quantum fluctuations overpowering the signal, therefore hampering the desired functionality of the logic gates.

In 2016, we theoretically proposed how optical nonlinearities causing self-phase modulation in microring resonators can be utilized to emulate coherent Ising machines in an integrated photonics platform [17,18]. Ideally, ultrafast all-optical nonlinearities such as the Kerr-effect would be utilized inside the circuits representing the Ising nodes (or neurons). However the proposed scheme is also compatible with free-carrier based nonlinearities and even the much slower thermal nonlinearities in integrated photonics material stacks where the Kerr-effect is not yet readily available. Coherent Ising machines can be utilized to solve intractable combinatorial optimization problems and have an architecture which is reminiscent of Hopfield neural networks, which is a recurrent neural network in which the neuron states need to be interpreted in a binary way. At its core, the proposed integrated coherent Ising machine uses programmable multiport Mach-Zehnder interferometer meshes to **efficiently calculate a matrix-vector product** to update the Ising node states until convergence (see Figure 5).

The ability to store a matrix inside a programmable integrated photonic circuit that can efficiently perform matrix vector multiplications at low latency can also be leveraged in related photonic deep learning or neuromorphic accelerator architectures, either by taking advantage of the aforementioned MZI meshes, or by utilizing ring-based DWDM routing using similar building blocks as used in the transceiver circuits for datacom/HPC applications [19]. Importantly, to be competitive in terms of energy-efficiency and cost with emerging (analog) electronic accelerators, the SiPh platform needs to enable **non-volatile in-memory processing**. Specifically, the tuning mechanism utilized inside the photonic circuits storing the matrices with the neural network's synaptic weights, should be based on physics that is compatible with persistent information storage (in contrast to power consuming tuning using, e.g., heaters). Amongst several options such as phase-change materials, the ferro-electric effect, opto-mechanics, our group is currently focusing its efforts on the usage of memristive photonic devices based on the hybrid III-V-on-Si platform, as it allows for compact non-volatile multi-state tuneability using the same scalable fabrication process as the one we have described in Section 3 [20].

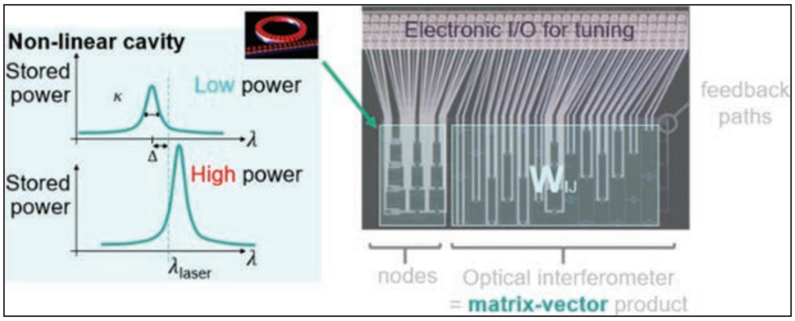

Figure 5. The SiPh platform can also be used to implement photonic accelerators such as this 4-node coherent Ising machine circuit. Like many other neuromorphic-inspired photonic accelerators, at its core, the proposed Ising machine contains an optical engine for efficient matrix-vector products. To be energy-efficient, the tuning mechanism for this matrix should be non-volatile.

5. Future Upgrades

We focus here on a couple of possible future upgrades of the CMOS SiPh and heterogeneous SiPh platforms:

Grating couplers (GCs) are an appealing and scalable solution for optical I/O in large-scale integrated photonic circuits that allows for wafer-level testing. In the traditional design, coupling to a mode propagating along the direction perpendicular to the chip results in a large back-reflection into the waveguide. Therefore, most applications use GCs that couple light into a mode that is slightly tilted off-axis. On-axis gratings could be used to reduce the alignment tolerance in grating coupled lasers and build optical vias in multi-layer 3D photonics applications. Using new design approaches, including adjoint design method [21], our group has designed and tested vertical GCs that can be fabricated using only a single-etch step in a 193nm DUV immersion lithography process, while maintaining good coupling and low reflection. We have measured insertion losses of less than 2 dB, bandwidths larger than 20 nm, and moderate in-band reflection of less than -10 dB [21]. On the other hand, for the heterogeneous platform, a III-V thin film overlay on Si can form a novel GC structure to enable increased directionality toward the optical fiber, like previous demonstrated ones with poly-silicon overlay [22]. It represents an example of fully taken advantage of wafer-bonded III-V material, not only for active but also passive functionality.

A high-speed modulator based on p-n depletion mode is the latest Si modulator structure we are adding into our toolbox and PDK family in addition to p-i-n injection and MOSCAP-based ones. The first attempt has been rewarding by demonstrating a two-segment 100 Gb/s PAM4 microring modulator from a standard CMOS foundry multi-project processing run [23]. It can instantly enhance the aggregated bandwidth to 2.4 Tb/s if we implement this design in the same 24-channel DWDM CMOS SiPh transceiver without much change in process and chip footprint.

Optical power monitoring is critically necessary for integrated photonic system in debug, performance, and lifetime monitoring. We are developing novel power monitoring techniques to harvest optical power in passive and active components without the need for conventional monitor photodiodes that measure a small portion of the light, tapped from a waveguide, thereby reducing loss and complexity in layout, fabrication, and power requirements.

Finally, both for datacom as well as optical information processing applications, incorporation of **ultra low-loss waveguides** (<1dB/m loss) and/or having access to ultrafast optical nonlinearities such as the Kerr-effect is a worthwhile addition to the hybrid III/V-on-Si platform. For instance, in 2021, integration of InP/Si lasers with ultra low-loss SiN waveguides has resulted in a successful demonstration of single-soliton comb sources, which is a major milestone for this technology. More generally, the ability to combine the advantages of the aforementioned III/V-on-Si platform with the nonlinear and low-loss properties of SiN, potentially in a multilayer topology, brings unseen capabilities to the original SiPh platform, as it allows system-level designers to pick the optimal material layers for the desired device functionality, without the need to go off-chip.

6. Summary

We here presented a high-level overview of our vision and approach in advanced SiPh development primarily for high-performance connectivity in computer-com applications in datacenters and HPCs. We develop in parallel CMOS SiPh and heterogeneous III-V-on-Si platforms, continuing to innovate device structures, process integration methods, architecture, packaging, and system implementation. We are also extending our SiPh R&D domain from communication to computing, e.g. optical neuromorphic computing. The world first demonstration of a memristor laser [20] recently provides new sparks to ramp up effort in computing applications our group initiated a few years back [17,18]. More and more emerging applications in communications, metrology and sensing are further pushing the momentum to drive innovations and grow SiPh into a much larger business. Our commitment to promote and lead the development of an open ecosystem with our foundry and supply chain partners will help our work to generate larger impact not only for our business but also to the entire integrated photonics community.

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Industry Engagement

Life at a Photonics Startup: Lessons Learned

Early Days in a Venture-Backed High-Growth Photonics Startup (or: I'd Like Money for Lasers, Please!)

By Cibby Pulikkaseril, Ph.D.
Co-founder and CTO, Baraja

It's the sixth year of co-founding my startup, Baraja, and as we prepare to roll out incredible photonic technologies for the next generation in high-performance LIDAR, I have to admit, sheepishly: I don't know how I ended up here.

Young engineers have looked at my LinkedIn profile and concluded that I have crafted a perfectly tailored narrative for how I came to helm Baraja with my co-founder and co-conspirator, Federico. After all, it appears that I've taken a straight line: Bachelor's in EE, one year at JDSU in Ottawa, Master's in electro-optics, then a Ph.D. in heterodyne fiber optic systems. Then five years at an optical telecom company (Finisar) in Australia where I worked on the development of the WaveShaper and WaveAnalyzer products, leading to resigning a great job in photonics to form Baraja in my co-founder's cold and miserably damp garage.

Well—I was lucky to have incredible mentors along the way that first pushed me into grad school, and then worked with me at Finisar to give me the hunger for making products, not just research. It was the excitement of bringing a real product to market that caught me like a virulent disease. We'd hack together a demo, take it to OFC to stick it under someone's nose and attempt to pry a pre-order from them; we'd get interest, or maybe not, but it was an early introduction to attempting to find product-market fit.

Fed was the one who approached me about joining up to start a company, but I had already made my own plans - and they were truly terrible. I still have my original business plan, where my pitch to investors was, apparently: "give us $2M, and we'll work on tech for three years and have no outcomes!" I had asked a few friends to join me in starting this business, but I couldn't convince them, nor myself, really. When Fed showed me his pitch, I was electrified - he had clearly vocalized the market, the competition, and the specs to beat. On top of that, because there was no real market information about LIDAR sales, he took comparables from automotive sensors and electrification to generate a business model that was really, really exciting.

So—we were both in, and we made plans to leave. The real obstacle was money, of course. Where was it? Who has it? I knew vaguely about people called investors, and suspected that they wore monocles, but I had no idea how to get money.

I had two very young children, and Fed was expecting his first, so we were barely getting by. Who was going to back us?

Raising Money for Photonics

It was going to be expensive to start Baraja and Fed and I were full-time, living off our meager savings while trying to figure out how we were going to pay for equipment and startup costs. We started reaching out to friends around the world—old high school friends, classmates at college—and asked for $5000.

I was surprised how many people wanted to be a part of the venture—one friend, when I told him I was quitting my job, immediately blurted out, "Can I give you money?!?" I was taken aback; he had just had a kid, and I told him it was going to be really, really risky and he should keep his money.

"I understand it's risky. People like me never get into these deals, and that's the opportunity. All I have is $5000, but you can have it," he replied, eyes shining with hope.

Shocked, I agreed, and realized, for the first time, that I wasn't begging for money—as my friend had adamantly declared—it was an opportunity. While we are still a private company, those earliest investors that backed us as friends have seen gargantuan returns on that original investment, so my friend was right to aggressively pursue the chance to back a friend.

This got us enough cash to start—we lodged a patent, bought some equipment. I started setting up some experiments to verify the ideas that we had, but I quickly reached a limit on my technical skills. We were going to need to hire a team.

We started talking to angel investors, but we didn't really find the amount of money we were looking to fund a hardware startup; as well, it was clear that there was not an appreciation in the investor market for our incredibly difficult and technical journey. There was a boom in software startups, and compared to them, we looked unappetizing.

At this time, we heard two common refrains: "Move to the US," and "It's never gonna work!"

Moving to the US didn't seem like an option - we both had very young kids, and even more impactful, our network of talented engineers was here in Sydney, and we would lose that edge by starting afresh in a new location. We had to raise money in Australia, and if not from angel investors, it was going to need to come from Venture Capitalists (VCs). In Australia, the VC sector had seen a long drought, and I was warned by several people about VCs and their anti-founder views, so I was extremely skeptical. Fed, on the other hand, was reading everything that the local VCs were putting out, and he really resonated with a relatively new fund, Blackbird Ventures, who had made their mark in their first fund by investing in some incredible software businesses. Would they invest in a hardware business that was going to need a lot of capital, blood and sweat?

There are many ways to get a meeting with a VC, and it is possible to send a cold email and attract their attention. It's just not ideal—what do you do if they don't reply? Keep trying? Maybe, but the best way to get in front of them would be through a warm intro: get someone from their network to recommend them to speak to you. It's hard to figure out a cobweb of connections, but it is a great demonstration of your ability, as a founder, to hustle and make it happen.

Fed took yet another approach: he went to local startup events where he knew the Blackbird partners would be speaking, and then he would bull-rush them after they left the stage, elbow his way past all the other founders and speak to them face-to-face. Eventually, they relented and gave us a meeting.

We pitched them, and it was halfway exciting, but ultimately fell flat. We were so stressed about the technology and the risk, that it was not a compelling pitch. "If you had double the money," they asked us, "could you go twice as fast?"

Ridiculous, we thought. After all, hardware is hard, and we have so many technical risks to solve. This was photonics at it's hardest - could we take a concept for a LIDAR and actually prove it works in 6 months? After some deep soul searching, we came back with a revised plan that asked to raise more money from investors, grow the team larger than we thought, and accelerate the timeline. With that, we were in - and walked away with a term sheet with founder-friendly terms.

Money, Now What?

Money always seems like the biggest obstacle when starting, but once you have it, the much-more terrifying future awaits… having to execute on your plan and deliver on the promises that you've made. In a photonic startup, this seems massively difficult, as you need to recruit new employees with specialized skills, working in nice, secure jobs. Why would they leave?

As new founders, we didn't know what to do, so we recruited slowly. Our first employee was an optical engineer who was then working on crash-test dummies, so he was extremely eager to join Baraja. That was lucky for us; we were so protective about IP that we were uncomfortable to talk about anything regarding the technology or company plans. Other than that first employee, we quickly learned that the story and the tech was the secret to convincing great people to come work at Baraja for less money.

We started to trickle in employees, bringing in the core of skills that we needed to get to a demo: firmware, electronics, photonics. Those were exciting, blissful days, where we were all rowing in the same direction, and the excitement was thick like butter. The founders were racing around doing everything to keep the company chugging along—I took out the trash, did the purchasing, ran downstairs to collect the parcels. Anything that I could do that would keep the team moving, I did that.

There was no need for real meetings, since we were a small team and could discuss things by turning around in the same room. As the team grew, though, it became harder to communicate across different issues, and we were falling out of sync. The second we grew into two separate rooms, it was instantly more difficult to keep everyone up-to-date on the rapidly changing plans and discoveries. At that time, I started a weekly whiteboard session called "The Grind," where I would go up and sketch out the system we were making, component-by-component, asking the audience to guide me in drawing the electrical and optical flow. As we continued to grow, this was a natural onboarding for employees, as they saw that anyone could ask "stupid" questions of the CTO, and these would often dive into unusually rich discussions about the nature of light.

We reached a terrifying point in that first year—our system could steer the beam really well, exactly like we predicted, but the real challenge in making a LIDAR system is to detect the unbelievably tiny amount of light that comes back from a diffuse target. After several iterations of receiver concepts, I realized that the system just was not practical, and would never scale to manufacturing. We made the difficult decision to pivot our approach and radically rethink the system, enabling us to retain a large optical aperture to collect photons.

It worked, and we put all our effort into accelerating to make our first prototype, bringing together every engineer and outside consultants to bring the concept to fruition, even getting a nice finish on the housing to make it look slick.

While it worked, it didn't work very well…. So, we pivoted to our second prototype, which we modelled, built and tested in a month. I don't remember that time, but we ended the year with a big celebration, inviting our friends and investors to come and see the demo in an auditorium. We were delirious with joy—we finally were a real LIDAR company because we had a working LIDAR! We put the sensor output on the big screen, and the team oohed and ahhhed over the details that they saw on the LIDAR point cloud.

At a lull in the raucous celebration, one of the investors piped up: "Is that what it's supposed to look like? It just looks like a mess—to be honest, I'd drive straight through that."

Sobering feedback.

Five Years Later

Five years later, Baraja continues to be one of the leaders in the automotive LIDAR space, still to this day offering the only software-defined LIDAR on the market, a technology that we believe is crucial for successful deployment of autonomous vehicles. We've grown the team to 150 staff, occupy our own building, and have teams in Australia, the US, Asia and Europe.

It might not sound like a startup, but it definitely still feels like it. While the overall organization is much larger, and we have specialized functions across the company, we still organize engineering-effort into small "squads," which are cross-functional and work closely with product managers. Some of our technical problems have been so hard to solve that we've had many pivots and detours along the way.

My role has changed so substantially in these five years—where I was heavily involved in the technical design of the first iterations, now I am so far abstracted that my main output appears to be attending meetings. That transition was incredibly difficult for me, as I have always measured myself on my technical contribution, and that has diminished over time.

How do I stay engaged? At some point, I saw the wild variety of the brilliant ideas coming from the team, often from young, inexperienced engineers, hot-blooded and ready for action—their energy and drive to solve these problems created tremendous value in the company, and I've learned to find joy in those moments. We have so much work ahead of us to be successful, but as the CTO, my job is to keep the technology strategy serving the best interests of Baraja's commercial ambitions. I often say to the team, "I won't be happy until our LIDAR is on cars in the street," and that's an incredibly ambitious goal. Fortunately, we have an incredibly dedicated and brilliant team to take us into the next 10 years!

A Bit About the Author

Cibby Pulikkaseril is the Co-founder and CTO of Baraja. His background in developing optical sensing technology stems from his R&D role at Finisar Australia where he led technical teams to investigate new technologies, leading to the commercialization of instrumentation used by industrial and academic research laboratories. Cibby brings more than 20 years of experience in optics and photonics, from developing electrooptic and waveguide devices to modelling noise behaviour of microwave photonic systems. Cibby completed his B.Sc.(EE) at the University of Alberta, followed by a M.Eng.(EE) at McGill University, and a Ph.D.(EE) at the University of Sydney.

About This Column

This is a regular column that explores business aspects of technology-oriented companies and in particular, the demanding business aspects of photonics startups. The column touches on a broad range of topics such as financing, business plan, product development, program management, hiring and retention, manufacturing, quality, sales methodology and risk management. That is to say, we include all the pains and successes of living the photonics startup life.

This column is written sometimes by Daniel Renner, the column editor, and sometimes by invited participants, so that we can share multiple points of view coming from the full spectrum of individuals that have something to say on this topic. At the same time, this is a conversation with you, the reader. We welcome questions, other opinions and suggestions for specific topics to be addressed in the future. **Please send us your views and opinions to ipsnewsletter@ieee.org.**

The expectation for this column is to provide useful business-related information for those who intend to start, join, improve the operation, fund, acquire or sell a photonic startup. A fascinating area that can provide enormous professional reward to those engaged in it.

Get to Know Your IEEE Photonics Society Leadership

Anna Peacock, Professor
Head of the Nonlinear Semiconductor Photonics group, Optoelectronics Research Centre, University of Southampton
VP Professional & Technical Development (PTD) of IEEE Photonics Society

Our volunteer leaders are the driving force behind the IEEE Photonics Society's mission. This column will celebrate leaders who have made positive impacts on the photonics community around the world.

In this issue, Anna Peacock, the IEEE Photonics Society's Vice President of Professional & Technical Development (PTD), is featured. Learn more about her new role steering the PTD Council and what motivates her as a leader.

What is Your Current Professional Job?

I am currently a Professor of Photonics within the Optoelectronics Research Centre (ORC), University of Southampton. I lead a research group in Nonlinear Semiconductor Photonics, where we investigate both novel material optical fibres and integrated photonic platforms. I am also part of the ORC's senior management team where I am responsible for our school's education programmes.

What Role Does Your Volunteer Leadership Position Play in the IEEE Photonics Society? What Challenges Do you Face?

I serve as the VP for Professional and Technical Development within the IEEE Photonics Society. The role of our council is to identify and curate professional and technical activities that contribute to advancing the professional development of the members of the society. This is a new council, only formed this year, and it has one of the largest and most diverse remits. Thus, one of the biggest challenges we have faced so far is trying to set sensible and achievable goals so that we have strong foundations from which to build on as the council evolves. A key aspect that I want to focus on is creating tools to help with the professional development of our full range of members, so that we have a rich and diverse pool of volunteers to support the society going forward.

Why "Photonics"? What was Your "Photonics Moment?"

As an undergraduate student, my core subjects were quantum and nuclear physics – in fact, I did not take any optic courses at this level. However, the Physics Department within the University of Auckland was quite small, and research opportunities were limited by availability of suitable lecturers. My photonics moment came via a conversation on a bench outside our physics labs where a young and enthusiastic photonics lecturer convinced me that it was not too late to change research fields. The lecturer was Professor John M. Dudley, who has since gone on to be the driving force behind the UNESCO International Year of Light and Light-based Technologies (2015), and now the on-going International Day of Light. It seems that I was just the first of many who would be persuaded by this passion for the optical sciences.

What About Our Society's Mission and Work that Motivates You?

I am passionate about diversity and inclusion, and I would love to be able to make an impact to improve participation of minority groups across the IEEE Photonics Society's activities. There are lots of different opportunities that are suitable for a wide range of interests and participation levels within our society, and we are working on ways to improve visibility and accessibility. I share the Society's vision that great science and innovation requires bringing together talents and perspectives of people with different personal, cultural, and disciplinary backgrounds.

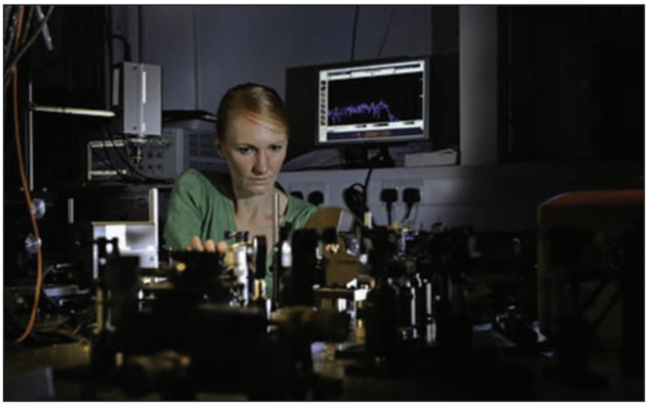

PHOTO CREDIT: ANNA PEACOCK

PHOTO CREDIT: ANNA PEACOCK

PHOTO CREDIT: ANNA PEACOCK

Why Do You Think Members Should be Involved as Society Volunteers? What are the Benefits?

I think it is important to remember that there are mutual benefits to these roles – for the society, membership, and volunteers. Although volunteering can represent a considerable commitment on our time, it is incredibly important to sustaining and improving the services that we have all come to rely on, conferences, journals, awards, student chapters etc. Moreover, as volunteers we tend to get more exposure to our community, which can help to expand our networks and increase our opportunities, ultimately enhancing our professional and technical development. Another positive aspect of being part of the IEEE Photonics Society's leadership team during the pandemic is that it has been a useful way to keep up connections across the wider community when global travel has ceased to be an option. I would strongly encourage people to consider taking up a volunteer role at some point in their career—it is just about finding the right role at the right time.

What Advice Would You Give Someone Going Into a Leadership Position for the First Time?

Find a good mentor—someone who is already involved in volunteering or has a good track record for this. It is helpful if you can receive guidance/advice on what is important and what is less so, that way you can maximise the impact of your involvement. It is also a good idea to talk to people before taking up your position in the first place, so you can gauge what the expectations are (time commitment, travel etc.) and have the capacity to make a meaningful contribution. And, most importantly, make sure that you pick something that you are passionate about!

What is One Characteristic That you Believe Every Leader Should Possess?

I believe the ability to listen and reflect on a range of different views is a very important part of being a leader. I often hear people claim they are good listeners, but this is only meaningful if they are also prepared to change their opinion or accept a new pathway. It also frustrates me when people refuse to roll back from a poor decision. As leaders, we do not always get things right, so it is important to accept this and take ownership and action to correct things when needed.

Tell Us Something Fun About Yourself!

My hobbies include running and baking – they help to maintain a great balance!

This column is prepared by Naznin Akter, PMP® (naznin@ieee.org). Any questions or suggestions for the improvement of this column are highly appreciated.

Photonics Worldwide—This Is My Lab

In this edition of "*Photonics Worldwide—This is my Lab*", we introduce you to Anuj Kumar Singh, a Ph.D. student who turns the shortcomings of 2D materials into a feature to create tunable sensors. We would also like to introduce you to Sinan Genc, who changed his field of study completely to now focusing on contamination sensors for supporting a more sustainable future. And we want to share the inspiring story of Luis R. Rivera Fernandez, who is teaching about antennas and is reminding us of the bigger picture in working with light and electromagnetic waves.

Please do get in touch if you would also like to share your story with us!

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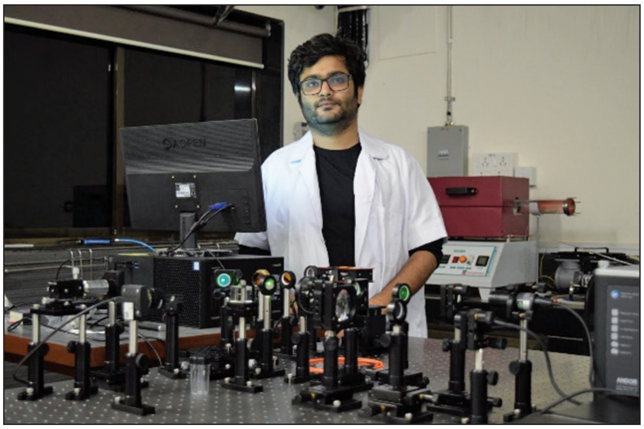

My name is **Anuj Kumar Singh**, I am a Ph.D. student at the Laboratory of Optics of Quantum Materials (LOQM) at the IIT Bombay and I am working on tunable photonics with 2D materials. Recently discovered two dimensional (2D) materials, or materials whose thickness is just a few atoms, have found numerous applications in building photodetectors, nanoscale light sources, sensors and quantum information processing. Since these materials are very thin, their optical and electronic properties change drastically if you stretch them by even a little bit. Usually this is a shortcoming because one has then to be extra careful in fabricating these materials. In my research I am trying to turn this problem into an opportunity and using this strong dependence of the optoelectronic properties on the strain as a tuning knob! The goal of my research is to develop artificial quantum emitter arrays by applying controlled strain on these systems. Such a technology will help in generating deterministic single photon emitters in 2D materials—so far most efforts in this direction are based on randomly occurring defects in these crystals.

As an Indian teenager entering the sciences, I always looked up to Dr C. V. Raman (Nobel Laureate 1930) as an inspiration. I had therefore developed a keen interest in light scattering and vibrations of crystals during undergraduate years. When I had to make the transition to Ph.D., the field of quantum materials was booming and I wanted to see if I could apply these principles to develop an innovative optoelectronic technology using this new material platform. There was an opening at the Laboratory of Optics of Quantum Materials (LOQM) at the IIT Bombay, where I joined to pursue these ideas. Nowadays, I am performing Raman spectroscopy almost every day, building new optical setups and growing these 2D materials in our lab at LOQM. It's an exciting time to be doing photonics!

I am **Sinan Genc** from Turkey. I have received my B.Sc. from Sakarya University and M.Sc. from Abdullah Gul University in Electrical Electronics Engineering. Currently, I am a Ph.D. Candidate at Abdullah Gul University, in Electrical and Computer Engineering.

My first encounter with photonics happened in 2016, the year that I started my M.Sc. and this was also the year I got in touch with the IEEE Photonics Society. Working on quantum dots and display technology in the Mutlugun lab and doing research for high-color-quality displays provided a great opportunity to both dive into the field of optics and photonics and also to extend my network in the Society. The IPC 2017 was my first experience with presenting my research at an international conference and I remember very well how nervous I was during that time.

With the years, I have noticed that I want and need to do something for the environment, something for nature. So, I have moved a totally different field: sensors. After three semesters of my Ph.D., I really would like to thank my advisor, Prof. Kutay Icoz. It would be so hectic without his support. Now, in the Smart Nanophotonics Research Group, I have been working on optical sensors to characterize microplastics in aquatic environment. Thanks to my co-advisor Prof. Talha Erdem, I had a smooth transition on the new field and day by day I feel more comfortable. Currently, we are developing a low-cost, hand-held optical sensor to have much more information about the contamination in liquid samples. To overcome the limitations of Mie Scattering, we integrate machine learning algorithms. I believe that my research will contribute to environmental research and drive a sustainable future a step further.

“I work with light” that is what an electrical engineer, who focused on electromagnetics says to his niece, as he works constantly surrounded by light. My name is **Luis R. Rivera Fernandez** and in the confinement of my lab at the University of Puerto Rico—Mayaguez Campus, I teach how to construct antennas with the capability of interacting with the invisible flow of electromagnetic radiation that surrounds us. These devices have led humanity to interconnect with the entire world by enabling all of us to communicate with anyone and anywhere, in fractions of a second, a true marvel of our era. Sparked by this knowledge I became interested in electromagnetics and in the idea of something that is invisible, but still interacts with the universe in the most profound sense. Light not only illuminates our world, but it also has made us evolve, it is our currency for visual perception and its concepts are far reaching as it manifests in everything that we lay our eye upon. What do you think? Consider the concept of the optical spectrum and look for anything that might resemble it in your surroundings, soon enough you will find something. And, if you really want to find the truth... Let yourself be guided by the light!

News

Tyndall Explorer, National Deep Tech Pre-Accelerator Announces 2021 Winners

The Tyndall Explorer 2021 program brought together six competing teams from university and industry sectors across Ireland for this national deep technology pre-accelerator. The program was led by David McGovern and Patrick Morrissey of the SFI Research Centre, Irish Photonic Integration Centre (IPIC), based at Tyndall National Institute and Helen Fullen of Alinea who directed the program. Explorer was launched earlier this year as a collaboration between IPIC, Tyndall, the IPCEI European cluster collaboration, international high-tech photonics OSRAM Opto Semiconductors, and IQE with support from SFI, Munster Technological University, DCU, National University of Ireland, Galway, Trinity College Dublin and University College Cork.

In the final showcase, six competing finalists presented their applications, which spanned across various innovative technology areas.

AIC is an AI-based platform leveraged with novel machine-learning algorithms to provide users with recommendations/predictions of different features related to public health care. AIC applications include predicting the safest time and routes of closed spaces indicating the risk level of Covid-19 contagiousness, asthma and wheezing attacks indoors.

Enegma provides novel solutions for application-level energy consumption measurement, monitoring, modelling, and optimization for applications on modern computing platforms such as supercomputers, high-performance computing clusters, and cloud computing infrastructures.

Atlantic Photonic Solutions (APS) is a photonics start-up that uses light to resolve biological problems. APS has focused on the global parasite/host problem of sea lice on farmed salmon and have discovered a "sweet spot wavelength" which affects the sea lice without harming the salmon.

InPhoSS is a gas sensing platform providing high-resolution real-time gas measurements. With growing concern worldwide about pollution resulting from human activity, emissions monitoring has become increasingly important. InPhoSS offers a real-time and accurate method to measure these pollutants.

CreativeConnections is a platform that changes the way online creators and brands find and match with each other by streamlining the search for brand ambassadors. CreativeConnections benefits both the brands and online creators by focusing on improving their respective businesses.

APS team Laura Britton, Kevin Murphy, Rory Casey.

INSPIRES employs micro-transfer printing technology to miniaturise bulky and expensive optical spectroscopy systems to chip-sized, low-cost devices. INSPIRES seeks to identify high-value applications to meet market demands of sensitivity, speed, compactness, or volume production capability to realize such products.

APS were announced as the winners of the Tyndall Explorer Program 2021. The APS team leveraged the program to help to further develop their commercialization plans and to expand their customer discovery and market engagement activities. The program helped connect this innovative team to a wide network, which will enable the company to address new markets and to use their patented technology in additional applications. Furthermore, APS have secured EU funding to commercialize their patented process.

The next Explorer program is now seeking early stage photonics and microelectronics-based ideas that have the potential to develop into scalable start-ups and address current societal challenges. The participating teams will learn from commercialization and technology experts to better understand prospective customer needs, help de-risk their deep-tech ventures through product and customer validation, and prepare the teams for grant funding and investment. In addition, teams will be supported by industry mentorship from international experts to help bring their idea from concept to pitch. The program also assists teams in gaining both national and international exposure and facilitates access to the investing community.

Explorer will be releasing details on https://www.tyndall.ie/explorer for its next program from October 2021.

If you have queries regarding Explorer, please contact a member of the team by emailing **explorer@tyndall.ie**.

IEEE SA Technology Spotlight: How Can Quantum Computing & Artificial Intelligence Transform the Healthcare Industry?

Free On-Demand Webinar Available that Discusses Quantum Technology in Healthcare and Policy Implications

Beyond Standards Blog Article

The answers to some of the challenges facing the world today—connectivity for all people and businesses regardless of location, equitable healthcare, sustainable and reliable energy, and reducing the transportation industry's dependence on fossil fuel—will likely be found in data.

However, we can only discover solutions for these problems, and those that will arise in the future, by processing massive amounts of data quickly and safely. With the increase in quantum computing, corporations, academia, and government have access to technological power needed to begin creating a roadmap for overcoming these obstacles.

What is Quantum Computing? How is it Used?

With the traditional method of computing, your system doubles each time the amount of data doubles. This makes it challenging and slow to process the massive amounts of data required in many industries, such as healthcare, engineering, data analytics, and financial services.

Instead of increasing the size of the system, quantum computing doubles the potential power of the computer with every single cubit added. Systems can then process increasingly large amounts of data in almost real-time without increasing the footprint. Various use cases across industries with large amounts of data are now turning to quantum computing to quickly address previously unsolvable calculations.

The benefits of quantum computing are already being seen in healthcare, specifically in personalized medicine, as researchers and healthcare providers work to predict health risks and determine the best treatment for groups of individuals who meet certain characteristics. Unlike traditional medicine that relies on a more general approach, personalized medicine is patient-centered care that uses patients' genetic profile to uncover health risks in order to devise treatments that could work best for individuals.

To effectively process the massive amounts of health data from millions of dissimilar data points, experts in the emerging field are increasingly relying on quantum computers' unique ability to resolve complex data management challenges with great speed. This supports the advancement of personalized medicine and its positive impact in healthcare systems.

The accuracy of the insights and predictions from personalized medicine are made possible by using artificial intelligence (AI) along with quantum computing. Combining these two technologies opens up many new use cases for processing large amounts of data to overcome challenges in healthcare and other industries.

To help bring all perspectives together to understand the current gaps with quantum computing and AI, the IEEE Standards Association (IEEE SA) recently hosted the Executive Summit on Quantum Computing and Artificial Intelligence. During the month-long conference, global industry leaders and policymakers shared their perspectives and insights to encourage collaboration as we, as society, take the next steps forward.

Creating Quantum Computing Policy for Today and Tomorrow

Speakers, including United States Congressman Bill Foster and Kilian Gross from European Commission Brussels, Head of Unit DG CNECT A/2, Artificial Intelligence, shared the work being done on creating policies that address key concerns regarding the technologies, between capacity-building fundamental open research and applied competitive research with immediate national security and commercial implications.

Foster spoke about upcoming legislation that expands the National Quantum Initiative by helping to create a bigger pipeline of workers with the highly specialized skills needed. The funding helps improve training in the military as well as college programs related to quantum. The goal is to increase the Department of Defense workforce in quantum, which will help further the effort to use the speed and power of quantum for solving the biggest challenges.

Gross explained that policies must address constituents' key concerns with AI, including breaching fundamental rights and discriminatory outcomes. As part of this effort, Europe is currently reviewing its Coordinated Plan on AI, which was created in 2018.

He also said that the legislative framework must create an ecosystem of trust by focusing on safety and fundamental rights with a risk-based and proportionate regulatory approach to high-risk uses of AI. The first step is determining which AI systems are most likely to affect people's right to safety or fundamental rights, such as privacy, and focusing legislation only on these use cases. Then the legislation can create mandatory requirements, such as training data, human oversight, and data/record keeping.

Three Steps to Long-Term Thinking in Quantum Computing

Dr. Paul Lopata, Ph.D. Principal Director for Quantum Science at the Office of the Under Secretary of Defence Research and Engineering gave his insights on what organizations should do today to build the pathway to success with quantum in the future. He explained that high power computing isn't a single technique, but instead built with supercomputers, field-programmable gate arrays (FPGAs), application-specific integrated circuits (ASICs), and graphics processing units (GPUs).

Lopata says that organizations should focus on the long game with quantum computing and start strategizing today for the long-term future. He shared his three steps to long-term thinking in quantum computing: *Align to your organization's values; Build your internal expertise; Partner with like-minded organizations; and Enhancing Well-Being with Quantum Computing and AI.*

Quantum computing could become one of several breakthrough solutions that help expand our capabilities to ensure healthy lives and to promote well-being for all at all ages and help create a more sustainable society in the long run. Using quantum computing, along with AI, enables us to address some of today's biggest issues, and in the process building recreatable and scalable technology frameworks and processes as we work toward achieving universal healthcare for all.

Learn more about the Executive Summit on Quantum Computing and Artificial Intelligence and watch the on-demand recording for free, here: *https://bit.ly/3hfmqel*

About IEEE Quantum

IEEE Quantum programs are supported IEEE Future Directions and outreach units, like the IEEE Photonics Society. The IEEE Quantum initiative launched in 2019 and serves as IEEE's leading community for all projects and activities on quantum technologies and has developed a project plan to address the current landscape, identify challenges and opportunities, leverage and collaborate with existing initiatives, engage the quantum community at large. Learn more, here: quantum.ieee.org

About Beyond Standards

Beyond Standards features contributions from IEEE SA's global network of volunteers, members, staff, and partners, serving as a trusted source of information, education, and inspiration for industry, government, academia, and the public. Learn more, here: beyondstandards.ieee.org

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IEEE and CERN Agree to Transformative Open Access 'Read and Publish' Deal

IEEE announced that it has entered an open access read and publish agreement with CERN, the European Organization for Nuclear Research, the world's largest particle physics research center located in Geneva, Switzerland.

The transformative read and publish agreement enables CERN-corresponding authors to publish open access articles in all IEEE journals and combines reading access to over five million documents from the IEEE Xplore Digital Library, including scientific journals, conference proceedings, and IEEE standards. The agreement also makes it more convenient for authors to publish open access articles with IEEE as article processing charges (APCs) are prepaid by CERN's centrally funded IEEE open access APC account. CERN's authors are now able to publish open access articles in 160 leading hybrid journals and all fully open journals published by IEEE, making articles instantly available and free to read by the general public.

"IEEE is proud to announce its agreement with CERN," said Karen Hawkins, IEEE Chief Marketing Officer. *"With this new agreement, CERN researchers now have new ways to publish the results of their research in the leading publications in their fields as open access and maintain access to all the published research in IEEE Xplore. We look forward to working with other institutions to create innovative agreements to share the work of leading researchers with the global research community to further scientific and engineering progress and support economic development."*

According to CERN Library section leader Tullio Basaglia:

"The CERN Library, as a matter of policy, is pursuing transformative agreements which combine OA publishing alongside reading access arrangements. Our aim is to eventually transition our spend over time to entirely support OA publishing services."

Basaglia further added: "As CERN is home to the world's largest scientific instrument, the Large Hadron Collider, the research conducted here goes beyond just high energy physics. We are particularly pleased to be entering into an agreement with IEEE to ensure that authors from among the community of thousands of engineers working at CERN are similarly able to benefit from open access publishing services."

To learn more about the IEEE open access options for authors and institutions, please visit: open.ieee.org

European Photonics Industry Consortium Forms Partnership with IEEE Photonics Society

The IEEE Photonics Society, a vital part of the world's largest technical professional organization dedicated to advancing technology for the benefit of humanity, and the European Photonics Industry Consortium (EPIC), a membership-led, not-for-profit industry association that promotes the sustainable development of organizations working in the field of photonics, have announced that their associations have entered into a multi-year agreement to promote joint activities, cross-disciplinary technical dissemination and cooperative programs between membership bodies.

Resulting from the Societies' agreement, both organizations seek to enhance engineers, physicists, scientists, industry professionals, and students access to industry-relevant training and continuing education opportunities in the related fields of the organizations' scopes, ranging from LED Lighting, Photovoltaic Solar Energy, Photonics Integrated Circuits, Optical Components to Lasers, Sensors, Imaging, Displays, Projectors, Optic Fibers, and other photonic related technologies.

> *"EPIC being the largest photonics industry association in the world, I am very much looking forward to partnering with the most important academic knowledge base in the world of Photonics. Together we will be able to achieve great things to the benefit of the Photonics community!"*
>
> —Carlos Lee,
> Director General at EPIC
> (European Photonics Industry Consortium)

EPIC offers a vibrant photonics ecosystem and strong network acting as a catalyst and facilitator for technological and commercial advancement throughout Europe. The IEEE Photonics Society will benefit from EPIC's relationship with start-ups, SMEs, large companies, research organizations and other stakeholders that accelerate technological advancements and reach emerging photonics markets.

The IEEE will provide EPIC's members access to highly cited publications, conferences, academics, and eligibility for annual awards contributing to advancements in technology. There are over 400,000 IEEE members in over 160 countries, more than 60 percent of whom are from outside the United States. As 1 of 39 technical Societies of the IEEE, the IEEE Photonics Society will provide avenues for local and international engagement with innovators the field and the next generation of photonics engineers and scientists of tomorrow.

The partnership will facilitate collaboration across the IEEE, launch initiatives, and recommendations for the development of products and services that meet the needs of industry.

> *"The IEEE Photonic Society's partnership with EPIC is a fantastic opportunity to work collectively to advance the missions of both organizations. It will directly support the efforts of the Society's Industry Engagement Committee to develop programs and activities that enhance the experience and engagement of Photonics Society members and the wider community working in industry."*
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> —Dalma Novak,
> IEEE Technical Activities Division X Director &
> IEEE Photonics Society
> Industry Engagement Committee Chair

The Society's Industry Engagement Committee, led by Novak, will directly steer services between the parties' agreement as well as encourage entrepreneurship initiatives and increase the elevation of industry members within relevant IEEE leadership positions.

Both parties will collaborate where possible to increase the endorsement of technology standards, roadmaps, information exchange, and community support of technician and trade development initiatives.

> *"I can't be more excited about working with the IEEE Photonics Society. Together we can boost innovation, by connecting academic knowledge with industrial unmet needs.*
>
> *This will result in industrial early adopters having quick access to leading R&D lines, and young entrepreneurs finding a direct link with their investors, customers and suppliers."*
>
> *—José Pozo,*
> *Director of Technology & Innovation of EPIC*
> *and member of the IEEE Industry Engagement Committee*
> *& board of the IEEE Photonics Society Benelux*

About European Photonics Industry Consortium

European Photonics Industry Consortium (EPIC) is the world-leading industry association that promotes the sustainable development of organizations working in the field of photonics in Europe.

EPIC fosters a vibrant photonics ecosystem by maintaining a strong network and acting as a catalyst and facilitator for technological and commercial advancement. EPIC publishes market and technology reports, organizes technical workshops and B2B roundtables, supports EU funding proposals, advocacy and lobbying, education and training activities, standards, and roadmaps, pavilions at exhibitions. www.epic-assoc.com

Careers and Awards

Board of Governors Candidates

Ballots for the election of candidates to the Board of Governors have been distributed to all voting members. We hope you will take the time to exercise your vote and help choose the future direction of the society. You will need your IEEE Account username/password to access the ballot. If you do not remember your password, you may retrieve it on the voter login page. Voting ends September 3, 2021

The candidates are:
- Arti Agrawal, University of Technology of Syndey, Australia
- Thomas R Clark, Jr., John Hopkins Applied Physics Laboratory, USA
- Amr S. Helmy, University of Toronto, Canada
- Hugo Hernandez-Figueroa, University of Campinas, Brazil
- Hitesh Mehta, Eagle Photonics, India
- Roland Ryf, Nokia Bell Labs, USA
- Elaine Wong, University of Melbourne, Australia
- Weidong Zhou, University of Texas – Arlington, USA

Please vote for up to FOUR candidates. **VOTE NOW** using the following URL: **https://eballot4.votenet.com/IEEE**

IEEE Photonics Society Selects the 2021 Distinguished Service Recipient

The Photonics Society Distinguished Service Award was established to recognize an exceptional individual's contribution of service which has had significant benefit to the membership of the IEEE Photonics Society as a whole. This level of service will often include serving the Society in several capacities or in positions of significant responsibility.

The 2021 Distinguished Service Award will be presented to Martin D. Dawson, "For sustained leadership in society governance from local to international level, with special distinction in conference organization and strategy."

Martin Dawson is Professor and Director of Research at the University of Strathclyde's Institute of Photonics (IoP) in Glasgow UK, which he helped establish 25 years ago. He is also, since 2012, the Head and Scientific Director of the Fraunhofer Centre for Applied Photonics, the UK's first Fraunhofer centre which is co-located with the IoP. Together, these two organizations employ over 100 staff and Ph.D./EngD students and have had funded R&D collaborations with over 150 companies.

Martin's research interests span III-V semiconductor materials science, microfabrication and optoelectronic and photonic devices, and extend to applications in communications, sensing, displays and imaging. He is best known for his pioneering contributions to gallium nitride micro-LEDs (a new form of electronic visual display technology), optically pumped semiconductor lasers and diamond photonics.

Martin has been involved in the creation and development of several spin-out companies, including mLED Ltd which was acquired by Facebook/Oculus in 2016. He holds fellowships of the IEEE, OSA, IOP and Royal Society of Edinburgh and he served as a member of the IEEE Photonics Society's Board of Governors from 2013–2015 and as Vice-President Conferences from 2016–2018.

Laura Lechuga and José Capmany Awarded the 2020 Spanish Research Award

The Spanish Research Awards were conferred last 17 May 2021 in a ceremony held in the Royal Palace of "El Pardo" (Madrid, Spain), in the presence of the King and Queen of Spain. Amongst the awarded researchers were two of our IEEE Photonics Society members: Prof. Laura M. Lechuga and Prof. José Capmany Francoy.

Prof. Laura Lechuga is the Head of the NanoBiosensors and Bioanalytical Applications Group at the Catalan Institute of Nanoscience and Nanotechnology (ICN2) and Full Professor of the Spanish National Research Council (CSIC). She received the "Juan de la Cierva" Award in the area of Technology Transfer, being the first woman ever to receive this recognition and thus breaking a new wall for female researchers The jury highlighted the quality of her work, which combines outstanding scientific research and technology transfer, translating results in patent development or spin-off companies' creation. The principal focus of her research is the development of novel nanobiosensor devices based on nanoplasmonics and silicon-based photonics for point-of-care diagnostics. She has been at the forefront of photonic biosensor research for more than eighteen years, making key contributions and opening new horizons in this technological field. She has published over 270 articles, book chapters, and proceedings, has 8 families of patents, and has presented her work worldwide in more than 360 invited talks. She has also co-founded the spin-off companies Sensia and Biod.

Prof. Laura Lechuga receives the National "Juan de la Cierva" Research Award from Spanish King Felipe VI.

"I am very honored of receiving this recognition and I hope it contributes to make visible the extraordinary talent of women scientists in our country" highlighted Laura.

Prof. José Capmany is Full Professor and lead researcher of the Photonics Research Labs (PRL) at Universitat Politecnica de Valencia. He was awarded the "Leonardo Torres Quevedo" Award in the area of Engineering for his pioneering contribution to the field of photonic engineering and optical telecommunications, through a cutting-edge scientific activity with a significant international impact. The jury highlighted as well the exemplary nature of Capmany's professional career, his leadership capacity and his perseverance in developing the practical application of his research. His work is a world-wide reference in the fields of microwave photonics and integrated programmable photonics. He has led more than 70 research projects and has co-founded the spin-off companies VLC Photonics, iPronics Programmable Photonics and Ephoox. He has published more than 600 journal and conference articles and is author of 19 patents.

Prof. José Capmany receives the National "Leonardo Torres Quevedo" Research Award from Spanish King Felipe VI.

"This award recognizes the top-level research and technology transfer work carried out by a group of distinguished and talented people, to which I dedicate the award. I am blessed with the daily privilege of working with them and feel very proud of contributing together to the development of science and photonics technology", pointed out José.

The Spanish Research Awards aim to recognize the merit of Spanish researchers who are carrying out an outstanding work in scientific fields of international relevance and their extraordinary contribution to the scientific progress, the transfer of technology and the progress of Humanity. These prizes grant 30.000€ per category. The Kings of Spain, Philip VI and Letizia, highlighted the special relevance of the awards granted this year because *"effective vaccines to stop coronavirus pandemic have been delivered in a surprisingly short time period thanks to science and innovation research"*.

Awards

Society Members Honored at IEEE VIC Summit

The IEEE Vision, Innovation, and Challenges (IEEE VIC) Summit was held as a virtual event May 11–13, 2021. The event included the presentation of IEEE's highest awards during the IEEE Honors Ceremony. These awards, presented on behalf of the IEEE Board of Directors, are given to a diverse array of engineers, technologists, scientists, and practitioners who truly exemplify the mission of the IEEE of advancing technology for the benefit of humanity.

Please join us in congratulating the Photonics Society members who were honored at this event and whose achievements serve as an inspiration to the next generation of technologists.

IEEE/RSE James Clerk Maxwell Medal

Sponsored by ARM, Ltd.

Evelyn L. Hu

For leadership in nanoscale science and engineering, and for seminal contributions at the intersection of semiconductor electronics and photonics

A pioneer in the development of semiconductor nanostructures, Evelyn L. Hu has been pivotal in pushing microelectronics to smaller size regimes for production of more-efficient, higher-performance photonic devices. The techniques she has helped to develop have found broad use in patterning and sculpting semiconductor structures at the nanoscale, with an emphasis on low-damage techniques that preserve the photonic and electronic performance of the underlying materials. Bridging diverse fields of applied physics, materials science, soft condensed matter, and electrical engineering throughout her career, Hu brought interdisciplinary teams together to match nanofabrication techniques with the integration of materials and devices that demonstrate exceptional electronic and photonic behavior for efficient control and coherent output of devices. Most well known for her seminal work in III-V and III-nitride semiconductors that efficiently interact with light, her early work at Bell Labs included the application of e-beam lithography for the nanofabrication of superconducting tunnel junctions and the dry etching of narrow silicon MOSFETs, laying the groundwork for electronic devices that are fabricated so small that quantum mechanical behavior comes into play. She played a central role in the University of California at Santa Barbara's world-renowned Center for Quantized Electron Structures (QUEST) in developing appropriate processing techniques for patterning a wide variety of III-V semiconductor materials required to realize a full range of quantum electronic and optoelectronic devices. She has had great impact on today's technologies, in particular III-nitride light emitting diodes, and her recent research at Harvard University is being applied to the emerging field of quantum technologies. Her breakthroughs in tightly confining light at the nanoscale, and efficiently coupling it to solid-state quantum photonic platforms, have led to discoveries in generating quantum light or storing quantum information in atomic-like spin states.

An IEEE Life Fellow and fellow of the American Academy of Arts and Sciences, Hu is the Tarr-Coyne Professor of Applied Physics and Electrical Engineering at the John A. Paulson School of Engineering and Applied Sciences at Harvard University, Cambridge, MA, USA.

Scope: For groundbreaking contributions that have had an exceptional impact on the development of electronics and electrical engineering or related fields.

IEEE Jun-ichi Nishizawa Medal

Sponsored by the IEEE Jun-ichi Nishizawa Medal Fund

James J. Coleman

For contributions to the development of strained-layer semiconductor lasers

Ushering in a new era of laser design, James J. Coleman's work on strained-layer semiconductor lasers has enabled high-power lasers for all-optical telecommunications systems and technologies we take for granted today such as DVD players and laser pointers. Coleman recognized early the importance of strained layer lasers as efficient sources in the 980-nm pump band of erbium-doped fibers and was the first to systematically study and demonstrate reliable strained-layer semiconductor layers operating in the 900-1100-nm range using indium gallium arsenide quantum wells. His pioneering studies were the first to relate strain, performance, and reliability in this system and confirmed earlier predictions that threshold current densities are lower for these devices compared to unstrained lasers. These lasers are now widely used in fiber-optic telecommunications networks as pump sources for optical amplifiers. The simple, all-optical erbium-doped optical-fiber amplifier has replaced more complex, more costly, and less reliable optical-electrical-optical regeneration circuitry. Prior to Coleman's work there had been theoretical predictions of the potential advantages of strained quantum-well lasers in the 980-nm band; however, his experimental work established their commercial viability, which was crucial for the acceptance of this technology. Today, virtually all semiconductor lasers routinely use strain-reduced valence band (hole) effective mass as a design variable. In his early career, Coleman contributed to the development of long wavelength telecommunication diode lasers grown by liquid phase epitaxy, and he was involved in early demonstrations of the effectiveness of metalorganic chemical vapor deposition (MOCVD) to make quantum well lasers, solar cells, and photodetectors with better performance characteristics. His more recent work includes high-performance lasers, integrated lasers, and other photonic devices produced through selective-area epitaxy and novel growth processes for quantum-dot lasers and other three-dimensional nanostructures. Other commercial products also utilize his laser designs for applications in displays and information storage and retrieval.

An IEEE Fellow and member of the U.S. National Academy of Engineering, Coleman is the Presidential Distinguished Professor of Photonics at the University of Texas at Arlington, Arlington, TX, USA.

Scope: For outstanding contributions to material and device science and technology, including practical application.

IEEE Edison Medal

Sponsored by Samsung Electronics Co., Ltd.

Kenichi Iga

For pioneering contributions to the concept, physics, and development of the vertical-cavity surface-emitting laser

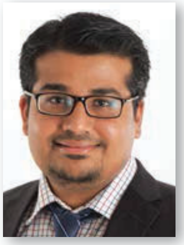
Kenichi Iga's pioneering development and continuous improvement of the vertical-cavity surface-emitting laser (VCSEL) has provided an indispensable technology powering applications ranging from short-range optical communications to high-speed printers and facial recognition sensors in smart phones. In 1977 Iga proposed the VCSEL and two years later he demonstrated a current-driven VCSEL at 77K. His goal was to change the direction of the light output from parallel to the substrate surface as in conventional edge-emitting lasers to perpendicular to the substrate surface. This format provided advantages including: a maximum operating power that was not limited by catastrophic optical damage of the exit aperture as in edge-emitting lasers, lower-cost production because testing can be performed while the devices are still in wafer form, and more reliable operation. Iga and his team worked to overcome challenges in improving the technology and recorded many milestones in VCSEL development. He succeeded in achieving continuous surface emission at room temperature of 850-nm band, which demonstrated the potential of VCSELs as an engineered semiconductor laser for the photonics community. He achieved the first room-temperature operation of 1300-nm lasers in 1993. Iga has demonstrated many unique features of VCSELs, including circular output beam, ultra-low-threshold current, ultra-low driving power consumption, dynamic single-frequency operation, and high-speed modulation, all originating from a short cavity length and a small cavity volume. He also introduced highly reflective semiconductor multilayered distributed Bragg reflectors and multi-quantum-well high-gain media into VCSELs, a proof-of-concept experiment of wavelength tunable VCSELs, and two-dimensional integration and operation of VCSEL arrays. The first high-volume commercial use of VCSELs was as the light source for high-speed LAN. Another commercial use of VCSELs was in computer mice, where the small-diameter circular beam and low power consumption made them ideal for precise pointing functions. The VCSEL arrays developed by industries world-wide significantly improved the performance of laser printers and sensors and led to today's smartphones employ hundreds of VCSEL chips for facial recognition applications.

An IEEE Life Fellow and foreign member of the U.S. National Academy of Engineering, Iga is Professor Emeritus and former president of the Tokyo Institute of Technology, Tokyo, Japan.

Scope: For a career of meritorious achievement in electrical science, electrical engineering or the electrical arts.

IEEE Theodore W. Hissey Outstanding Young Professional Award

Sponsored by the IEEE Young Professionals, the IEEE Photonics Society, and the IEEE Power & Energy Society



Kartik Kulkarni

For contributions to the technical fields of transactions and in-memory databases, as well as for enabling young professionals working on technologies for sustainable development

An expert in data management, transactions, and memory hardware-aware data access, Kartik Kulkarni has helped engineer the massive scaling of the Oracle database engine by leveraging the hardware advantages of in-memory data storage and parallel computing on thousands of server threads critical to meeting the needs of "big data" and real-time analytics. The algorithms coded by Kulkarni and his group are critical to the performance of transactions processed by the Oracle database, which has more than half of the market and enterprise data volume share in the world. Kulkarni has also been dedicated to using his expertise and influence in advancing technology for humanity. As chairman of the IEEE Humanitarian Activities Committee from 2019–2020, he directed IEEE's portfolio of programs and multimillion-dollar project investments that leverage the worldwide IEEE membership in applying and advancing technology solutions for sustainable development. In 2020, he led the IEEE member-driven COVID response by supporting 101 projects around the world. He has also chaired the IEEE SIGHT (Special Interest Group on Humanitarian Technology) Steering Committee, which created a network of 100 groups of engineers in 40 countries working on sustainable development. Through SIGHT, Kulkarni has provided young engineering professionals with meaningful engagement opportunities in IEEE beyond just access to professional and technical resources. Kulkarni was honored in 2009 as one the IEEE Distinguished Student Humanitarians in the first IEEE Presidents Change the World Competition for leading a team of university student volunteers in developing electronic learning methods for children at the Ushas Center for Exceptional Children in Hubli (Karnataka), India.

An IEEE Senior Member and immediate past chair of the IEEE Humanitarian Activities Committee, Kulkarni is the manager of special projects with the Database Engine Team at Oracle Corporation, Redwood City, CA, USA.

Scope: For contributions to the technical community and IEEE fields of interest.

2021 Laser Instrumentation Award Recipients Announced

The **Photonics Society Laser Instrumentation Award** was created to recognize key contributors to the field for developments of laser-based and electro-optical instruments, which lead to the development of innovative systems enabling major new measurements or process capabilities of relevance to applications in industrial, biomedical avionic and metrology fields.

The field(s) considered are: classical and Self-Mixing Laser Interferometry; Optical Coherence Tomography, Digital Holography; Diffraction and Interference-based Measuring Devices like Particle Size Analyzers; Laser Interferometers; Optical Gyroscopes; and Laser Doppler Velocimeters; Measurements of distance and kinematic quantities, realized in either bulk optics or integrated optics technologies.

The 2021 Photonics Society Laser Instrumentation Award recipients are Scott Diddams, Andrew ‘AJ Metcalf and Connor Fredrick, “*For development, deployment, and operation of an electro-optic laser frequency comb that enables the most precise near-infrared astronomical Doppler spectroscopy*.”

Scott Diddams is a Fellow of the National Institute of Standards and Technology (NIST) and an Adjoint Professor at the University of Colorado, where he carries out experimental research in the fields of precision spectroscopy and metrology, nonlinear optics, microwave photonics and ultrafast lasers. He received the Ph.D. degree from the University of New Mexico in 1996. From 1996 through 2000, he did postdoctroral work at JILA, NIST and the University of Colorado. Since 2000, Diddams has been a research physicist at NIST where he has pioneered the development of optical frequency combs and their use in optical clocks, tests of fundamental physics, novel spectroscopy in the visible and mid-infrared, and ultralow noise frequency synthesis. In recent years, special attention has been given to infrared frequency comb sources as well as high repetition rate laser-based and microresonator frequency combs, which are being explored for applications in microwave photonics and astronomy. Among many awards, Dr. Diddams received the Department of Commerce Gold and Silver Medals for “revolutionizing the way frequency is measured”, as well as the Presidential Early Career Award in Science and Engineering (PECASE), and the IEEE Rabi award. He is a Fellow of the Optical Society of America and the American Physical Society and a Senior Member of IEEE.

Andrew ‘AJ Metcalf is a civilian research scientist at the Air Force Research Laboratory. Dr. Metcalf earned his BS in Electrical and Computer Engineering from University of Wisconsin-Milwaukee and his MS and Ph.D. degrees from Purdue University. He worked for two years at Harley Davidsons Product Development Center, five years at Purdue’s Ultrafast Optics and Fiber Communications Laboratory, and three years at NIST’s Time and Frequency Division in Boulder CO. Dr. Metcalf’s research has focused on the generation and manipulation of optical frequency combs to target a diverse set of applications. In 2018 he joined AFRL’s Space Vehicles Directorate where he led an S&T program developing Quantum technology for space applications. Dr. Metcalf now serves as the Directorates Mission Lead for all Space Communication and Position Navigation and Timing research. Dr. Metcalf is a senior member of IEEE, a member of OSA, AIAA, and Tau Beta Pi. He has published over 60 articles in peer-reviewed journals, conference proceedings, and strategic S&T documents. His awards include the 2010 UWM CEAS Deans Award, 2018 Eaton Award in Design Excellence, 2019 AFRL Space-Vehicles Civilian of the Year, and the 2020 AFRL Directors Cup Award.

Connor Fredrick is a Ph.D. candidate at the University of Colorado Boulder and works in Scott Diddams’ group at NIST. His research focuses on lasers, nonlinear optics, and optical frequency combs with an emphasis on applications for precision astronomical spectroscopy.

Call for Nominations: IEEE Technical Field Awards and Eric Herz Staff Award

Nominations are open in early July IEEE Technical Field Awards (TFA) and the IEEE Eric Herz Outstanding Staff Member Award.

Nomination guidelines, award-specific criteria, and components of a nomination form for TFAs and the Herz Award can be downloaded from https://ieee.secure-platform.com/a/page/ieeemedals_recognitions_techfieldawards/ieee_technical_field_awards and http://www.ieee.org/about/awards/recognitions/recognitions_herz.html. Nominations are due **15 January**. All nominations must be submitted through the online nomination portal.

Since 1917, the IEEE Awards Program has paid tribute to technical professionals whose exceptional achievements and contributions have made a lasting impact on technology, society, the engineering profession, and humanity. By this means, the image and prestige of the organization, its members, and the profession are all enhanced.

For more information about IEEE Awards, visit https://corporate-awards.ieee.org/corporate-awards/ or e-mail awards@ieee.org.

Membership

IEEE Introduces New IEEE Diversity, Equity, and Inclusion (DEI) Website

To further promote diversity, equity, and inclusion in the IEEE and the engineering profession, the organization has launched a new website that contains a wealth of information, resources, and tools for members, volunteers, and the broader community. Developed by the IEEE Ad Hoc Committee on Diversity, Inclusion, and Professional Ethics, this website builds on the momentum of recent diversity and inclusion actions across the IEEE, including adoption of the IEEE Diversity Statement in 2020 and a significant overhaul of reporting and adjudication process for ethics violations released earlier this year.

The website launch also follows the reaffirmed statement of the president, past president, and president-elect of IEEE, which states that "IEEE is, and remains, strongly committed to diversity, equity, and inclusion and we see no place for hatred and discrimination in our communities.

The platform lists a variety of IEEE resources such as its nondiscrimination policy, code of ethics, and accessibility statement. The new site also highlights ongoing efforts by various IEEE groups that are taking action toward building a diverse, equitable, and welcoming environment such as IEEE regions and geographic units, technical societies, the IEEE Board of Directors, Technical Activities Board committees, and IEEE Women in Engineering.

In addition, the website includes links to resources that are taking initiative in the diversity, equity, and inclusion arena.

"The website will serve as a critical resource for our members, volunteers, and the broader engineering community. It will showcase the importance of diversity in creating technology to benefit humanity, provide resources for awareness and best practices around diversity, inclusion, and equity, and inspire through storytelling about diverse members and their impact. I envision this website as a catalyst to improve diversity, inclusion and equity in the IEEE and in the profession" says Andrea Goldsmith, chair of the Ad Hoc Committee on Diversity, Inclusion, and Professional Ethics.

The new web presence further reflects IEEE's longstanding commitment to engage diverse perspectives for the betterment of the engineering profession, ensuring a welcoming environment that equitably engages, supports, and recognizes the diverse individuals dedicated to advancing technology for the benefit of humanity.

Visit the DEI Website, here: *bit.ly/3hyjR7t*

IEEE Pride in Photonics Initiative Featured as DEI Website Best Practice: For Building a More Vibrant and Safer Community

The IEEE has featured the IEEE Pride in Photonics initiative, led by the IEEE Photonics Society, as a best practice to celebrate the work of LGBTQIA+ people in STEM, create spaces to openly share personal experiences, and increase acceptance of inclusion.

"LGBTQIA+ discrimination is still present in the STEM field, leading us to closets, career difficulties, and sometimes to dropping out entirely. These adversities greatly intensify for trans researchers. Things are luckily changing, but we need to facilitate this change through education in the workplace, updated administration policies, and visible role models."

- Aitor Villafranca Velasco (He/Him), IEEE Photonics Society Associate Vice-President for Equity & Inclusion and current lead of the IEEE Pride in Photonics initiative.

A significant fraction of LGBTQIA+ physicists have experienced or observed exclusionary behavior in STEM. A report, "Exploring the Workplace for LGBT+ Physical Scientists," conducted by the Institute of Physics, Royal Astronomical Society and Royal Society of Chemistry, shows that LGBTQIA+ students are less likely to follow an academic career, half of transgender/GNC physicists were harassed in academia, and one-third of out American physicists have been told to stay in the closet in the workplace.

In order to build a more inclusive community, the IEEE Photonics Society leads with the understanding that identity and its impact on individuals and institutions can improve equity in education and the workplace. For example, LGBTQIA+ people in STEM often experience difficulty identifying allies and mentors to help mitigate isolation, exclusion, or marginalization. In turn, the initiative's in-person and virtual events seek to create a welcoming atmosphere for LGBTQIA+ scientists to be their authentic selves, in the company of allies, as well as inspire collaboration, invite open conversation, create educational opportunities, and network through technical dissemination.

"As a queer woman in STEM, one thing that I believe is that LGBTQIA+ people should not need to change themselves so that they can benefit from careers in STEM. Instead, we need to change the culture of STEM careers so that we can benefit from more people from all walks of life. Everyone should feel safe, respected, and valued as their authentic selves, in the path that they would like to pursue."

- Dr. Niamh Kavanagh (She/Her), IEEE Photonics Society Diversity Oversight Committee Chair and Co-Founder of the IEEE Pride in Photonics initiative.

In June 2021, the Society supported another Pride Month talk given by JanMell Dugenio, Trinity College Dublin, on, *"The Persistent Struggle for Pride in the Philippines: A Case Study of the Status of Queer People in STEM in a Developing Country."* She addressed the importance of LGBTQIA+ visibility in STEM, how diversity and inclusion can lead to innovation, and the need for mentorship resources for marginalized groups and the queer community. As a trans woman in STEM, from a developing country, Dugenio expressed the journey of applying for a Ph.D. position, emigrating from her home country, and the challenges she faced along the way. The stories of LGBTQIA+ scientific leaders, like this, can serve as inspiration, motivation and a model for others to follow.

To learn more about IEEE Pride in Photonics, visit: *bit.ly/2XbVh1J*

PHOTO CREDIT: IEEE PHOTONICS SOCIETY

"JanMell Dugenio, from Trinity College Dublin, shared her story to serve as a mentor to other marginalized members in the LGBTQIA+ community."

IEEE Women in Photonics: Expanding Resources to Emphasize the Importance of Gender Diversity in STEM

Q&A with new Associate Vice-President of Women in Photonics on her plans to address gender gap disparities in the photonics community.

The IEEE Women in Photonics initiative was created to promote activities that support the participation, engagement, and advancement of women in the photonics and optics community. In partnership with the IEEE's parent Women in Engineering program, the Society organizes various professional development and technical events, such as tech talks, soft skill seminars, summer schools, networking mixers, K-12 outreach, chapter workshops, meet-ups and online events. Together the hope is to inspire girls and women around the world to follow their academic interests and scientific, professional pursuits.

The IEEE Photonics Society also recognizes that diversity and inclusion are essential to innovation. In turn, the IEEE Women in Photonics initiative seeks to diversify the range of individuals, allies and perspectives building the technology and information of tomorrow, for all.

As the IEEE Women in Photonics program enters its eighth year, a new Associate Vice President (AVP), Professor, Deepa Venkitesh from the Department of Electrical Engineering at Indian Institute of Technology Madras (IIT), has been appointed to steer the continued development of programs directed towards the advancement of women. Her scientific interests include *Photonic Signal Processing for High Capacity Optical Communication, Microwave Photonics, Narrow Line and High Power Fiber Lasers*. However, she will strive to advocate for all women seeking to excel in their respective scientific areas of interest.

To learn more about Venkitesh's drive to support youth in STEM and her plans to address gender disparities in the photonics community, a short Q&A overview is below.

More on the IEEE Women in Photonics' long-term campaigns and volunteer opportunities during her tenure will come in future newsletter issues throughout this year and next.

As the Associate Vice President for the IEEE Women in Photonics program, what are some specific goals you'd like to accomplish within your role?

At the outset, I am thankful to those who trusted me with this leadership position. I wish to keep my goals simple, pragmatic, and sustainable. The following are the three areas that I would like to initially focus on, during my tenure:

Reignite: Back to Career (BTC) Initiative—IEEE Women in Photonics plans to roll-out a targeted initiative to strategically reach and better support women and gender minorities who are returning or transitioning to photonics and optics fields. It will include mentorship pairings, soft-skills trainings grants to support individualized project goals and onboard learning. Across the globe, the scientific community has seen many women discontinuing their jobs/ R&D positions - both in academia and industry. These are mostly due to their life and cultural commitments—*family, relocation, childcare, caregiving, and so on*. After a break of more than two years, their confidence levels tend to spiral down and getting back into research environment becomes much harder. Isolation from the scientific community, lack of mentorship, ever-evolving requirements from industries, rapid shifts in the skill-set needs, competitiveness in the tech space—all compound to a reluctance to join back to a career commensurate with their abilities. This comes at a cost and detriment to the knowledge domain and scientific community in general, as the loss of trained and talented women greatly contributes to the 'leaky pipeline' and lack of diverse, social, and technological advancements in the field.

The BTC initiative seeks to: *(a) Proactively identify women and gender minorities who wish to transition back into the photonics and optics community, i.e. both within academia and industry, after a prolonged break. This will be done through concentrated outreach efforts, such as assessing retention information, supporting localized chapter recruitment activities to better understand global circumstances/needs, addressing university teaching faculty (those who are not involved in research), and through working closely with diversity partners; (b) Expose participants to new career possibilities and provide mentoring services through a mentor/mentee match, in-person at conferences and online; (c) Offer seed grants for continuing education trainings, financial hardships during transitions, onboarding support, individualized project goals, etc.; (e) Sensitize senior professionals and employers towards understanding and accepting professionals returning to the work place often with gaps in a resume. Constructive trainings and interpersonal sessions for hiring management will be offered.*

Strengthen the "Introduce a Girl to Photonics" Program—High school and pre-university students are not typically exposed to the word Photonics', let alone the infinite possibilities of the subject and its impact in different domains. Awareness about the subject could greatly change the perspectives young women and girls have towards pursuing STEM in general. With the help of chapters and devising strategic grassroots drives, the IEEE Women in Photonics program intends to inspire young minds to cultivate interests in light-based sciences as well as dedicate resources and funding towards STEM Outreach each year.

Volunteers will be encouraged to coordinate K-12 STEM activities to show how photonics impacts the daily lives of all around the world. In conjunction, successful and diverse women members will also be recruited to regularly serve as role models, share journey stories, and guide curriculum development to inspire and motivate the next generation of women in photonics.

PHOTO CREDIT: IIT MADRAS

"Deepa Venkitesh, AVP of Women in Photonics, with distinguished researcher Agrawal and her team consisting of Post-Doctoral Fellows, Ph.D. students and a visiting student in her lab at IIT Madras, India. Venkitesh is passionate about instilling gender sensitivity and balance within her group as well as providing her students with invaluable mentorship opportunities."

<ins>*Encourage More Women Participation in Conferences*</ins>—Alongside the Society's Professional Advancement Committee, a Working Group is being formed to address gender balance disparities within conferences. The group plans to create accountability guidelines for conference leaders to follow and enforce within sub-committees to better support diverse recruitment and gender balance of keynote speakers, invited talks, posters, tutorials, and more.

A proposed first accountability project is: *Creating an active recruitment database of women and gender minorities willing to serve within their expert areas and/or specific areas of scientific interest. The Society would actively make this vetted database available to General Chairs and Technical program committee leaders, in order to expand diverse programs, representation and accessibility to talent. This database could also support Editors of prominent journals when recruiting Associate Editors and contributors for editorial teams.*

Why Photonics? What sparked your interest? Can you describe the moment you realized this was a field you'd like to pursue?

I don't think I can identify a specific "Aha" moment where I decided that I would pursue Photonics. It might sound clichéd, but Optics always fascinated me because one can "see" and thus get a firsthand experience of most of what is taught in a first course. I must say, the teacher who taught Physics in high school had a very big role to play in deciding the choices I would make later. This is one of the reasons why I am passionate about investing more resources and time into growing the "Introduce a Girl to Photonics" and STEM programs.

PHOTO CREDIT: IEEE PHOTONICS SOCIETY"

"Over the pandemic several IEEE Women in Photonics events and strategy meetings have taken place with allies to advance the mission and celebration of gender inclusion."

PHOTO CREDIT: IIT MADRAS

A live demonstration given by her lab group on 'Radio Over Fiber for Wireless Communication' in the National Conference on Communication.

I had pursued Physics and Maths during my undergrad and master's degree programs. Considering the innumerable opportunities that Photonics opened in the engineering world, my focus is on the interesting engineering applications of light manipulations since my early career. I am of course still learning and continually amazed at the infinite possibilities that light has to offer!

What about the IEEE Photonics Society's Mission and the work of the Diversity Oversight Committee really motivates you? Why do you volunteer?

IEEE Photonics Society has been initiating a lot of proactive programs that are specifically targeted to instill and celebrate diversity in the community. The volunteers involved in these activities, their passions for change and their commitment to the cause is addictive. I also think of this as a wonderful opportunity I have been given, AVP of Women in Photonics, as a way to represent the Indian perspective. I am considering ways I can increase the number of Photonics based research activities throughout in India, in addition to my global work.

Why do you think it is important to cultivate scientific curiosity in young girls early?

I feel it is important to ignite scientific curiosity in all young children in their crucial stage of cognitive development. Rather than rote learning, inculcating scientific curiosity by encouraging them to ask questions in an early age would make them better thinkers and better problem solvers. Science does not favor gender, but somehow the women representation in STEM gradually tapers down when children grow. Several factors contribute to this, which could get complicated to analyze. In communities and cultures where gender bias is ingrained in the social structure for various reasons, it is much harder for young women to imagine or dream of themselves in STEM careers.

It is the Society's hope to offer programs and options where collectively, we as a community can eliminate barriers of entry and change mindsets. Allow young women and girls interested in STEM to pursue and do what they enjoy the most. My pursuits will be focused on offering more experiential learning opportunities, which is a crucial factor in fostering scientific interest. Successes in small experiments give a sense of accomplishment and can inculcate confidence in young girls. I am tempted to quote Gandhiji here, "If you educate a man you educate an individual, but if you educate a woman you educate an entire family", and hence society.

Chapter Best Practice Spotlight: IEEE Women in Photonics Affinity Group Outreach in Oakland

This past Spring 2021, the IEEE Women in Photonics Silicon Valley Affinity Group held a jointly sponsored event with The Optical Society and SPIE. Molly Anderson, of Lighthouse Community Charter School (LCCS), and Meilin Lu, of Lodestar Charter School, in Oakland partnered with the group on a 2-Day STEM session to reach 50 students in eighth grade. Interactive, online demonstrations on total internal reflection and its use to power fiber optic communications were given via Zoom. The program was effective, as each public school supports collaborative education opportunities and was eager to work with local volunteers drawn from the technology industry. LCCS also has a Family Resource Center, a place for parents to build a strong social network to share needed resources, such as technology education and literacy as well as hands-on STEM trainings.

During this online activity, students and parents were provided kits, containing plastic optical fiber, green filters, and SPIE's 'Women in Optics and Photonics' planners. In total, 150 kits were distributed across all the classrooms of 8th grade. The instruction was led by the Women in Photonics Silicon Valley Affinity Group, i.e. *Sri Priya Sundararajan, Sabarni Palit, Juthika Basak, Rebecca Schaevitz, Maria Mirianishvili, Taylor Lacey, with Spanish translations by Miriam Clifford*, and advised by *Gloria Hoefler* and *Shalini Venkatesh*.

Initially, the students were shy, interacting more with teachers rather than the volunteers, but as the hour went on and the leaders held icebreaker activities and concept lessons, they warmed up by peppering the scientists with questions, such as *"Does all the light stay in the plastic rod, or does some of it leave?"* and *"How do you decide if you want to be in Space science or Optics?".*

The first video demonstration walked the students through a demo of 'Total Internal Reflection' and light guiding, using a green laser and plastic optical rod. The second demonstration followed up with a video illustrating light coupling into a plastic optical fiber using a white light source, and then followed by a green filter.

After the plastic optical fiber demo at the second session, the organizers were excited to see one intrepid student achieve light guiding on her own. It was a quiet moment but a satisfying one, one that made the weeks of effort leading up to the event, the socially distanced packing of kits, enlisting Spanish language support, conducting dry runs online, debriefs and planning sessions, all worth it.

The team wrapped up both sessions with an open discussion where the scientists shared their own personal journeys and provided a few words of encouragement to the students. A recognition card was given to the team that included appreciative quotes from her students, like *"it was super fun and I was really entertained listening to real scientists speak to us about cool stuff."* Students, parents, teachers, and scientists all walked away from the event recharged and rewarded.

This initiative directly aligns to the parent IEEE Women in Photonics' goal of inspiring young minds to cultivate interests in light-based sciences and dedicating funding towards small events, hands-on activities, or classroom presentations in local communities. If your chapter or local affinity group would like to hold a similar event, please contact: PhotonicsChapters@ieee.org

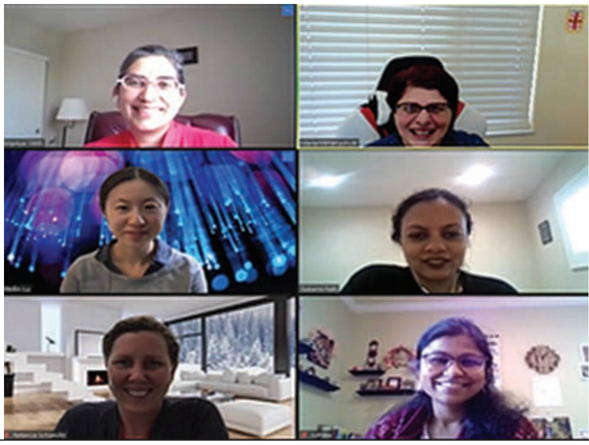


PHOTO CREDIT: SILICON VALLEY IEEE WOMEN IN PHOTONICS

"The Silicon Valley IEEE Women in Photonics Affinity Group held interactive, virtual sessions with local Oakland schools to engage K-12 students in light-based science activities. They prepared kits by hand for 8th grade students to participate from home via Zoom."

Students in Transition: New Society Strategic Leadership Directions

Building leadership skills are essential aspects one can gain as a member and volunteer. Students need to experience leadership opportunities during their academics to build relationships within teams, establish leadership styles, grow interpersonal skills, and balance projects. In support of this, the IEEE Photonics Society and Associate Vice-President (AVP) of Student Membership, Yesenia Rivera-Lopez, a student from the Puerto Rico Photonics Institute and the University of Puerto Rico, is crafting new opportunities and positions to train future leaders and innovators of tomorrow. It also provides a learning opportunity where students work intergenerationally with senior members, fellows, and mentors.

"I believe our involvement in activities of outreach and volunteerism help us gain experiences in professional interactions, from academic years and early careers, which leads to potential opportunities in the industry and academia. Leadership activities are important in unifying capabilities of the public and Scientific groups with the aim of expanding our resources and helping communities."—Yesenia
Rivera-López, Associate Vice-President (AVP) of IEEE Photonics Society Student Membership


PHOTO CREDIT: IEEE PHOTONICS SOCIETY

"IEEE Photonics Society student leaders, Associate Vice-President (AVP) of Student Membership Yesenia Rivera-Lopez, and, STEP Representative Naznin Akter, are working to advance opportunities that will help student members develop professional skills and identities in the photonics and optics community."

For example, a *'Student Task Force'* has been established to drive student programs and recruitment initiatives to support the Society's goal of delivering valuable member

IEEE PHOTONICS SOCIETY

"The IEEE Photonics Society supports student activities worldwide. However, its leadership recognizes that more can be done to nurture student talent and its growing membership base. Resources and funding opportunities will come from a new Student Taskforce and revitalized STEP program."

experiences and benefits globally. The student leadership positions available on the Taskforce include *Technical & Career Activities; Education & Leadership Training; IEEE Etta Kappa Nu (HKN); Membership & Chapter Development; Technician/Trade Representatives; Newsletter & Social Media Editors; etc.* Furthermore, the AVP of Student Membership is open to additional position proposals if a member has a creative project they'd like to lead.

Any Associate of Applied Science (AAS), undergraduate, and graduate student member should consider applying. If interested in joining this team, learn more here: *https://bit.ly/3jnILJf*

Another outreach area of development for students, which has been revitalized, is the *'IEEE Student Transition and Elevation Partnership'* (STEP) program. Under the direction of the Professional Advancement and Young Professionals Advisory Committees, Naznin Akter, a Graduate Research Assistant at Florida International University, is serving as the Society's STEP Representative. Her goals are to devise and facilitate intermediate programs and professional activities to assist undergraduate students during their first-degree transitions or as graduate students evolve into young professionals at the onset of entering the workforce.

"Volunteering, in my opinion, can help students progress academically and professionally. They can obtain practical experience and strengthen skill sets, such as leadership, problem-solving, time management, and emotional intelligence. These crucial skill sets help students succeed in their post-graduation professions." - Naznin Akter, IEEE Photonics Society STEP Representative

The STEP program will bring valuable soft skills and career-oriented activities, such as *Value of Mentorship: Mentoring Up Concepts; CV Reviewing/Mock Interviewing; Salary Negotiations; Understanding the Patent Process/Intellectual Property; Leading Project Teams: Emerging Technologies & Smart Design; Bridging Leadership Gap: Connecting Technical Skills w/ Management Skills; Evolving Role of the "Traditional" Engineer; Engineering Ethics; Reviewer Training; Diversity & Implicit Bias; Mental Health Literacy; etc.*

The IEEE Photonics Society supports delivering high-quality student member experiences for lifelong, professional success and helping students grow into productive young professionals with diverse networks.

To learn more about the IEEE Young Professionals program, visit: *yp.ieee.org*

To learn more about IEEE Student Resources, visit: *students .ieee.org.*

People and Culture—Factor Number One to Success

Patryk Urban, IEEE Photonics Poland Chairman, IEEE Photonics Globalization and IEEE Photonics Industry Engagement Committee Member

Adam Piotrowski, Ph.D.
CEO VIGO System S. A.

In this series partnered by Wave-Jobs we invite people at different career stages to share about their experience in Photonics and lessons-learnt in professional development. Today we interview Dr. Adam Piotrowski, CEO, VIGO System S.A., Poland, very successful Warsaw stock-indexed company focused primarily on photodetectors technology.

Patryk: What is the field of your interest in Photonics and how did it all start in your life?

Adam: It all started quite early on in my life. My father was professor at Military University of Technology, Warsaw, Poland. When I was a kid he used to take me to his laboratories where I spent hours listening to passionate scientific discussions. That's where I first learned about semiconductors, detectors and new inventions. He inspired my career path. In the 1970s my father and his team developed the technology of HOT IR detectors. His discovery laid the foundation stone for a dynamic development of infrared detectors technology, culminating in the creation of VIGO in 1987. 15 years later I joined as full time engineer in the epitaxial laboratory. Over 30 years, VIGO System has grown from an innovative research based company with a handful of employees into a global, medium-sized manufacturing company with around 170 employees, which produces the best in the world high-tech uncooled photodetectors.

Patryk: What do you consider to be your biggest achievement and contribution so far to the development of Photonics science and industry?

Adam: The detectors industry is a truly high-tech industry requiring highly specialized and skilled experts. We boast a number of top-notch specialists and R&D professionals who in many cases are pushing the boundaries of what is technically feasible. But the key thing is to provide solutions that are not only technically feasible, but also commercially viable. My biggest achievement is that I have been able to translate VIGO's unique research discoveries into practice. I have developed and implemented MOCVD technology which formed the basis for the production of VIGO's MCT detectors. VIGO has in-house capabilities for the entire development chain—from epitaxial growth, through device fabrication, to assembly of fully packaged modules and subsystems. We have also launched III-V epi-foundry producing epitaxial structures for photonic devices such as lasers and photodetectors, microelectronic devices and others. We are planning the acceleration and upscale of the detectors production, broadening products offer with new high quality detectors and developing new applications for photonic devices such as PICs (Photonic Integrated Circuits). We also intend to control all key technology chain links including fabrication of semiconductor materials (MOCVD and MBE epitaxy) and epi-wafers characterization.

Patryk: What excites you most and keeps you motivated to further contribute to this field?

Adam: It may sound a bit pretentious but what truly excites and motivates me is the real impact VIGO can bring into people's everyday lives. After all, we all want to make a positive difference in the world. Our products find applications in vital economy sectors: environment protection, science and medicine, safety and defense, chemical analysis, transportation. Our gas analysis detectors have even been used in Curiosity rover sent to Mars for space exploration. The opportunities and potential in the industry are near an all-time high. So there is so much more we can do.

Patryk: What are the main obstacles you and your peers experience when hunting for proper candidates?

Adam: The most challenging is to find candidates with strong technical background that meet the company's needs. And these can be broad. In our team we have specialists across the entire photonics/semiconductor production chain, from epitaxy through processing and device assembly to final measurements. Photonics is truly highly specialized and dynamically developing industry and it is quite challenging for universities to adapt to and serve this changing demand.

Another issue is that even if universities can provide their students or graduates with the appropriate technical skillset, they offer limited preparation for tackling real life situations. Candidates need life skills as well as technical skills. They have to understand how to work in a collaborative environment, build meaningful relationships, communicate effectively, adapt to a variety of situations. For years our engineers were actively involved in supporting universities in skill development.

Patryk: You are a very successful entrepreneur with company share price sky-rocketing in Q4/2020-Q1/2021 as well as successful scientist in the past. Is there any piece of advice you would give to those looking for first jobs in Photonics or Photonics-related fields?

Adam: Photonics and photonic related fields is considered one of the key technologies of the 21st century with applications in just about every industry. Employment opportunities are excellent. It is also a dynamic and vibrant sector with long term work perspectives and great chances to deepen your knowledge, find and pursue new ideas. My piece of advice would be to look for innovative companies with strong R&D background with global presence. But those which provide not only possibility to participate in international research projects but also offer real-world applications-related experience. Having said that, not the innovative technology, the business plan or the access to funding is the key thing. Those are all important, but people and the culture you create by and for those people are the number one factor to success. Another issue is that in many cases companies are looking for more experience than some recent graduates can offer. But I would say: "Don't be discouraged". Photonics technology progresses and photonics devices are becoming more and more ubiquitous, with countless opportunities for young applicants to find the right place for themselves. It's a great time to be in the photonics industry.

Patryk: Adam, thank you very much for the interview. I am sure that your personal insights and advice will inspire others to develop their careers and contribute to the field of Photonics.

Conferences

OFC 2021

Highlights From the Conference Chairs

OFC 2021 General Chairs
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Po Dong
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Ming-Jun Li
Corning Incorporated, lim@corning.com
Ramon Casellas
CTTC, ramon.casellas@cttc.es

OFC 2021 was held in a fully virtual format for the first time in its history. The virtual event featured a dynamic plenary session, over 150 invited speakers, four Symposia, three Special Sessions, ten Workshops, seven Panels, 49 Short Courses, and top-tier businesses presenting live technical showcases with industry-leading product announcements. The event drew over 6,500 registrants from 83 countries. Technology announcements and technical presentations spanned across the whole optical communications ecosystem, including advancements in optoelectronic devices, packaging and digital signal processing that are all rapidly evolving to achieve 800G and beyond, as well as high-speed and high-capacity systems, novel architectures and algorithms towards more intelligent optical networking.

Plenary Session

In the plenary session, industry luminaries Yiqun Cai, vice president, *Alibaba Group, China*; Young-Kai Chen, program manager, Microsystems Technology Office, *Defense Advanced Research Projects Agency (DARPA), USA*; and Nancy Shemwell, COO, *Trilogy Networks, USA* shared their insights on the evolution of networking, photonics and Artificial Intelligence and deployment of edge cloud for rural communities. In the last part of the plenary session, live Q&A sessions were held with each plenary speaker and more insights were shared with the audience.

Yiqun Cai

Vice President, Alibaba Group, China

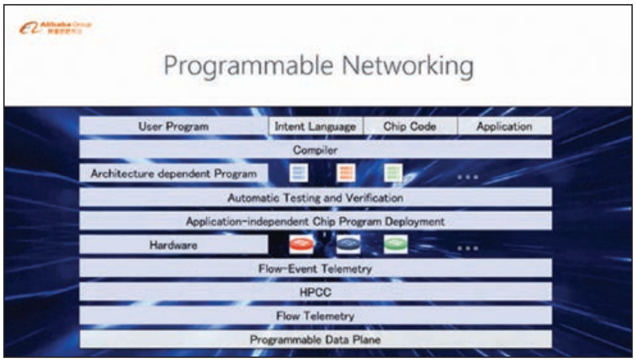
Talk: Hammers and Nails: How Technologies and Applications Drive the Evolution of Networking in Alibaba

Alibaba Cloud is a global common computing infrastructure across the world. Yiqun talked about challenges to develop and operate a network with that scale. The main focuses of such challenges are availability, complexity, and software.

On availability, the traditional way to measure it using the number of nines doesn't necessarily translate to user or application experiences when the network grows too large. A gray failure to induce random packet loss causes more significant outages than that counted with the number of nines. Another aspect is that traditionally the networking stack is designed to detect and recover failures in a layered fashion, as described by ISO or TCP/IP models. This doesn't work so well today in web and mobile applications happening on the Internet scale. Tooling is always lagging behind as well. An important element for improving it is high resolution telemetry. The recent progress of distributed computing and data plane technologies make it possible to generate and process the high-resolution telemetry. Another element is to emphasize on prevention as well as mitigation. By monitoring and reacting on failure indications, the network downtime in outage can be greatly reduced. The third element is to ingrain availability in the whole life cycle.

On complexity, it is not easy to deal with it as the network gets more and more complex because of the progression of technologies and ever-increasing requirements. It is important to understand where the complexity exists, what can be reduced, and what can be replaced. Backward compatibility is paramount in the network. But sometimes we may have to break the compatibility curse in order to move it to a new stage. A good example to move the complexity in the right direction is Remote Dynamic Memory Access to bypass the kernel stack in order to reduce the latency. The entire protocol suite was revamped based on the high-resolution telemetry to compensate for the omission of the kernel so that the flow control was totally improved.

On software, while the foundation of the network is hardware, we all come to the conclusion that networking is really about software in the past decade. One important aspect is



Elements for programmable networking.

how to invest in a programmable network. Alibaba designed its own hardware to fully leverage the computing power, new flow control algorithms that achieve low latency in the network based on telemetries, verification tools that allow data plane developers to program, and so on. There is no only way to do programmable networking, but this allows one to fully realize software in networking.

He concluded his talk by saying that networking is a combination of art, science and engineering in terms that it needs creativity, originality, fairness, discipline, pragmatism and precision.

Young-Kai Chen

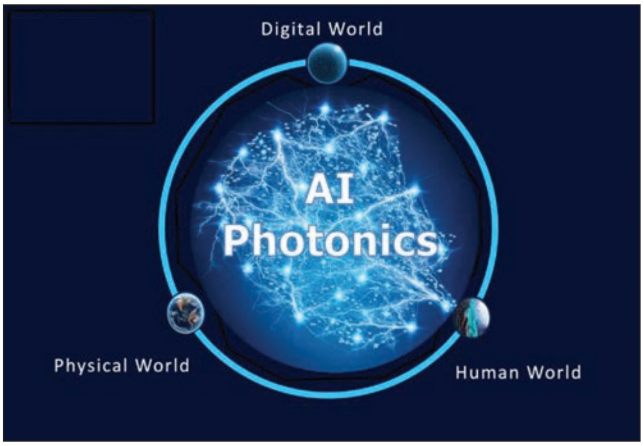
Program Manager, Microsystems Technology Office, DARPA, USA

Talk: Symbiotic Perspective of Photonics and Artificial Intelligence

In his talk, Dr. Young-Kai Chen discussed the "Symbiotic Perspective of Photonics and Artificial Intelligence". Young-Kai's research interests cover ICs, photonics, microwaves, optical communications, and artificial intelligence. He highlighted that tremendous advances in photonics and artificial intelligence over the past decades have enabled the next generation of communications and computing.

Photonics has played an essential role in data communications in the last few decades, fulfilling the demand of tremendous bandwidth growth in various communication networks, e.g., telecom and datacom. This has enabled ubiquitous AI cloud infrastructure which has advanced many technical fields. Emerging photonics technologies can enhance distributed AI processing by increasing socket I/O bandwidth, efficiency, and data reach by 100X and more. Young-Kai specifically highlighted that silicon photonics and its high-density integration with advanced microelectronics cores offers high-bandwidth I/O solutions with low power consumption by leveraging compact devices such as ring resonators, integrated comb sources and MEMS switches.

Photonics will also play an essential role in computing in the future. Analog photonic systems can act as machine learning accelerators where they act as physical neural networks. In a research demonstration from Cornell University, the researchers trained mechanical, electronic, and optical systems to recognize digits in an image. The optical system achieved 97% accuracy using nonlinear optics. The fundamental advantage of using an optical system is its low energy requirement. Researchers have demonstrated that 90% accuracy was achieved with only 0.64 photons per multiplication. In addition, a high-speed optical fiber link can function as a photonic delay loop reservoir, which embeds many virtual temporal neurons to perform deep learning tasks. This reservoir computer seamlessly utilizes traditional optical devices in fiber communications. As modern optical fiber communications can offer data rates >100 Gb/s, the computing capacity can be tremendous based on the use of high-speed optical signals in fibers. Photonics therefore will be the key for the next generation of communications and computing.



Photonics sits in the center of physical world, human world and digital world.

Nancy Shemwell

Chief Operating Officer, Trilogy Networks, USA

Talk: Industrial Revolution 4.0 — Gone Country

Nancy's talk was on how the Industrial 4.0 Revolution will impact the rural, non-urban environment around the world. She stated in her first slide that what she really wanted to talk about was "Solving World Hunger". It is expected that an additional 2.2 billion people will be added to the world population by year 2050, and the growing world population demands more and better food. Without additional acres of land and additional drops of water for agriculture, how to increase the yield and profitability of agriculture to support growing world population is a global challenge. Precision agriculture, which utilizes data and technologies to improve productivity and efficiency of agriculture, can help solve world hunger.

The essential part of precision agriculture is to bring broadband connectivity and cloud to the rural areas, which is a huge challenge due to vast geographical size and inadequate infrastructure in rural areas. Take rural broadband in the United States as an example; there are 2 million farms spanning 1.5 million square miles across the country, and there is a diverse and massive number of service providers serving these areas, including 850 community-based telco providers, 280 local municipalities, 120 cellular providers, and 900 rural electric cooperatives. With broadband connectivity, a cloud-computing-based edge delivery platform can be established, which enables seamless integration of real-time data collection in the field by robots, real-time data processing at farm edge sites, and massive data computation in the cloud. Cross-domain interdisciplinary collaborations and massive technology innovation are required to solve the challenge. Enormous global initiatives have been started.

Nancy used Hurst Greenery that includes 16 greenhouses across 600 acres of land between Iowa and Missouri as an example, where two states, four carriers and seven technology partners worked together to deliver a fully automated greenhouse

The challenge of rural broadband in the United States

operation, which reduced human resource cost and improved the greenhouse productivity by 10%. Extending cloud to the rural to unlock the potential of today's farm will not only bring massive societal value, but enormous economic value as well. Bringing broadband connectivity to the rural is similar to the electricity rollout across the United States in the 1930s. Who would have ever imagined where we use electricity today?

Highlights from Selected Technical Sessions

Four symposia were dedicated to topics of present and growing interest for the community: i) Emerging Photonic Technologies and Architectures for Femtojoule per Bit Optical Networks, which included tutorials on high level data center needs for low energy photonic and fJ silicon photonics and discussions on fundamental limits; ii) MEC-based Network Architectures in Support of Enterprise Cloud, which brought together leading experts from industry and academia to discuss the opportunities and challenges that arise in enterprise networks through enhancing the capabilities and functionalities at the network edge, showing that we need to address the role of Edge to enable emerging models of open access/networking, further disaggregation, split compute, human-centric service models, including a reflection on the role of photonics/optical networks; iii) Quantum Information Science and Technology (QIST) in the Context of Optical Communications, which addressed both applications —including talks from two operators—as well as fundamental research providing broad view of QIST networking aspects, stimulating reflections on open issues to be further investigated and future challenges to be addressed; and iv) The Role of Machine Learning in Optical Systems and the Role of Optics in Machine Learning Systems, to explore optics, machine learning and AI techniques for next generation systems.

There were three special sessions. *Special Chairs' Session: Vision 2030 – Taking optical communication through the next decade* gave a diverse view of Visions for the next decade from around the world. *Free Space Optics* (FSO) was organized in two parts: Terrestrial and Space optical links and LiFi systems described from commercial companies and service offerings. The consistent message was that FSO has arrived as a viable commercial technology. *Special Session: Lessons Learned: Networks 2020 Status and Next Steps* had a diverse group of speakers who represented different parts of the network: content, conventional carriers, and equipment supplier/analytics debated on the significant increase in traffic in the early stages of the Pandemic, up to 700% for some applications as well as lasting changes in both in traffic volumes and user behaviors, with the pervasive theme that the Internet has moved from a best effort service to an essential one, on which we critically rely for nearly all aspects of our lives: work, education, E-commerce, entertainment or personal connections.

The Rump Session provocatively asked "Did the Optics Industry Blunder by Switching Intra-Datacenter Links from NRZ to PAM4?" and "Will More DSP like PAM6 and Coherent Follow, or Will WDM and Parallel Save the Day?" The teams debated the issue and polls of the audience at the end found a majority disagreeing that PAM4 was a mistake but agreeing that WDM and parallel are the future.

OFC2021 workshops were held virtually yet provided opportunities to discuss and debate the latest technologies, including a wider range of topics such as cognitive network automation; optical signal processing, neuromorphic computing; Quantum Information Processing; Multiband, Multidimensional and SDM systems; Optical Wireless Communications; Photonics integration and Next-Generation Optical Access; Pluggable Coherent Technologies and Applications; Low Latency Communications; Co-packaged Optics; Wide-band Optical Frequency Combs and Beyond 400G technologies. Complementary to workshops, panels aimed at providing interactive learning environment and covered Deployment Challenges of 400G Optics and Beyond; THz Communication for Beyond 5G Networks; Challenges of Coherent Transponders Approaching the Shannon Limit; PON Disaggregation, from SDN Abstraction to Full Virtualization. Benefits, Obstacles and Trends; Advanced Laser Technologies in Post-100Gbaud Era; Pros and Cons of Low-margin Optical Networks; Optical Switching for Large-scale Deployment.

The workshop "Will Multiband, Multidimensional, SDM Effectively Address the Need for Increased Network Capacity?" organized by Antonio Napoli, Infinera Corporation, Germany, Taji Sakamoto, NTT, Japan, and Yikai Su, Shanghai Jiao Tong University, China, invited experts discussing ultra-wide band, multiple fibers and multicore and multimode fiber technologies for addressing network capacity increase. While increasing the number of fibers is the most straightforward solution, adding more available wavelength bands and utilizing multicore and multimode SDM technology will increase further the fiber transmission capacity.

Hollow-core fiber and low latency transmission became a hot topic in this year's OFC. The workshop "Low Latency Communications — Where Do We Need It? How To Achieve It?" organized by Michael Freiberger, Verizon, USA, Yinying Wang, Jinan Univ., China and Benyuan Zhu, OFS Laboratories, USA, discussed requirements and technical challenges on low latency for different time-sensitive applications, and the enabling technologies including time-sensitive network architectures and radical solutions such as hollow-core fiber cables.

Co-packaging attracted a lot of research attention. The workshop "Are We On the Right Track to Bring Co-packaged Optics To Its Prime Time?" organized by Xin Chen, Corning Incorporated, USA, Zhensheng Jia, CableLabs, USA, and Di Liang, Hewlett Packard Enterprise, USA provided discussions on the necessity and challenges to partially/completely replace pluggable solutions, and to explore current CPO technology readiness and its future development direction in datacenters and beyond.

Photonic integration, especially silicon photonics, remained an important topic for OFC. The workshop on "Is Photonics Integration Ready for Next-Generation Optical Access Demands?" discussed if integrated photonics could offer lower cost at high volumes than discrete counterparts, and the potential to be the solution to the more complex but still low-cost transceiver technologies needed for next-generation optical access.

400G data rate and beyond is inevitable in increasing the capacity in datacenters and low-cost coherent technology would be an enabling technology for short reach datacenter applications. The workshop on "Which Device Technologies Will Get Us Beyond 400G?" organized by Theodor Kupfer, Cisco Systems, USA, Hai-Feng Liu, HG Genuine, China, and Reza Motaghian, Amazon, USA discussed different potential optical device technologies for 200Gbps/lane in parallel and WDM short reach 800G IMDD systems and single carrier 600-800G coherent systems including high speed EML and DML/DMT, high speed modulators based on SiPh, InP, thin film LiNbO3, and plasmonics. The panel on "Deployment Challenges of 400G Optics and Beyond" organized by Friedel Gerfers, Technische Universität Berlin, Germany, Zuowei Shen, Google, USA, and Liang Zhang, Huawei Technologies, Germany. The panelists shared views of the major deployment challenges in 400G optics and beyond, such as interoperability, system integration, field deployment. The workshop on "Pluggable Coherent Technologies and Applications: Where are We and Where Will We Land in 5 years?" organized by Antonio Eira, Infinera, Portugal, Andreas Matiss, Corning, Germany, and Xiaoxia Wu, SpaceX, USA reviewed recent progress in network deployment requirements/schedule, interoperability, DSP/photonics technology and development status, and shared their views of the coherent pluggable technology and applications in the next few years.

For rapidly growing high bandwidth data center applications, optical switching could provide software-defined virtual connectivity with low costs by increasing utilization and power efficiency through resource disaggregation. The Panel "Is Optical Switching Finally Ready For Large-scale Deployment in Datacenters and Advanced Networks?" discussed recent advances in optical switching technology and development roadmaps along with the driving forces behind current and emerging applications in datacenters by addressing the key question as to whether optical switching technologies are finally ready for large scale deployments.

Finally, and as in previous years, the Open Networking Summit put together speakers to present the evolution towards Converged Open Packet-Optical Networks and the OFC2021 demo zone showed current demonstrations of research projects and proof-of-concept implementations in the space of optical communication devices, systems, and networks. Despite being virtual, the demo zone was highly successful, covering topics ranging from SDN/NFV and software tools/functions to software and hardware aspects on all conference topics. 19 demos were selected by a dedicated evaluation committee, with a wide range of topics covering, notably, optical disaggregation, machine learning, neural network switches, integration of GNPy network planner path validation and computation into SDN control planes, high-precision indoor localization or Quantum Key Distribution.

With the show floor program, the Network Operator Summit (NOS) included keynote talks by Neil Mc Rae (BT), a panel "Reality Check for 5G Networks: Network Operator Perspective" organized by Mehran Esfandiari (NTE), and a panel "Less Hyper Scale and More Co-location and Compute at the edge?" by Robert Blum (Intel). The Data Center Summit (DCS) included keynotes by Gaya Nagarajan (Facebook), a panel "What is next for Inter Data Center Interconnects (DCIs)?" organized by Loukas Paraschis (Infinera), and a panel "Inside the Data Center" by Hideki Sono (Fujitsu). Market Watch panels discussed the State of the Industry; Industrial Internet of Things, Smart Manufacturing and Industry 4.0; Terabit WDM Channels; Evolution to Coherent WDM integration in Routers; Next-gen Access Networks; Evolving Photonics Integration and Packaging and Optical Interconnect and Computing for Scaling Machine Learning Systems.

Technical Sessions Overview

This year's OFC featured 554 oral presentations that included 20 tutorials, 154 invited talks, 380 contributed talks, and 98 poster presentations. Below are some highlights of this year's technical presentations in D, N and S tracks to cover Devices, Networks and Systems, respectively.

D-Track

Sessions Tu6B Multicore fibers I and W7B Multicore fibers II presented new fiber designs and characterization techniques for multi-core fibers. Session M3C Optimization of single-mode fibers and cables discussed reduced cladding and reduced coating diameter fibers, which could be a nearterm solution for increasing the cable density. Session W7D SDM Transmission focused on MIMO transmission over coupled multicore fibers and ring-core multimode fibers, which could have a larger channel density than uncoupled multicore fibers. Post-deadline paper F3B.4 "Real-Time Transoceanic Coupled 4-Core Fiber Transmission" reported the first experimental demonstration of transoceanic distance of 7200km with real-time MIMO DSP over coupled multicore fibers, which demonstrated the feasibility of real-time ultralong-haul coupled-core multicore fiber transmission.

Session F4C Hollow-core Fibers represented current research work on hollow-core fibers including designs, characterization and low latency transmission through a field deployable hollow-core-fiber cable. There were two post-deadlines papers on hollow-core fibers. Paper F3A.4 "Hollow-Core NANFs With Five Nested Tubes and Record Low Loss at 850, 1060, 1300 and 1625nm" reported hollow-core NANFs with 5-nested-tubes, achieving the lowest loss ever reported in a hollow-core fiber at 1300 and 1625nm (0.22dB/km), 850nm (0.6dB/km) and 1060nm (0.3dB/km). Paper F3B.5 "Ultra-Long-Haul WDM Transmission in a Reduced Inter-Modal Interference NANF Hollow-Core Fiber" reported record transmission of 41xPM-QPSK C-band channels @32GBaud with average GMI 3.64 bits/symb through 2070km hollow-core fiber with reduced inter-modal interference. These new breakthroughs have advanced the hollow-core fiber technology towards practical applications.

Session Th4A Advanced Photonic Integration and Co-packaging contained 3 papers on co-packaging devices achieving 3.2 to 10 Tb/s. Also, the invited paper F2F.1 discussed Current State and Outlook on High-Bandwidth in-Package Optics.

Session M5G Coherent for Data-center Applications: DSP presented new research results on DSP for coherent transmission for short reach in data centers. Session Th5F Coherent/Free-space Optics for Data-center Applications also contained papers on coherent receivers for data centers. Post-deadline paper F3A.3 "Long-Term Reliable >200-Gb/s Directly Modulated Lasers With 800GbE-Compliant DSP" demonstrated the long-term reliable operation of a 70-GHz-class DFB+R laser and its capability of 108-GBd PAM-4 signaling under +4.8-ps/nm dispersion with ultra-low complexity equalizations as well as faster-than-Nyquist PAM-2 signaling up to 280 GBd.

Post-deadline paper F3A.1 "Wide and Parallel LED-Based Optical Links Using Multi-Core Fiber for Chip-to-Chip Communications" demonstrated >200 optical lanes in 0.5mm diameter imaging fiber with a speed-optimized GaN LED array, and independently, NRZ links of each LED to 10Gb/s over meters, extrapolating to >2Tb/s at a density >10Tb/mm^2. This technology could enable new architectures, such as disaggregated systems, large combinations of XPUs for ML and faster and more extensive memory access for chip to chip applications.

With new applications such as Internet of Things (IoT), optical sensors are an essential part of the network. Session Tu1L Fiber-optical Sensing Systems consisted of one tutorial on "Distributed Optical Fiber Sensor for Oil and Gas Industry and Agricultural Applications", and one invited talk on "Distributed Acoustic Sensing for Seismic Monitoring". Session Tu6C Novel Sensors and Applications devoted to new research results on optical sensors for various applications. In particular, post-deadline paper F3B.2 "Field Trial of Vibration Detection and Localization Using Coherent Telecom Transponders Over 380-km Link" demonstrated vibration detection and localization based on extracting optical phase from the DSP elements of a coherent receiver in bidirectional WDM transmission of 200-Gb/s DP-16QAM over 380 km of installed field fiber. This represents a new trend of using telecom fiber networks to perform various monitoring functions.

Session W1A Optical Switching and Network Devices presented new optical starching devices for different applications.

Session M5A Integrated Photonics Devices and Systems presented laser and detector integration on silicon and other platforms. Session Tu6A Integration in Photonic Systems presented new photonic integration for different device and system applications.

N-Track

The technical sessions of the N-track continue to highlight the fundamental role of the optical communications technologies in multiple domains: access, metro and core networks; inter- and intra- data center connectivity; quantum communications (including QKD); and new and emerging applications such as machine learning, neuromorphic computing or fiber sensing. Dedicated sessions included distributed sensing or sensing in existing operators' networks, next generation field trails and standardization activities (e.g., in coherent systems or ZR optics). 5G and beyond still remain a main focus of research.

Notable technical contributions addressed optical networks for emerging computing architectures, data center and edge. In particular, OFC2021 included the latest advances in Photonic Neural Networks and Neuromorphic Computing based on photonic technologies, including 3D tensorized neural networks, neural networks in a monolithic silicon CMOS photonic platform or the development of a silicon photonic coherent neuron.

The role of Machine Learning in optical networks has been a deeply researched topic. From a macroscopic perspective, ML papers covered aspects such as estimating quality of transmission (e.g., in-band ONSR estimation), estimation of power efficient SDM submarine cables, failure management and performance estimation and prediction. OFC2021 has clearly shown the interest in researching the role of ML towards autonomous networking and operations addressing not only the photonic layer (e.g., scalable routing and wavelength assignment), but also from a packer over optical multilayer setting.

From the perspective of network design, operation, and techno-economics, technical contributions included resource assignment in SDM and multiband networks, energy/power efficiency considerations, network slicing, the role of pluggable and integrated high-capacity line interfaces, and amplifier optimization based on QoT estimation.

Security in optical networks sessions include end-to-end slice stitching using blockchain; autonomous security management and quantum networking, with the demonstration of programmable SDN enabled encryptors/decryptors for QKD networks or secure key distribution based on synchronization of polarization states.

Network disaggregation still remains a well-researched topic, including its relationship with intent-based networking, mathematical models of optical functional blocks or tests and validations of open-source components and solutions. Disaggregation not only covers the optical layer but also the integration with the packet layer and the relationship with cloud native and virtualized functions.

Considering research on optical access networks, OFC2021 included technical sessions that presented recent advances of the optical access technology. Such advances address optical access in support of mobile site connectivity, like a converged fronthaul network using silicon photonic switching; the evolution of coherent PON technology (adaptive modulation, coding schemes); advances in high-capacity (>100 Gb/s), low latency PONs (still a key driver for 5G and beyond) and DSP and AI for PON transmission.

S-Track

The technical sessions in S-Track spanned a full range of fiber optic communication applications. There were multiple sessions and papers on Direct Detection and Coherent for Data Center and Transport. Two sessions covered FSO, and two sessions covered Quantum. There were multiple sessions on data center architectures which included co-packaging, disaggregation and switching. Two sessions covered AI and ML optics applications. Multiple sessions covered RF Photonics, Microwave to Terahertz, RoF, and 5G. Several sessions covered optical component and system modelling and measurements. One session focused on SDM transmission. Non-communication applications were covered in a session on Sensing and Positioning.

Photonics Vision 2030 in Africa

OFC 2021: Special Session: Vision Talks: Beyond 2021 and Towards 2030

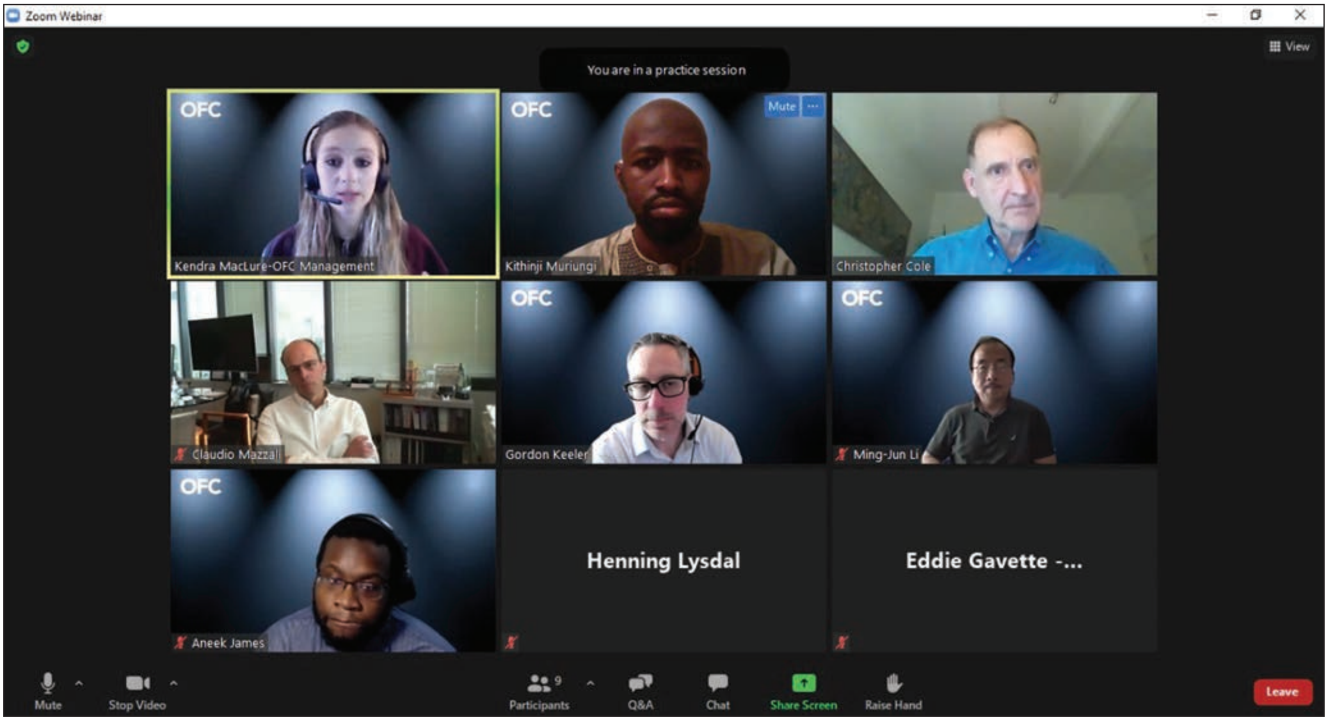
Kithinji Muriungi: IPS Global Strategy Rep (Africa), Globalization & YPAC (2021/23) | Chair, IEEE Photonics Society Kenya Section Chapter

"Africa holds a rich history that suggests the successful adoption of the fourth industrial revolution driven by photonics. This paper connects the dots and plots or projects how photonics in Africa might be in 2030." In this session, Kithinji Muriungi shares *Photonics vision 2030 in Africa* in an invited paper co-authored with Fidel Makatia. The special session featured other invited vision talk speakers in OFC 2021 to talk about *"Beyond 2021 and Towards 2030."*

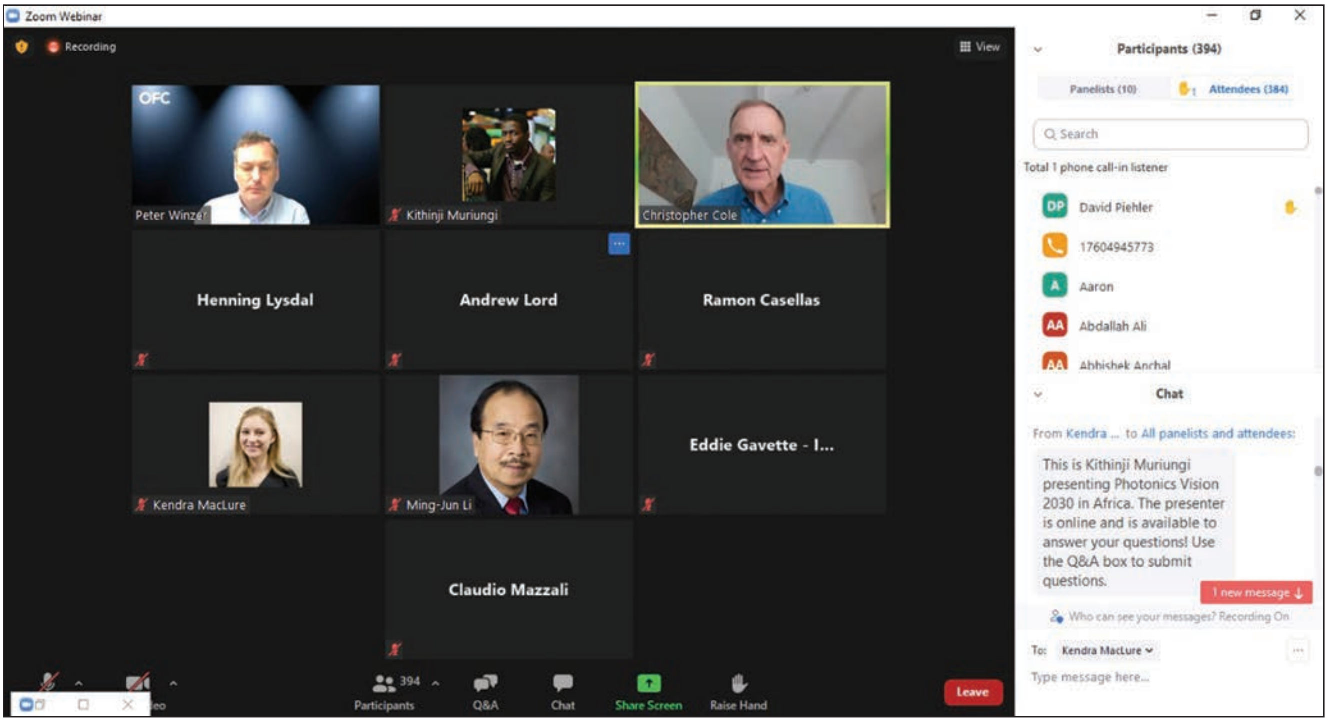
Kithinji Muriungi presenting an invited talk on "Photonics Vision 2030 in Africa".

Despite what is known about Africa, the *Photonics vision 2030 in Africa* talk focused on Africa's strengths, current actions, opportunities, and sustainability plans in ensuring that photonics adoption, growth, and development are achieved in 2030. The invited *Photonics vision 2030 in Africa* vision talk was initiated by Chris Cole to bring together Africa's representatives to share their vision globally. The vision involved coordinated efforts from most renowned African scientists and physicists such as Lawrence Norris, Andrew Forbes, Eyitayo Olatunde Olakanmi, and Hardus Greyling. Additionally, Lauren Mecum and Lisa Sandt provided much support in connecting with relevant IPS contacts in Africa.

Apart from showing Africa's strengths, the impact of the developing stories in the future of Africa, market share, research status, and convergence of the technologies, the talk highlighted some key focus areas. These include government and partnerships, research and academia, future networks, and smart cities, among other aspects. The partnerships highlighted in this talk strengthen the sustainability mechanism in Africa's vision 2030. This partnership involves African institutions such as Council for Scientific and Industrial Research (CSIR), The African Laser Centre (ALC), Africa Physics Society (APS), among others. The partnership highlights have also captured the global multinational organizations such as IBM (Quantum Research Lab in South Africa),



OFC 2021 Special Session Vision Talks Speakers during a briefing session.



Live Q&A during the Special Session Vision Talks.

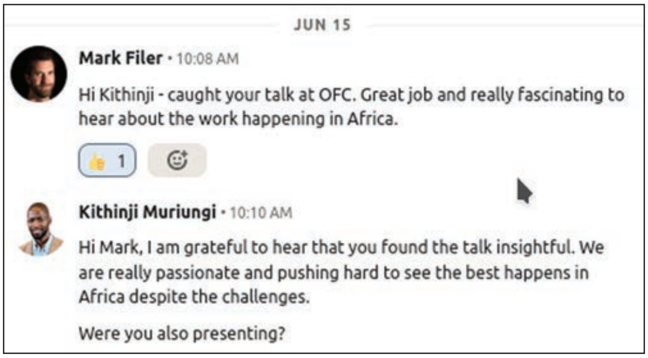
Microsoft (Healthcare Research Institute in Kenya), Google (AI Research Centre in Ghana), and Huawei (5G Innovation Lab in South Africa) to partner and develop capacity in Africa. Combining all these, the talk predicts the future of photonics in Africa and what needs to be done to accomplish that vision. ALC impact is also highlighted to champion "Brain Circulation" in Africa.

The talk also featured impactful vision projects in Africa and how they impact the future and photonics vision 2030 in Africa. Some of these projects include smart cities such as Konza Technopolis, popularly known as the Silicon Savannah or "Silicon Valley of Africa". Silicon Savannah is modeled around Silicon Valley with a vision "*to be a leading global technology and innovation hub*" and with a mission "*to develop a sustainable smart city and an innovation ecosystem, contributing to Kenya's knowledge-based economy.*" The development of futuristic smart cities, research centers, and data centers in Africa have seen a great need for specialists, experts, scientists, engineers, and technologists working in photonics.

The presentation was very successful, with over 400 participants tuning in online for the vision talks series. Apart from the feedback and questions received and answered during the session, more feedback followed, especially from the participants and speakers who attended vision talks and other sessions. Among them include feedback from a graduate student in Kenya:

*"I am an information technologist currently pursuing my Masters in Moi University-Main Campus. I believe that attending some of the OFC 2021 sessions has improved my thinking towards optical networking. The speakers were very knowledgeable and positively insightful, and for that, I appreciate their expertise. A lot that I did not know was covered, and I believe I left the conference a better person both career-wise and IQ-wise. "**Optical Wireless Communications: What is Stopping Us?**" was my favorite session of them all. I believe that the insights in this talk will help us tackle many issues in the technology industry that we thought were impossible to solve. I would recommend such conferences to my colleagues and friends, especially in Africa, because it would serve them a great deal. Thank you for coming up with the best thought-provoking sessions, so far the best I have ever attended.*" —Damaris Simiyu.

Additional feedback from LinkedIn:



Source: LinkedIn - Feedback regarding the Vision Talks

This talk presented Africa in the most ideal and perfect manner regarding its future. In reality, the future is not certain, and also Africa is facing immense technological challenges, but the current trends suggest a better and successful future. I am positive, hopeful, and optimistic that Africa will live to see the future vision of photonics become a reality. Furthermore, "*the best way to predict the future is to create it*" —Peter Drucker.

IEEE 5 NANO Conference 2021Highlights

2021 IEEE International Conference on Nanoelectronics, Nanophotonics, Nanomaterials, Nanobioscience & Nanotechnology (5NANO2021) Hosted by IEEE Photonics Society Student Chapter Mangalam College of Engineering, Kottayam, Kerala, India Held on 29th & 30th April, 2021

IEEE 5NANO2021 is a collaborative effort—a joint Venture, sponsored by AICTE, Govt. of India, technically co-sponsored by IEEE Photonics Society USA, in collaboration with MSME Technology Development Centre, Ministry of Micro, Small & Medium Enterprises (MSME), Govt. of India.

IEEE 5NANO2021 received 342 full paper submissions and 12 tutorial proposals. All the submitted papers were processed by the chairs and track chairs of the Technical Program Committee and the chairs of special sessions, while the tutorial proposals were processed by the tutorial chairs. They worked professionally, responsibly and diligently in soliciting expert international reviewers.

In addition to evaluations from reviewers, they also provided their own assessments in ensuring that only high-quality papers and tutorial proposals could be accepted. Their hard work resulted in a very solid technical program. After the detailed review 101 papers were selected for oral presentation. More than 150 participants from various institutions representing countries such as Russia, Australia, Poland, Egypt, United Kingdom, Switzerland and the United States of America.

During the conference, the website of Prakash Bharati (Indian Photonics Consortium) was also launched by Dr. Naresh Chand, Associate Vice President, Chapter Relations, IEEE Photonics Society. Besides the parallel technical sessions and technical activities, four keynote addresses were delivered, covering the state of the art in both theory and applications in Nanophotonics.

All the sessions, including the keynote address sessions, forum/panel sessions of technical activities, tu-

Figure 1. Opening ceremony.

Figure 2. Shri. Biju Varghese, Chairman, Mangalam College of Engineering delivers his presidential address during the opening ceremony.

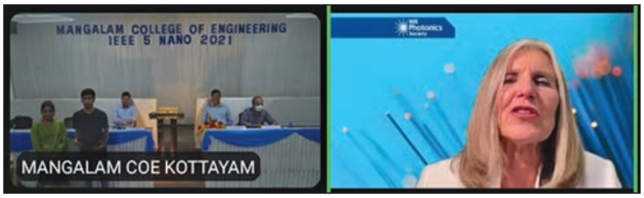


Figure 3. Prof. Carmen S. Menoni, President IEEE Photonics Society USA & Professor, Colorado State University, USA delivers her address during the opening ceremony.

Figure 4. Dr.Buddha Chandrasekhar, Chief Coordinating Officer, AICTE, Ministry of Education, Govt. of India delivers his address during the opening ceremony.

Figure 5. Prof. Niloy K. Dutta, University of Connecticut, Storrs, USA delivers his keynote address on Quantum Dot Semiconductor Optical Amplifiers for Optical Logic Applications.

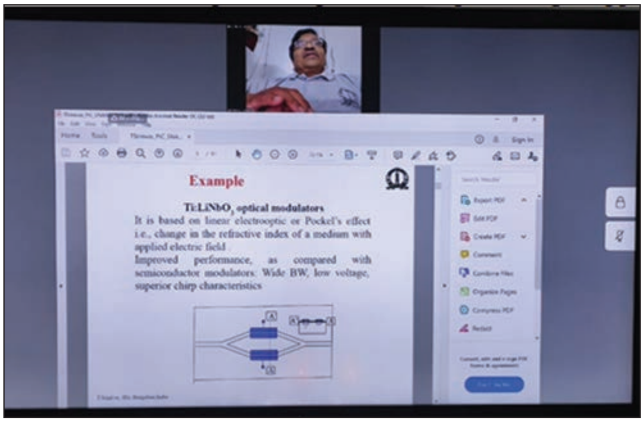


Figure 6. Dr. Srinivas Talabattula, Indian Institute of Science(IISC) Bengaluru, Karnataka, India delivers his Keynote address on Photonic Integrated Circuits for Communication and Sensing Applications.

Figure 7. Dr. Manpreet Singh Manna, Sant Longowal Institute of Engineering & Technology, Punjab, Former Director, AICTE, Ministry of Education, Govt. of India delivers his Keynote address on Role of Nanotechnology in Energy Generation and Conservation.

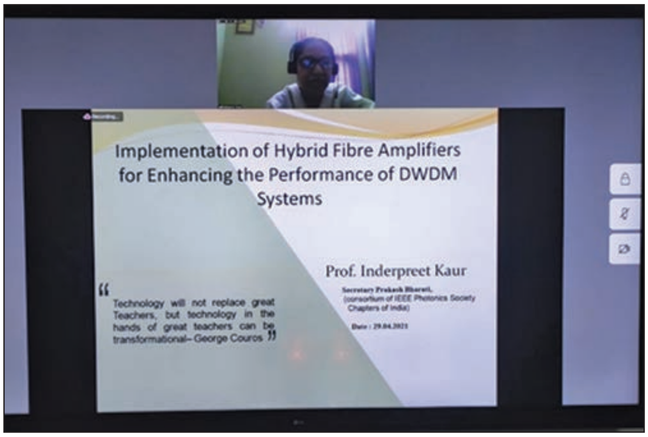


Figure 8. Dr. Inderpreet Kaur, Desh Bhagat University, Punjab, India delivers her Keynote address on Implementation of Hybrid Fibre amplifiers for Enhancing the performance of DWDM Systems.

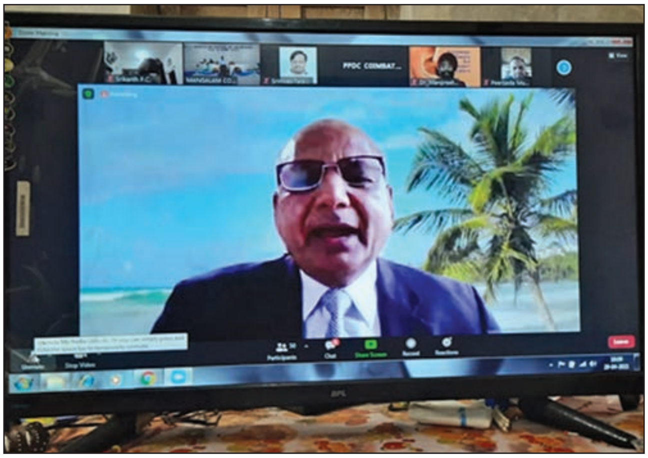


Figure 9. Dr. Naresh Chand, Associate Vice President, IEEE Photonics Society, USA interacting with the delegates.

Figure 10. The question-and-answer session following the address by Dr.Naresh Chand.

Figure 11. Prof. James E.Morris, President, IEEE Nanotechnology Council USA & Professor, Portland State University, USA delivers his Keynote address on Electron Transport in Discontinuous Metal Thin Films.

Figure 12. Prof. Shuai Li, Swansea University, UK delivers his Keynote address on Neural Networks for Model Based Robot Control.

Figure 13. Prof. Walid Tawfik, Cairo University, Egypt delivers his keynote address on Breakthroughs of using Photodynamic Therapy and Gold Nanoparticles in Cancer.

Figure 14. Dr. Wladyslaw Grabinski, MOS AK Association, Switzerland delivers his Keynote address on Compact/SPICE Modeling Perspective of FOSS TCAD/EDA Software.

Figure 15. Dr.R.Paneer Selvam, Principal Director, MSME Technology Development Centre, Ministry of Micro, Small & Medium Enterprises, Govt. of India declared BEST PAPER AWARD Winners

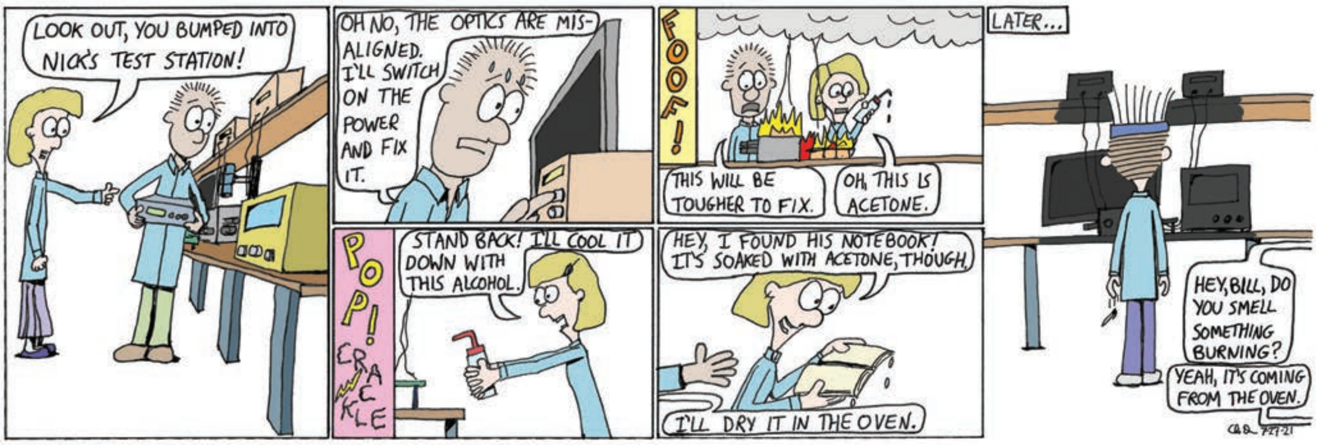
Figure 16. Shri. Biju Varghese, Chairman, Mangalam College of Engineering honoured best paper award winners.

torials and parallel technical sessions attracted active participation from those in attendance and produced fruitful discussions.

The only regret was the lack of physical networking and the valuable interactions that were canceled, such as the welcome reception and banquet. At the upcoming IEEE 5NANO2022 in India, we will provide a wonderful, holistic experience to compensate for this. We look forward to seeing you at IEEE 5NANO2022.

Subash
IEEE 5NANO2021 Chair

"Nick" Cartoon Series *by Christopher Doerr*



OGC2021
Optoelectronics Global Conference

Optoelectronics Global Conference (OGC) 2021 will be held concurrently with the 23rd China International Optoelectronic Exposition (CIOE) in Shenzhen, China, from August 31, 2021 to September 03, 2021. Due to various uncertainties about COVID-19 (Coronavirus) pandemic OGC will be held in a hybrid format. Conference delegates can choose to present their papers via in-person or virtual participation options by 1 Aug 2021. We will implement the latest recommendations from local government and health officials to mitigate risk of infection during the in-person conference and exhibition. OGC 2021 is sponsored by IEEE Photonics Society and hosted by Southern University of Science and Technology (SUSTech). Please visit the conference website for more information and latest updates: http://www.ipsogc.org/

Aug. 31 2021 Sep. 03
SHENZHEN, CHINA

PLENARY SPEAKERS

Connie Chang Hasnain
University of California, Berkeley, USA

Min Gu
University of Shanghai for Science and Technology, China

Henry Chapman
The University of Hamburg, Germany

www.ipsogc.org/

2021 OPTOELECTRONICS GLOBAL CONFERENCE

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Xiang Zhou, Google, USA
Tianye Huang, China University of Geosciences (Wuhan), China
Huanhuan Liu, Southern University of Science and Technology, China

Publication

Accepted papers of OGC2021 will be published in conference proceedings by IEEE, which will be submitted to the IEEE Xplore Digital Library®.

How to Submit

[Abstracts] Accepted Abstracts will be invited to present at the conference, the abstract will not be published.
[Full Papers] Accepted full papers presented at the conference will be published into the conference proceedings.

* Please send your manuscript to EasyChair online submission system: https://easychair.org/conferences/?conf=ogc2021
For more info. please visit: http://www.ipsogc.org/sub.html

Important Dates

Submission Deadline -----------------------	**[July 15, 2021]**
Notification Date----------------------------	[August 05, 2021]
Registration Deadline -----------------------	[August 15, 2021]
Camera-ready Papers Due-------------------	[August 15, 2021]
Conference Dates----------------------------	[Aug. 31-Sep. 3, 2021]

Call for Papers

OGC 2021 will cover all major areas in optoelectronics, optical communications and fundamental optics along with workshops in areas of current interest. Topics interested but not limited to:

S1. Laser Technology
S2. Optical Communication and Networks
S3. Near-infrared, Mid-infrared and Far-infrared Technologies and Applications
S4. Quantum Optics and Information
S5. Fiber-Based Technologies and Applications
S6. Optoelectronic Devices and Applications
S7. Biophotonics and Optical Biomedicine
S8. AI Photonics
S9. Silicon Photonics

Special Events

C1. Optoelectronics Innovation Challenge
C2. Photonics Global Student Conference (PGSC)

Special Sessions

T1. Perovskite Materials and Optoelectronic Applications
T2. Liquid Crystal Photonics
T3. Translational Photomedicine and Biophotonics
T4. THz Metamaterials and Device Applications
T5. Emerging Technologies for Information Displays and Lighting
T6. Photophysics of Structured Materials for Nanophotonics

Workshops

W1. Optoelectronics Technopreneurship
W2. Optical Fiber Upgrade
W3. Computational Imaging

Program at A Glance

Aug. 31, 2021---------- Preregistration & Short Courses
Sept. 01, 2021--------- Conference Opening &Technical Sessions
Sept. 02, 2021-------- Technical Sessions, Conference Banquet
Sept. 03, 2021-------- Technical Sessions & Closing Ceremony

Venue

Shenzhen World Exhibition & Convention Center
Add.: No. 1 Zhancheng Road, Fuhai Street, Bao'an District, Shenzhen, China
Tel: 0755-85903081
Web: www.shenzhen-world.com

CONTACT US Rachel Huang T: +86-28-87555888 M: +86-132 8128 0917 E: info@ieeeogc.com

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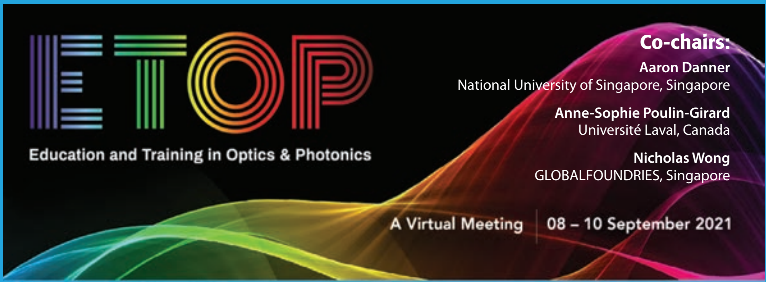

Sponsors:

For more information visit:
https://bit.ly/ETOP2021

We welcome your participation in the Education and Training in Optics and Photonics (ETOP) conference this 08-10 September 2021. This year, ETOP will held in an all-virtual, web conference format.

ETOP is a biennial conference that brings together educators from around the world to share information about the practice of teaching optics at all levels. The teaching of optics and photonics, critical fields at the core of today's world-wide technological infrastructure, must continually be upgraded and renewed in order to meet the growing demands of research, science and industry.

It is the goal of this international conference to bring together leading optics and photonics educators from all levels and orientations to discuss, demonstrate and learn about new developments and approaches to teaching in these fields. Through presentations, panel discussions, workshops and exhibits, it is the intent of this conference to inform professors, students, teachers and professional trainers on how to teach optics and photonics for the future.

ETOP addresses topics at the pre-college, technician and two-year, four-year and graduate-equivalent levels.
Typical session topics include:

- training and laboratory materials for demonstrations
- training and continuing education in collaboration with industry
- education in geometrical optics, quantum optics technologies for integrated diffractive optics
- software for teaching
- computer assisted learning
- curriculum development laboratories for optics and photonics education
- education and training for inter- and multidisciplinary applications

Finally Back in Germany—27th International Semiconductor Laser Conference

In 2021, the renowned International Semiconductor Laser Conference (ISLC) will be hosted in Germany for the first time in nineteen years. The conference is scheduled 10–14 October.

The ISLC is dedicated to latest developments in semiconductor lasers, amplifiers and LEDs. It represents excellence from all global regions and in all areas of currently active semiconductor laser research. The ISLC 2021 and the associated exhibition are organized by the Ferdinand-Braun-Institut gGmbH, Berlin and supported by IEEE Photonics Society as technical sponsor.

A full list of topics and committees, including laser legend, plenary and invited speakers as well as workshops on Automotive LiDAR and Photodetection Technology is provided on the conference website www.islc2021.org.

Paper submission is closed, and registration opens in June. A post-deadline session is planned, with a deadline in October.

All accepted and presented papers will be published on IEEE Xplore, adding to the more than 30 years of ISLC proceedings already available. The ISLC also gives authors the opportunity to submit an expanded version of their conference article to a special issue of IEEE Photonics Journal that will follow after the conference.

The organizing team for the 27th ISLC is working hard towards an "in-person" conference in Potsdam Germany, with online access for scientists who are not able to travel, following the wishes of the program and regional chairs and committee. This makes the ISLC one of the very first in-person international laser conferences since the start of the COVID-19 outbreak.

We look forward to hosting you and interacting at the conference in October!

Paul Crump, General Chair, Aki Kasukawa Program Chair

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The Annual Conference of the IEEE Photonics Society

IPC

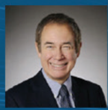
IEEE | IEEE Photonics Society

Virtual Conference
18-22 October 2021
www.ieee-ipc.org

Register for the conference today!

Announcing Plenary Speakers

Professor Sir John Pendry
Imperial College London, England



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Yale University, USA

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GFP2021

GROUP IV PHOTONICS

1-3 December 2021
Málaga, Spain
www.ieee-gfp.org

Registration Opens:
August 2021

General Co-Chairs:
Robert Halir,
Universidad de Málaga
José Capmany,
Universidad Politecnica de Valencia

Publications

The IEEE/OSA Journal of Lightwave Technology Best Paper Awards

This award is given annually by the Journal's Steering and Coordinating Committee to the top-cited original papers published in the Journal two to three years prior to the award.

As such, the award given at OFC 2021 takes into account all original papers published in the Journal of Lightwave Technology in 2018. A variety of citation metrics and databases are used by the Committee to determine the winner. In 2020, there were two winning papers for the JLT Best Paper Award.

Please join us in congratulating the award winners!

The winning papers of the IEEE/OSA Journal of Lightwave Technology's 2020 Best Paper Award to be presented this year are:

"End-to-End Deep Learning of Optical Fiber Communications"
by Boris Karanov, University College London
Mathieu Chagnon, McGill University
Felix Thouin, Georgia Tech
Tobias A. Eriksson, Nokia Bell Labs
Henning Bulow, Nokia Bell Labs
Domanic Lavery, University College London
Polina Bayvel, University College London
Laurent Schmalen, Nokia Bell Labs

"Kramers–Kronig Receivers for 100-km Datacenter Interconnects"
Xi Chen, Nokia Bell Labs
Cristian Antonelli, University of L'Aquila
Sethumadhavan Chandrasekhar, Nokia Bell Labs
Gregory Raybon, Nokia Bell Labs
Antonio Mecozzi, University of L'Aquila
Mark Shtaif, Tel Aviv University
Peter Winzer, Nokia Bell Labs

*all author affiliations are from the time of publication and are recognized as the corresponding institutions.

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Call for Papers

Announcing an Issue of the IEEE

JOURNAL OF SELECTED TOPICS IN QUANTUM ELECTRONICS on

Machine Learning in Photonic Communication and Measurement Systems

Submission Deadline: October 1, 2021

Hard Copy Publication: July/August 2022

The IEEE Journal of Selected Topics in Quantum Electronics (JSTQE) invites manuscript submissions in **Machine Learning for Photonic Communication and Measurements Systems**. Introducing intelligence as well using machine learning to design the next generation of components and systems as well as measurement systems is an emerging line of research in the photonics community. The hope is that the machine learning will enable a new generation of transformative photonic components and systems that can outperform current solutions in terms of: performance, flexibility, reconfigurability and power consumption. The strength of machine learning is to find effective solutions for problems that are highly complex such as; realizing power efficient long-reach high-throughput optical communication systems, low-noise lasers, repetition rate and spectrally reconfigurable optical frequency combs, multi-purpose photonic integrated circuits, secure communication systems and performing measurements at the quantum limit. The purpose of this issue of JSTQE is to highlight the recent progress and trends in utilizing machine learning techniques for developing next-generation of photonic communication and measurements systems. Areas of interest include (but are not limited to):

Optical components

- Semiconductor and fibre based lasers devices
- Optical frequency combs
- Programmable multi-purpose photonic integrated circuits
- Fibers
- Optical amplifiers

Optical communication systems

- Flexible transmitters
- Constellation shaping
- Spectrum shaping
- Fiber-optic channel impairment mitigation
- Free-space optics

Classical and quantum measurement systems

- Biomedical imaging
- Characterization of lasers and frequency combs
- Quantum limited phase sensing
- Quantum key distribution
- State estimation in cavity opto-mechanics

Optical networks

- Performance monitoring
- Optimization
- Security

The Primary Guest Editor for this issue is **Darko Zibar**, Technical University of Denmark. The Guest Editors are: **Sergei Turitsyn**, Aston University, United Kingdom; **Bahram Jalali**, University of California Los Angeles (UCLA), USA; **Keisuke Kojima,** Mitsubishi Research Laboratory, (MERL), Boston, USA and **Marija Furdek**, Chalmers University of Technology.

The deadline for submission of manuscripts is **October 1, 2021**. Hardcopy publication of the issue is scheduled for **July/August 2022.**

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Call for Papers

Announcing an Issue of the IEEE

JOURNAL OF SELECTED TOPICS IN QUANTUM ELECTRONICS on

Lidars and Photonic Radars

Submission Deadline: December 1, 2021

Hard Copy Publication: September/October 2022

The IEEE Journal of Selected Topics in Quantum Electronics (JSTQE) invites manuscript submissions in Lidars and Photonic Radars. The emerging field of Lidars and Photonic Radars has opened up new horizons for extensive transfer of state-of-the-art technologies coming from the areas of quantum electronics, lasers and electro-optics to high-precision wireless detection and sensing. Lidars have developed so fast that they are becoming the key sensors in applications including autonomous vehicles, augmented reality (AR) and virtual reality (VR), etc. Photonic radars achieve dramatically improved performance over traditional radars, enabling high resolution and fast detection in all-day and all-weather conditions. New trends of lidar and photonic radar have attracted much attention such as AI-enhanced system, lidar-radar fusion system and single-photon lidar and so on. The purpose of this issue of JSTQE is to highlight the recent progress and trends in developing leading-edge lidars and photonic radars technologies. Areas of interest include (but are not limited to):

Lidars and the key enabling technologies

- Emerging lidar techniques including time-of-flight (TOF) lidars, frequency-modulated continuous-wave (FMCW) lidars, flash lidars, Doppler lidars, differential absorption lidars. coherent lidar, multi-functional, solid-state, miniaturized and intelligent lidars etc.
- Key components for lidar system including laser sources, optical modulators, optical receivers, photodetectors, beam-steering devices etc.
- Solid-state lidar techniques including 3D flash LiDAR, scanned solid-state LiDAR, on-chip lidar, MEMs beam-steering, optical phase array etc.
- Lidar data processing techniques, high-resolution imaging, 3D real-time imaging, etc.

Photonic radars and the key enabling technologies

- Photonic radar signal generation and processing, including photonic digital-to-analog conversion, photonic analog-to-digital conversion, microwave photonic frequency multiplication and mixing, microwave phase controlling, etc.
- Optically controlled true time delay and phased array radar, photonic MIMO radar and fiber-connected radar networks
- Novel photonic radar architectures and photonic radar applications including target positioning, imaging, and DOA estimation, etc.
- Photonic integration and chip-based photonic radars

Development of novel lidar, photonic radar and new applications.

- Novel lidar including ghost lidars, single-photon lidars, super-resolution full-waveform lidars, lidars enabled by optical combs, non-scanning 3D imaging lidars etc.
- Artificial intelligence for lidar and photonic radar systems and applications
- Photonics-based lidar-radar systems for multi-sensor fusion
- Photonic cognitive radar and adaptive signal processing
- Lidars and radars applications for autonomous driving, AR/VR, etc.

The Primary Guest Editor for this issue is **Prof. Ming LI,** Institute of Semiconductors, Chinese Academy of Sciences, Beijing, China. The Guest Editors are: **Prof. Antonella Bogoni,** Scuola Superiore Sant'Anna, Pisa, Italy; **Mr. Li Zeng,** Huawei Technologies Co., China.

The deadline for submission of manuscripts is **December 1, 2021**. Hardcopy publication of the issue is scheduled for **September/October 2022.**

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Call for Papers

Announcing an Issue of the IEEE

JOURNAL OF SELECTED TOPICS IN QUANTUM ELECTRONICS on

Nonlinear Integrated Photonics

Submission Deadline: April 1, 2022

Hard Copy Publication: January/February 2023

The IEEE Journal of Selected Topics in Quantum Electronics (JSTQE) invites manuscript submissions in **Nonlinear Integrated Photonics**. The field of **Nonlinear Integrated Photonics** has opened up new horizons in optical signal processing, quantum technologies, and sensing by leveraging the strong light-matter interactions available at the nanoscale. The ample functionality enabled by nonlinear optical effects, combined with the potential for dense integration and high-speed low-power operation of nanophotonic devices, has turned this field in one of the most thriving scientific areas. The ***IEEE Journal of Selected Topics in Quantum Electronics*** invites manuscript submissions in the area of **Nonlinear Integrated Photonics**. Areas of interest include (but are not limited to):

Progress on nonlinear integrated optical sources

- Integrated frequency combs, mode-locked lasers, and supercontinuum sources and their applications in telecommunications, data centers, and sensing
- Microcavity Brillouin lasers and on-chip Raman lasers
- THz-sources on nonlinear integrated platforms

Advances on nonlinear integrated photonics for quantum applications

- Nonlinear integrated photonics for quantum sources such as heralded single-photon generation, entangled photon-pairs generation, and squeezed states of light.
- Spectral translation of quantum light in $\chi^{(2)}$ media, periodically poled $\chi^{(2)}$ media, and $\chi^{(3)}$ media
- Quantum photon-photon interactions in integrated platforms towards quantum-by-quantum control, all-optical deterministic quantum logic, single-photon switches and transistors

Nonlinear optical effects in novel material platforms and structured media

- Progress in on-chip nonlinear novel material platforms: Titanium dioxide, (thin film) lithium niobate, (ultra)silicon rich nitride, silicon carbide, and others.
- Nonlinearity-enhancement using metasurfaces, plasmonics, graphene-loaded waveguides, and others.
- Nonlinearities in topological and PT-symmetric nanophotonic structures

Nonlinear optics applications in telecommunications, data centers, and sensing

The Primary Guest Editor for this issue is **Dr. Andrea Blanco-Redondo,** Nokia Bell-Labs, USA. The Guest Editors are: **Prof. Dawn Tan,** Singapore University of Technology and Design, **Singapore; Dr. Christian Grillet,** CNRS/École Centrale de Lyon, France; **Dr. Bryn Bell,** Imperial College London, U.K.

The deadline for submission of manuscripts is **April 1, 2022**. Hardcopy publication of the issue is scheduled for **January/February 2023.**

IEEE photonics Society

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Preliminary Call for Papers

Announcing an Issue of the IEEE

JOURNAL OF SELECTED TOPICS IN QUANTUM ELECTRONICS on

High Density Integrated Multipurpose Photonic Circuits

Submission Deadline: February 1, 2022

Hard Copy Publication: November/December 2022

The IEEE Journal of Selected Topics in Quantum Electronics (JSTQE) invites manuscript submissions in **High Density Integrated Multipurpose Photonic Circuits.** The emerging field of **programmable photonics** is one of the fastest growing fields in photonics with applications including optical signal processing, computing and quantum photonics. The growing maturity of integrated photonic technology makes it possible to build increasingly large and complex photonic circuits on the surface of a chip, enabling a generation of photonic circuits that can be programmed using software for a wide variety of functions. Within this framework, the ***IEEE Journal of Selected Topics in Quantum Electronics*** invites manuscript submissions in the area of **integrated programmable photonics**. The purpose of this issue of JSTQE is to highlight the recent progress and trends in developing leading-edge large-scale integrated optics technologies. Areas of interest include (but are not limited to):

Novel reconfigurable circuit and system architectures focused on high-performance and scalable circuits.

- Large-scale feedfoward waveguide mesh arrangements and their applications.
- Large-scale general-purpose waveguide meshes and their applications / Field Programmable Photonic Gate Arrays.
- Reconfigurable photonic integrated circuits and their applications (Coupled resonators, Reconfigurable multiplexer, optical switches…)
- Reconfigurable systems enabling mode, polarization, and wavelength multiplexing.
- Large-scale photonic integrated circuit packaging for dense electrical and optical interconnections.

Advanced component design focused on large-scale integration: monitoring, phase actuators and fault tolerant components.

- Alternative phase tuning mechanisms.
- Phase change materials.
- Novel design, fabrication and packaging techniques for scalable building blocks.

Advanced programming and control routines.

- Complex circuit modelling.
- System reconfiguration and stabilization algorithms.
- Control system architectures.

The Primary Guest Editor for this issue is **Dr. Daniel Pérez-López,** Photonics Research Labs, Universitat Politècnica de Valencia, Valencia, Spain. The Guest Editors are: **Alexander Tait**, NIST, USA; **Leimeng Zhuang.**

The deadline for submission of manuscripts is **February 1, 2022**. Hardcopy publication of the issue is scheduled for **November/December 2022.**

Call for Papers

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For inquiries, please contact:
IEEE Photonics Society JSTQE Editorial Office - Chin Tan Lutz (Email: c.tanlutz@ieee.org)

The following documents located at http://mc.manuscriptcentral.com/jstqe-pho are required during the mandatory online submission.

1) PDF manuscript (double column format, up to 12 pages for an invited paper, up to 8 pages for a contributed paper). Manuscripts over the standard page limit will have an overlength charge of $220.00 per page imposed. Biographies of all authors are mandatory, photographs are optional. See the Tools for Authors link:
www.ieee.org/web/publications/authors/transjnl/index.html.

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Photonics Society Mission Statement

Photonics Society shall advance the interests of its members and the laser, optoelectronics, and photonics professional community by:

- providing opportunities for information exchange, continuing education, and professional growth;
- publishing journals, sponsoring conferences, and supporting local chapter and student activities;
- formally recognizing the professional contributions of members;
- representing the laser, optoelectronics, and photonics community and serving as its advocate within the IEEE, the broader scientific and technical community, and society at large.

Photonics Society Field of Interest

The Society's Field of Interest is lasers, optical and photonic devices, optical fibers, and associated lightwave technology and their systems and applications. The society is concerned with transforming the science of materials, optical phenomena, and quantum electronic devices into the design, development, and manufacture of photonic technologies. The Society promotes and cooperates in the educational and technical activities which contribute to the useful expansion of the field of quantum opto-electronics and applications.

The Society shall aid in promoting close cooperation with other IEEE societies and councils in the form of joint publications, sponsorships of meetings, and other forms of information exchange. Appropriate cooperative efforts will also be undertaken with non-IEEE societies.