

Electro Optics

- + Microelectronics UK's Michael Adeniya on solving the UK's photonics skills shortage
- + Ruti Ben-Shlomi says LightSolver's Boeing-backed LPU will replace clusters of GPUs
- + Cornerstone's Emre Kaplan explains why lithography PDKs should be open to all

Laser fusion by 2040?

Focused Energy CSO **Markus Roth** says the path to clean energy is less than 15 years away. But what does the road look like?



Environment + Energy

- + **Analysis:** Can environmental photonics save us money as well as the planet?
- + **Paul Anthony Haigh** bridges the sustainable energy sector's multi-medium network gap
- + Miniature multispectral arrays can slash harvest food waste, says **Abdel Ruvalcaba-Perez**



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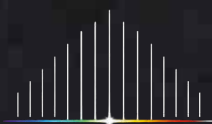
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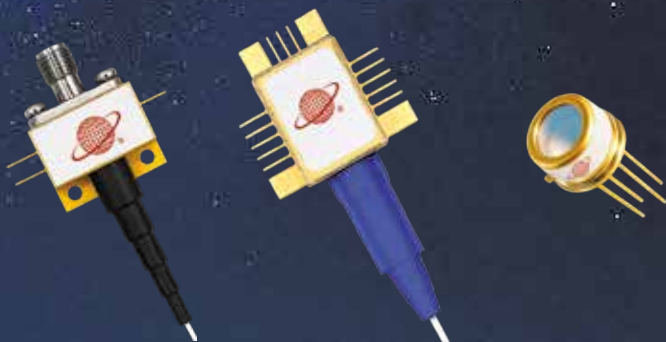
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Electro Optics

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Editor's Letter

Most career scientists get into it for one reason: to push ideas to their breaking point. And then break them. They tackle some of the biggest problems facing the world today with even bigger solutions, hoping to 'change the world' (if you'll excuse the phrase).

Environmental balance is, arguably, the biggest global problem we face and, indeed, have ever faced.

Fortunately, solving big problems is what science does best.

As I've put this Energy & Environment special issue of Electro Optics together, I've been hit by just how many times advances in photonics align with major environmental issues.

Clean fusion energy, for example, is an enormous, multi-generational engineering and manufacturing challenge, and it's using high-energy laser pulses to get over the final commercial hurdle; optical networking can ensure offshore energy infrastructure is as efficient as possible; multispectral imaging can take the guesswork out of harvest timing, stopping a third of the world's food going to waste; and photonics is seen in countless other industries such as recycling, construction and environmental monitoring.

But is that the best way to look at it?

With less waste, heat and power use comes fewer environmental effects, yes. But as resources become more stretched and more expensive across the globe, environmental solutions are becoming economic ones.

And that is not just good for photonics; it's good for us all.

James Wormald, Editor, Electro Optics

How photonics can make the circular economy pay

From recycling solar panels to sorting metals, detecting gas leaks and optimising cement fuels, photonics is finding increasingly practical ways to make industry more resource-efficient. But **James Wormald** asks if its strongest argument for adoption is no longer environmental, but economic.

While traditional photonics technology applications such as lasers, lenses and optical comms may still be big business, the most innovative, and arguably most important, developments are happening elsewhere. Power plants, recycling centres, hydrogen facilities and cement works; these all form part of the growing deep-tech renewable energy and environment ecosystem.

Over the past few months, a series of announcements and demonstrations have pointed to a surge in photonics-based technologies being deployed wherever industrial energy efficiency and material recovery gains can be best applied, helping environmentally minded companies to replace the consumable-intensive processes at the core of their businesses, and helping governments and regulatory bodies track and identify those that could do more. But is the case for environmental photonics technologies now a financial one?

Lasers take aim at solar-panel waste

One of the clearest examples comes from TNO in the Netherlands, where researchers have developed a laser process for dismantling end-of-life solar panels. The problem is a deceptively difficult one: panels need to survive decades of heat, cold, moisture and mechanical stress for reliability and long-term efficiency, so their constituent layers are firmly bonded together.

TNO's approach uses the solar panels' own optical properties to solve the problem. A laser converts light in the panel's active layer into localised heat, weakening the bond between the cells and the encapsulant without heating the entire module or using a chemical treatment.

Compared with the energy required by conventional solar panel separation techniques such as pyrolysis, which reportedly uses around 25kWh per module, TNO says its own process requires less than 1kWh per module, and the process can preserve glass and recover solar cells with very little adhesive residue, recovering as much as 99% of each panel's silver, for example.

"Laser-based techniques show that things can be done differently: energy-efficient and without losing value," says Mirjam Theelen, Research Lead at TNO. With a substantial wave of retired solar panels fast approaching, she says the technology can open a "goldmine of raw materials". TNO is already working with industrial partners and a Dutch machine builder to move from laboratory work towards complete-module processing.

Turning LIBS into a recycling platform

That same transition that sees a common photonics component used for wide-scale industrial infrastructure can also be seen in metal recycling. Earlier this year, TOMRA Recycling extended its AUTOSORT PULSE Dynamic LIBS (Laser Induced Breakdown Spectroscopy) system from separating only aluminium alloy to include stainless steel, heavy metals, magnesium and incinerator bottom ash (IBA).

LIBS uses a laser to drill through the surface of a material to determine its elemental composition, then it becomes a high-speed sorting tool. In mixed heavy metal streams, TOMRA says the system can now identify and separate copper, brass, zinc and stainless steel, where it can even discern between different grades in mixed streams. Instead of treating mixed scrap as a low-value commodity, recyclers

TNO



Mirjam Theelen, Research Lead, TNO

can identify and separate higher-value grades, says TOMRA.

"AUTOSORT PULSE has proven itself in aluminium alloy separation, and we have continued to develop what the technology can enable," said Tom Jansen, Vice-President and Head of Segments at TOMRA Recycling. "Our customers can use one system across several material streams. What changes is the application, not the technology."

A laser answer to black plastics

Along with glass and metal, plastics represent a huge portion of the recycling landscape, and a huge problem. Effective plastic recycling requires high material purity for accurate identification, but "conventional near-infrared spectroscopy may have difficulty identifying black plastics due to their light-absorbing properties," said Canon USA, which recently launched a Raman plastic analyser that uses advanced laser scanning to make identifying black plastics easier.

The system determines the plastic composition by oscillating the laser irradiation position and reducing energy density.

"Black plastics have historically posed a significant technical hurdle in the recycling industry," says Kenichi Kaneda, Senior Director and General Manager of Industrial Products at Canon. The company's aim, he says, is to recover plastics that were previously overlooked and create a more resource-efficient route for the industry.

Seeing methane before it escapes

Another major environmental opportunity enabled by photonics technology is measurement. Industry cannot reduce what it cannot reliably see, and optical techniques are increasingly being used to expose emissions that are unseen by conventional inspections.

In Australia, energy infrastructure operator APA recently trialled



Clean silicon after the recycling process

facility using Bridger Photonics' Gas Mapping lidar. The system, which according to Bridger identifies methane sources down to 0.5kg an hour with 90% probability, could locate sources of methane with approximately 2m of accuracy from a drone flying at 70m altitude.

In the past APA used helicopters to perform methane measurement studies, but local aviation regulations prevented any manned aerial craft from getting lower than 1,000ft, limiting the sensor's resolution. Instead of relying on higher altitude helicopters, the use of low-altitude drones could allow operators to obtain emission rates, source heights and more precise geographic coordinates of smaller assets.

Finding hydrogen leaks with Raman Lidar

Methane is not the only gas that can be identified with optical sensing, of course. Fraunhofer is developing RADIANT, a compact Raman lidar system designed to remotely detect hydrogen leaks. Hydrogen presents a particularly awkward sensing problem because it's colourless, odourless and has very weak conventional optical absorption, says Fraunhofer. So RADIANT uses Raman scattering to

identify gases and time-of-flight measurements to locate them.

The project, which combines work by Fraunhofers IMS, IAF and CAP, uses linear detector arrays to make the system more flexible than conventional Raman lidar systems, which are designed around a limited number of gases.

As hydrogen infrastructure expands, operators will need continuous monitoring without routinely exposing personnel to potentially hazardous environments, so the commercial prize at the end of the research rainbow could be significant.

Spectroscopy enters the cement plant

One of the most difficult materials to decarbonise, yet one of the most used, the cement industry accounts for around 8% of global CO₂ emissions. SPARC (Spectroscopic Process Analysis & RDF/SRF Control) is an inline spectroscopic process-analysis system announced recently by ZEISS that applies to alternative fuels used in cement production.

According to the company, the system continuously measures both the moisture and chlorine content and the calorific value of refuse-derived and solid recovered fuels (RDF and SRF).

Provided with that information, cement manufacturers could better understand the suitability of alternative fuels, making it easier to control the combustion process.

"The increased transparency allows operators to react more quickly to fluctuations and further increase the use of alternative fuels within their specific process and plant conditions," said Ria Sachse, Product Manager at ZEISS Spectroscopy.

The value of environmentalism

Many of these technologies still have work to do to prove themselves at scale, but the environmental advantages offered by photonics stretch further than energy-efficient lasers and faster optical connections.

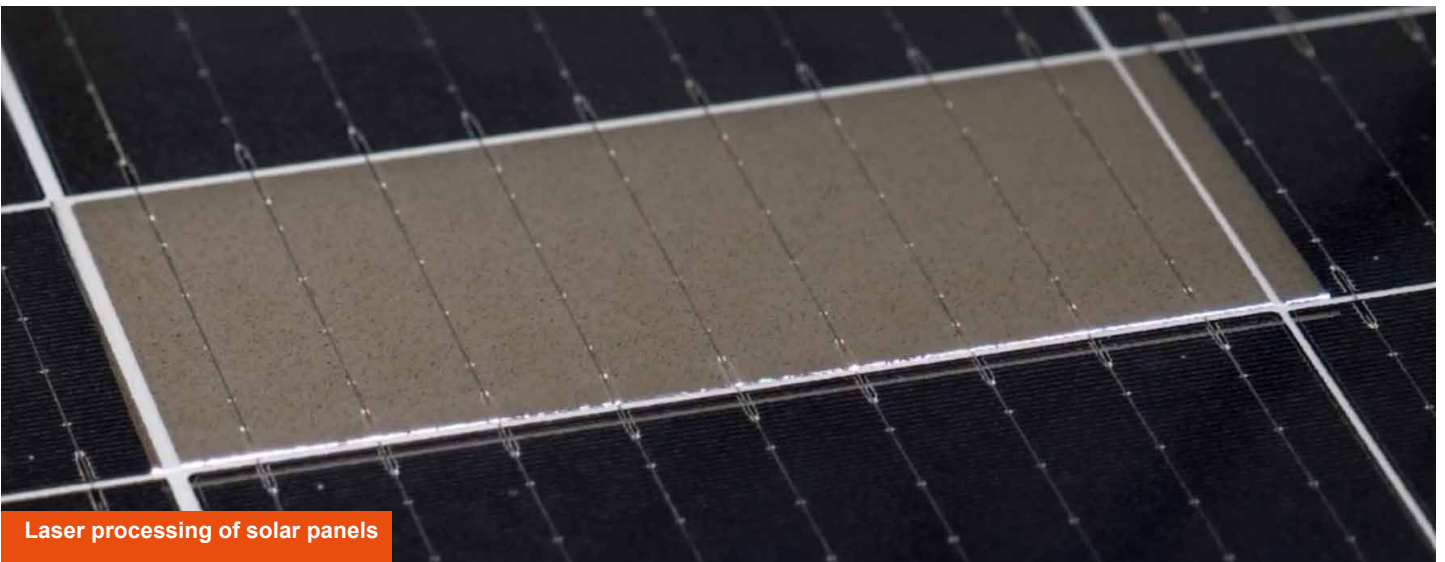
TNO's solar-panel work shows how precision lasers can deliver energy exactly where it's needed.

Rather than heating an entire object, and possibly damaging the material in the process, the system improves material recovery and cuts energy demand.

The innovative spectroscopy techniques applied by TOMRA, Canon and ZEISS demonstrate how optical analysis can distinguish individual materials in mixed waste streams, turning them into higher-value resources.

Lidar technologies from Fraunhofer and Bridger Photonics show a methane leak can be accurately located, rather than just detected, and even the loss of odourless, colourless hydrogen can be avoided.

For manufacturers, the industrial value of these innovations isn't just a green tick on an environmental report. By reducing waste and increasing resource efficiency, photonics is becoming a significant real-world cost-saving solution, as well as an environmental one. **EO**



Laser processing of solar panels

Semiconductor study reclassifies PIC firms

Companies involved with PICs now regarded as ‘dedicated’ not ‘diversified’ according to DSIT

The UK Department for Science, Innovation and Technology (DSIT) has published the second iteration of its national semiconductor sector study. It contains a methodological change with direct implications for the UK’s photonics industry: companies that design, develop or manufacture photonic integrated circuits (PICs) are now classified as “dedicated” semiconductor companies, rather than sitting in the broader “diversified” category used in the 2024 study.

The UK Semiconductor Sectoral Analysis, 2026 edition was produced by Perspective Economics alongside TechWorks, IfM Engage and the UK Electronic Skills Foundation, with input from an independent advisory panel and 38 sector stakeholders. It found 703 UK semiconductor companies – 295 dedicated and 408 diversified – up from 623 identified in the 2024 baseline. Of the dedicated cohort, 70% are UK-headquartered and 92% are classed as SMEs.

The report states that “42 company classifications were changed from ‘diversified’ to ‘dedicated’”, following collation of additional data and improved classification tools, and “companies designing, developing or manufacturing photonic integrated circuits (PICs) were classified as dedicated”.

The ‘dedicated’ cohort is the category DSIT uses to calculate the sector’s revenue, gross value added (GVA) and employment figures – and the one against which policy and funding decisions are calibrated. The change means PIC developers are now formally counted within the boundary of the UK’s semiconductor industry, rather than adjacent to it.

Photonics a national strength

The report identifies photonics as a UK strength through two independent evidence streams. Briefings produced as part of the UK Semiconductor Centre’s roadshow initiative point to UK strengths in “design and IP (Cambridge), compound semiconductors (especially the South Wales cluster), integrated photonics (Southampton/Glasgow/Northern Ireland), advanced packaging and neuromorphic computing”.

Separately, consultation with 38 stakeholders across industry, academia and policy produced a five-item strength list including “Compound Semiconductors and Photonics, with South Wales, Glasgow and Southampton routinely cited”.

In the report’s horizon-scanning chapter, which sets out future opportunities identified through workshops and consultations, artificial intelligence (AI) is named as the dominant driver of new demand.

“Workshop participants identified AI-enabled chip design and photonic chips as the two top technology priorities,” says the report. And photonic interconnect is listed alongside inference chips, edge devices, advanced packaging and power electronics as part of the AI compute stack “where the UK can compete on capability rather than capital intensity”.

Photonics is also given its own dedicated theme within the horizon-scanning findings, described as “a near-term opportunity where the UK has some differentiation, building on existing silicon photonics fabrication capability and a deep compound semiconductor ecosystem”.

The same section notes that workshop participants “proposed a dedicated photonics pilot line and scale-up facility to bridge the gap from UK research to production.”

The pilot line proposal

That proposal echoes a business case published separately by Cornerstone, the UK’s national silicon photonics prototyping service,

DSIT / Cornerstone



DSIT has issued a second part of its semiconductor study

based at the University of Southampton. Cornerstone’s paper, ‘The Case for a UK Silicon Photonics Pilot Line’, recommends a £305m capital investment in a national scale-up pilot line and low-volume manufacturing facility, combining PIC wafer manufacturing, heterogeneous integration and advanced packaging under one roof.

The document estimates this could contribute approximately £2.9bn to the UK economy by 2040, create around 2,850 new jobs and deliver a conservative return on investment of more than eight times the initial outlay, based on modelling developed with Moor Economics.

Within the DSIT study, Cornerstone is profiled as one of four national IKCs (Innovation and Knowledge Centres) providing “an open-source, licence-free silicon photonics foundry offering seven technology platforms from near-infrared to visible wavelengths on eight-inch wafers, (Cornerstone) is housed in a £120m cleanroom and serves collaborators in more than 20 countries through multi-project wafer runs”.

In a separate strategic analysis report, Optica’s CTO Jose Pozo describes the switch from diversified to dedicated as “the single consequential” sentence in the report, but cautions that the “photonics pilot line and scale-up facility is a proposal from workshop participants, (and) appears in the horizon scanning chapter, not in a funded programme list,” with “no budget, timeline, host institution or delivery mechanism” attached.

Patents and funding

The DSIT study also includes a patent analysis, which covers US patents granted between 2020 and 2025 with at least one UK inventor or assignee. A total of 1,139 were deemed semiconductor-related, with Device engineering – “mostly optoelectronics, transistors and diodes” – accounting for 336 (or 29%) of them, up from 27% in the earlier period, with fabless device companies such as Rockley Photonics, Cambridge GaN Devices and ORCA Computing named as contributors.

The view from Europe

Alongside DSIT’s semiconductor sector study, the European Commission has opened a call for tenders to establish up to seven AI gigafactories, backed by up to €10bn in EU and national funding and at least €20bn in expected private investment. The call closes on 12 November 2026, with award decisions expected by early 2027.



Keysight's Innovate software

Open Silicon Photonics for AI Systems Initiative coalition targets co-packaged optics

A 19-company coalition has officially launched the Open Silicon Photonics for AI Systems Initiative to develop a common architecture for co-packaged optics (CPO). Set up by founding member companies including Lightmatter, Keysight and Qualcomm as well as nine new ones, the initiative is an official workstream of the Open Compute Project (OCP).

The group's foundational 300-page white paper, 'Architecture Vision: Open Silicon Photonics for AI Systems' has been published to guide the development of a shared CPO blueprint for Modular Hardware System (MHS) and Open Rack v3 (ORv3)-compliant AI clusters, with the target to scale from 72 to more than 1,024 nodes.

One of the issues the Initiative has been set up to address is the limitations of electrical interconnects, which are becoming more evident as AI systems continue to scale. According to the coalition, SerDes rates (serialiser/deserialiser chip speeds) are approaching 448G, and the practical reach of copper connections has been reduced to tens of centimetres, meaning optical interconnects are in high demand in large-scale computing systems.

With the proposed OCP reference architecture, the group says it will provide a common framework across multiple SerDes generations, switch designs and accelerator or XPU development cycles. The architecture is technology-agnostic and is intended to accommodate silicon photonics alongside VCSELs (vertical-cavity surface-emitting lasers) and micro-LEDs.

The coalition says this approach is designed to support multi-vendor interoperability and a supply chain capable of addressing the bandwidth and power requirements of AI clusters containing up to 100,000 XPUs.

"Interconnect has become as fundamental to AI infrastructure performance as compute," said Nick Harris, PhD, Founder and CEO of Lightmatter. "The industry's shift to silicon photonics will unlock the next major leap in frontier model capabilities."

"Aligning 19 companies on a system-level architectural vision was an enormous undertaking, and I'm proud of what this coalition has accomplished," said Harris.

The coalition comprises nine new and 10 founding member companies, including Celestica, Corning, Dell Technologies, Flex, Foxconn Interconnect Technology, Hyve Solutions, Keysight, Lightmatter, Qualcomm and Quanta Cloud Technology. The next stage of the initiative is the submission of its first specifications, which is anticipated to take place in Q4 2026.

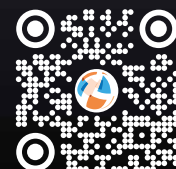
"The physical limitations of copper are increasingly constraining system scalability and accelerator utilisation in large-scale AI clusters, and that gap widens with each new generation of AI accelerators," said Jeff Janukowicz, Vice-President, Global Lead for Compute Infrastructure and Technologies at IDC, as the market intelligence company publicly backed the initiative, which, Janukowicz said, could "help move co-packaged optics from early deployments toward mainstream AI architecture".

ISOLATION OF CRITICAL WAVELENGTHS ANOTHER REASON TO CHOOSE ALLUXA



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Can AI automate lens design? Experts at SPIE Optics + Photonics debate

Artificial intelligence (AI) can support several optical design and photonics tasks, but researchers speaking at SPIE Optics + Photonics highlighted the limitations in both synthetic training data and the automation of lens design.

Speaking at the event, held in San Diego, California from 23-27 August, University of Laval Full Professor Simon Thibault examined the use of ray tracing to generate synthetic datasets for AI applications where experimental data are difficult to obtain, such as designing an optical system for snow density detection or using scattering profiles to simulate radiation dose distributions in radiotherapy. "What all these (applications) have in common (is that) they need data, and most of the time it's difficult to get those," said Thibault.

Ray tracing provides a way to model how light propagates and scatters through an optical system or environment, allowing datasets to be generated without collecting every example. The approach could also be applied to optical component testing, with simulations incorporating manufacturing tolerances and misalignments to produce more varied training datasets.

However, Thibault warned of a gap between synthetic and real-world data. Neural networks trained using idealised synthetic images can perform poorly when exposed to experimental data that contain effects absent from the simulations. He suggested incorporating detector noise, sensor response and manufacturing errors into ray-traced datasets to increase their diversity.

At the same event, Jacob A Sacks, a PhD student at the University of Rochester, examined whether AI can be applied effectively to lens design. His analysis focused on agentic large

SPIE/Joey Cobbs



Researchers and engineers met at SPIE Optics + Photonics

language models (LLMs), which can use tools and memory to perform iterative tasks with reduced human intervention.

Sacks proposed assessing optical design tasks according to how readily their results can be verified. His framework considers objective truth, verification speed, scalability, reliability and continuity. Writing macros or programming scored four-and-a-half out of five in his assessment, while local optimisation scored four. Global optimisation, which involves finding potential new optical designs, scored two, largely because candidate solutions are difficult to verify quickly and at scale. And general optical engineering scored one.

For research into zoom lens design, Sacks used a Python-based Monte Carlo search tool to identify paraxial layouts and Claude Code to prompt for a full-frame visible zoom lens for mirrorless cameras. He found that the AI system could identify different design forms, including configurations with positive and negative front lens groups, but although specific metrics such as vignetting and size can be optimised, it cannot yet determine which performance metrics are relevant or establish if searches are exhaustive without human intervention.

Synopsys unveils OIF-compliant 112G PHY IP for linear optical links

Synopsys has announced what it describes as the industry's first physical layer (PHY) IP compliant with the Optical InterNetworking Forum's (OIF) CEI-112G-LINEAR-PAM4 specification, marking a key development in the adoption of linear optical interconnects for AI and hyperscale data centre networks.

Designed to support DSP-less optical modules operating at 112Gb/s per lane using 53 Gbaud PAM4 signalling, the technology relies on linear optical architectures to move signal conditioning into the host PHY rather than digital signal processors (DSPs) or retimers inside the optical module.

Linear architectures allow the optical module to be "stripped down to its essentials: linear drivers, modulators, photodiodes and transimpedance amplifiers (TIAs)," said Synopsys.

The approach can reduce the power consumption of optical links by up to 50% compared with conventional retimed optical modules, while also reducing latency, lowering thermal loads and simplifying the design.

However, this architecture places significantly greater demands on the host PHY. Without DSP-based equalisation inside the module, the transmitter and receiver must maintain signal integrity across the electrical channel while remaining interoperable with equipment from different vendors to meet industry standards.

The OIF developed the CEI-112G-LINEAR-PAM4 specification, which defines electrical performance limits, test methodologies and compliance requirements for 112Gb/s linear interfaces, to give designers confidence in linear optics. The specification aims to provide a common framework for interoperable host-to-module interfaces, reducing the need for system-specific optimisation.

According to Synopsys, its transmitter "goes well beyond" the required performance metrics for voltage modulation amplitude

Synopsys



Synopsys headquarters in Sunnyvale, California

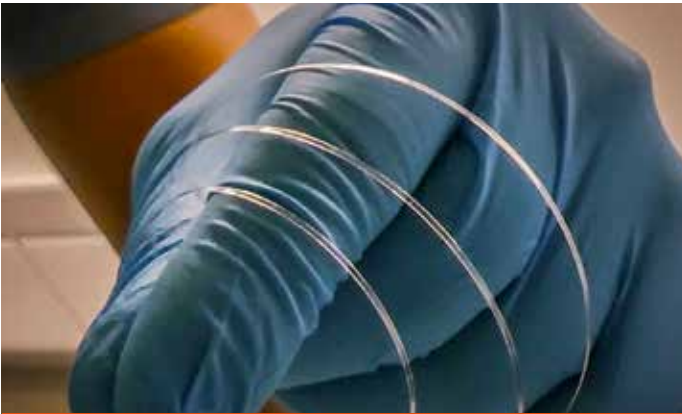
(VMA), jitter and eye closure under standardised test conditions across multiple temperatures.

On the receive side, jitter tolerance testing demonstrated reliable data recovery under injected sinusoidal jitter and channel impairments. The results "confirm (the 112G PHY can) support DSP-less host-to-module connectivity while maintaining signal integrity across the full link," said the company.

Increasing AI workloads are driving technological advances in optical networking. As accelerator clusters continue to grow, power consumption and the latency of optical interconnects have become increasingly important design considerations.

And linear optical architectures have emerged as a leading approach to improve system efficiency by reducing the complexity of pluggable optical modules.

For future improvements, the OIF is already extending the approach to higher data rates through the CEI-224G-Linear project, and framework activities for 448G electrical interfaces are also underway. "112G linear compliance is a milestone, not a destination," said Synopsys, adding that "every future data rate will have a linear variant, and the PHY IP that meets those specs will sit at the centre of every optical link".



The fibre is 1,000 times more sensitive than standard fibre

Flat fibre enables x1,000 sensitivity for pressure and temperature monitoring

A flat silica optical fibre offering pressure sensitivity up to 1,000 times higher than conventional circular fibres has been developed by researchers at KTH Royal Institute of Technology and the University of Southampton.

Rather than flattening a standard fibre, the team, whose work is published in Nature Communications, engineered the flat structure from the outset, using its high-aspect-ratio geometry and a controlled internal microstructure.

Laser-based glass processing then introduced internal features such as air channels and metal fillings enabling temperature and pressure sensing.

"This is not just a different-looking fibre," said KTH's Pawel Maniewski, "it is a new design space for optical fibre."



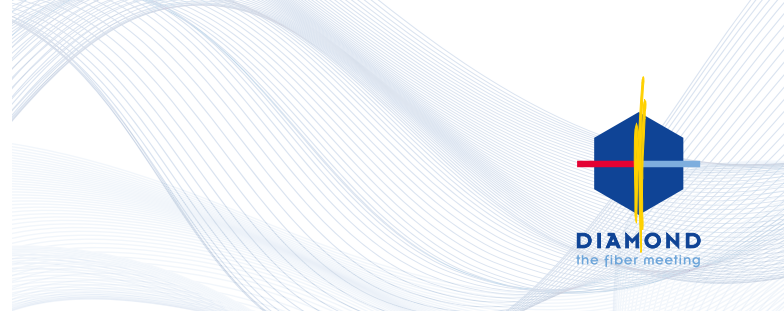
GoPro made its name selling rugged sport cameras

Struggling action-cam company GoPro to sell IP to optical market

GoPro is merging with US photonics company Starman Optical in a deal aimed at recapitalising the action camera-maker and expanding into optical transceivers for AI infrastructure, defence and other strategic markets.

Under the agreement, GoPro shareholders will receive \$285m in aggregate cash (\$1.14 per share) and retain around 10% of the combined company. GoPro's ~\$92m debt will be repaid in full, and the firm will remain publicly listed, continuing to support its consumer, subscription and cloud products.

GoPro's IP portfolio spans more than 2,500 patents built over 24 years, and the deal will bring Starman's US-made optical transceivers onboard, with the combined company applying its optics and imaging capabilities across AI infrastructure, government, robotics and aerospace, and aid investment in US onshoring efforts.



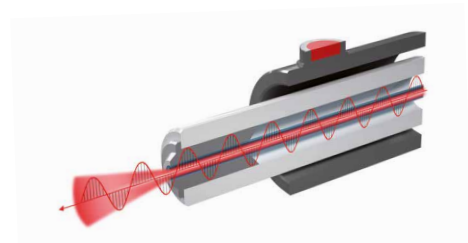
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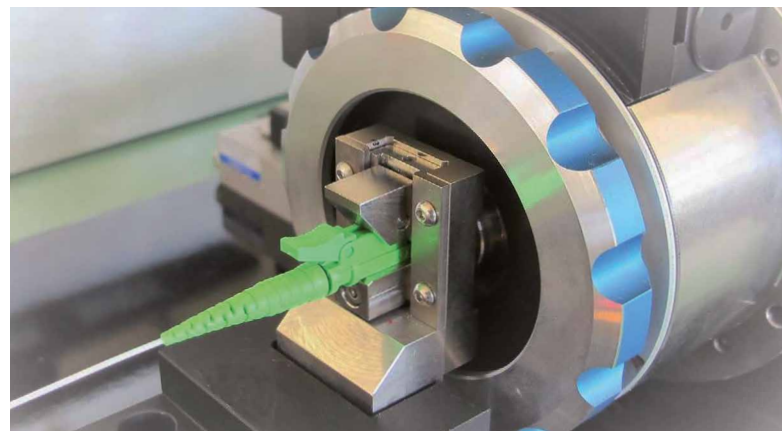


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Talent Foundry takes on the tech-sector's skills challenge

The UK's microelectronics sector has no shortage of ambition. From photonics and semiconductor manufacturing to optical computing, quantum technologies and advanced embedded systems, the country has significant technical expertise and a growing ecosystem of innovative companies. But, **Mark Elliot** asks **Michael Adeniya** (below), Group Event Director of Microelectronics UK, where will the people come from to deliver that growth?

For Michael Adeniya, the answer to the "where will the people come from" question has to involve industry, universities and early-career engineers working much more closely together. That is why this year's Microelectronics UK, staged at Excel London in September, introduced the Talent Foundry, a dedicated programme designed to connect emerging talent directly with experienced professionals.

"When we were first scoping out this show, we identified this issue of talent attraction and retention at the outset," Adeniya explains.

"In conversations that I had with companies... I was speaking to organisations finding it hard to get the right people through the door – even when they're already based in the UK."

That challenge is not simply about the number of graduates being produced: Adeniya points to the international competition for skilled engineers, with UK-based talent sometimes choosing opportunities in locations abroad.

His initiative builds on work already undertaken at the inaugural Microelectronics UK event. Last year, the show featured a skills zone, mentoring and a jobs board through which sponsors and partners could promote vacancies.

The jobs board returned this year, but Adeniya says his team wanted to "take this talent piece to the next level".

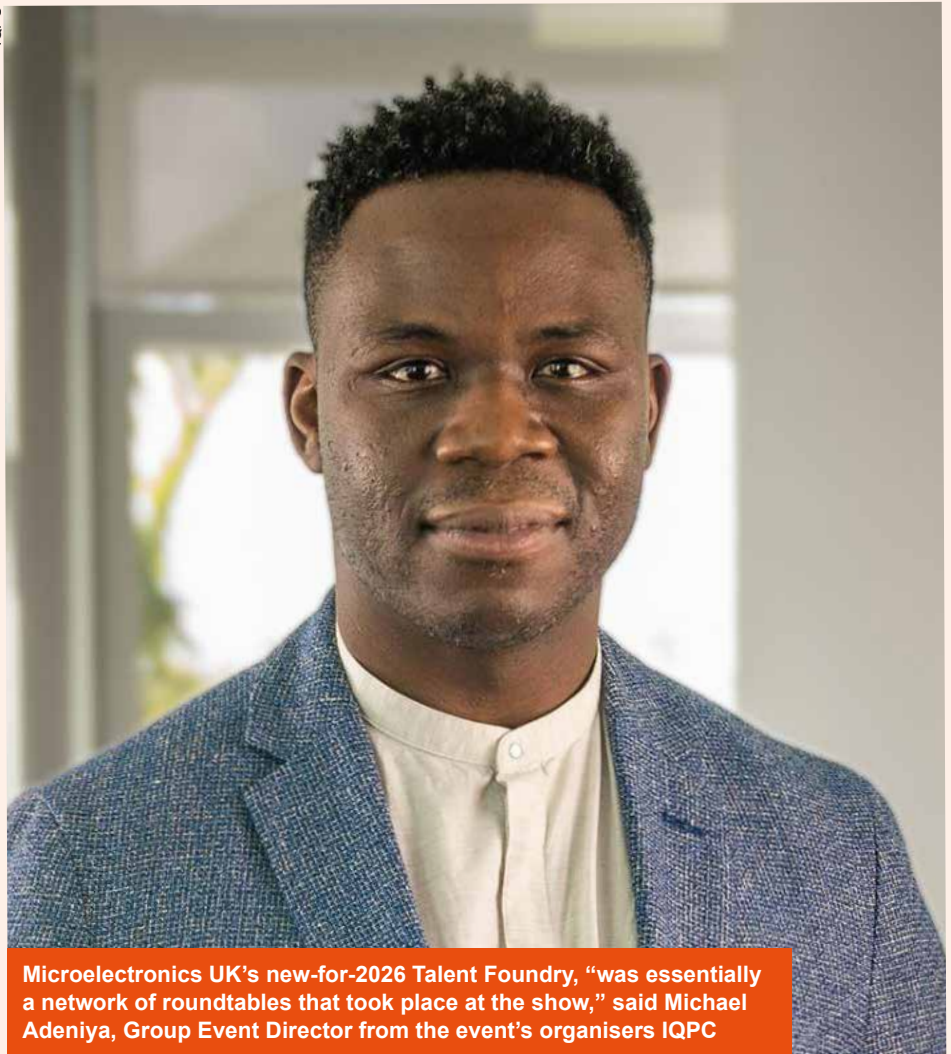
That resulted in a combination of recruitment support, mentoring and, most importantly, direct interaction between students and industry professionals.

Bristol-based technology talent agency 5VTech supported the jobs initiative by being available to "mentor people, and give them advice on different career paths".

The Talent Foundry went beyond simply matching candidates with vacancies. "We thought the Foundry name was quite an interesting play on words relating to the industry," Adeniya says. "But it was essentially a network of roundtables that took place at the show."

Three second-day sessions designed specifically for students and early-career

IQPC



Microelectronics UK's new-for-2026 Talent Foundry, "was essentially a network of roundtables that took place at the show," said Michael Adeniya, Group Event Director from the event's organisers IQPC

engineers gave participants face-to-face access to professionals from across the industry, with discussions focused on career pathways, skills and the realities of working in different technical roles.

The speakers demonstrated the breadth of the ecosystem the initiative is trying to expose young engineers to. The first session included Mahdiah Ghoddsi of the UK Electronics Skills Foundation, John Robertson of DSTL and Robert Atchison of ClearspaceUK. The second brought

together Vibishna Balagopal of Thales and Karen Jane Gordon of Leonardo UK. The final session featured senior figures from Arm, BT, Dassault Systèmes and Nokia.

As Adeniya explains, each roundtable intended to provide a much more realistic picture of what a career might look like.

"Those experts were there to give a group of anywhere between 10-to-15 individuals per roundtable an insight into a day in the life of an embedded engineer, how would you get into a career

“They want to get undergrads and new talent into the university, but they have an obligation to help the people in their university get great jobs in industry”

in optics and so forth,” he says. Crucially, participants also had the opportunity to ask questions and get “some tangible insight and advice so they can go and explore those career paths”.

The search for new talent

The Talent Foundry is also being supported by growing engagement with universities, with institutions such as UCL involved in the event. For universities, Adeniya argues, the relationship with industry is becoming a two-way responsibility. “They want to get undergrads and new talent into the university, but they have an obligation to help the people in their university get great jobs in industry,” he says.

That creates what could be described as a complete talent pipeline: attracting people into relevant courses, connecting them with industry while they study and helping them move into employment or entrepreneurship afterwards. “Part of that narrative is about excellent people in university that are creating their own IP,” Adeniya says. “That entrepreneurial pathway is just as important as conventional recruitment. They could join corporations, but a good chunk are also exploring their own entrepreneurial paths.”

Electro Optics again took up hosting duties on the Photonics UK stage at

Microelectronics UK. The first day of programming focused on areas including the photonics roadmap, free-space optical communications, space-based systems and orbital infrastructure, photonics manufacturing in low Earth orbit and defence-related applications. Day two moved on to compact photonic integration, fibre sensing, optical computing, AI, 6G, AR/VR and quantum technologies.

Microelectronics UK entered its second year with considerably greater scale. Adeniya says the show had just in excess of 3,000 attendees in its first year and had targeted around 4,500 for 2026. At the time of writing exhibitor numbers were expected to have grown from just less than 100 to around 180 this year, with additional interest coming from abroad.

As Microelectronics UK brings photonics, semiconductors and embedded systems together, the Talent Foundry is designed to ensure that the next generation is not simply watching that convergence happen, but has a route into becoming part of it.

The industry may be building increasingly sophisticated technologies, but Adeniya’s message is straightforward: the UK’s ability to exploit them will depend on having the people with the skills to build, deploy and commercialise them. **EO**

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From ignition to industry: path to scale commercial laser fusion

Following the National Ignition Facility's fusion energy breakthrough in 2022, the debate is no longer whether the science is possible, but how quickly it can be industrialised.

James Wormald asks Focused Energy's Founder and Chief Scientific Officer **Markus Roth** (right) to outline the technology, the milestones and the manufacturing challenges on the road to a commercial fusion power plant



Electro Optics: Tell us about Focused Energy, your approach to laser fusion and your plans for a commercial laser fusion facility.

Markus Roth: Focused Energy really started back when I was a professor at the University of Darmstadt, working on fusion, when a group of young people showed up and asked me to quit my professorship, move down to Munich and work with them to actually make fusion happen. My first reaction was "what a stupid, crazy idea that is!" But when I woke up the next morning, I thought, "what if it really works?" I was about 50 at the time, and I'd never have forgiven myself if I missed that opportunity.

I started working with Marvel Fusion as Chief Scientific Officer, but when they wanted to deviate from deuterium-tritium fusion and instead start working on non-thermal boron proton fusion, I didn't think it would work. When you're Chief Scientific Officer and you can't convince your CEO of the right scientific path, you have to take the consequences. So, I left.

Then Tom Forner (ex-CFO at Marvel) and I received a call from some venture capital investors who asked if we were still pursuing it, and they convinced us to start Focused Energy. Now we're the world's leading laser fusion company, with more than 160 scientists and engineers across Darmstadt, Berlin, Austin and San Francisco.

Our approach is inertial confinement fusion: we use high-energy laser pulses

to compress and ignite a pea-sized capsule of deuterium and tritium, and that energy is then converted into heat, steam and, finally, electricity, exactly as in a conventional power plant.

We build directly on the National Ignition Facility's 2022 breakthrough, which remains the only demonstrated net energy gain in fusion.

EO: On that breakthrough at the National Ignition Facility, that was the first time the technology was realised, even though it had been theorised for decades. How confident are you it can be scaled quickly enough for a commercial facility by the mid-2030s?

MR: A lot was learned in the first 30-to-40 years of fusion research that culminated in the successful ignition of fusion. Now we know how it works and why it works. That was the big fundamental question.

But you're absolutely right, so far the National Ignition Facility has achieved a gain of around four – meaning the fusion energy generated is four times the laser energy that was put in.

You need a minimum gain of around 25-to-30 just for the plant to power itself, and you need a gain of around 100 to make fusion energy at a commercially attractive price for the electricity market.

We've got a long way to go, but we're confident about doing that.

First, the National Ignition Facility is an amazing system, but it was built on technology from the 1980s. It's a

flashlamp-pumped glass system that does fewer than one shot per day, and it took 400 shots for it to achieve successful ignition. If you can only do 40 a year, it's going to take around 10 years.

Laser technology has changed dramatically over the past 40 years. We have lasers with a wall-plug efficiency of 10%, we have lasers with enough energy and lasers with far higher rep rates than the 10Hz we're looking for.

What we don't have are lasers that do all three at the same time, and that's our engineering challenge.

We are confident we can solve all these and other problems (we've come up with a risk register of 600 entries), but we're also realistic. Since 2022, the question hasn't been whether the physics works. It's an engineering and industrialisation challenge, and those are the types of problems the industry knows how to solve.

Assuming financial problems are not the major issues, we believe we will achieve our milestones in the next 10-to-15 years, but I want to be precise about the timeline: we're talking about a 100 to 200MW prototype around 2037, and a commercial gigawatt plant will follow also in the second half of the 2030s.

EO: What are those key milestones you're aiming to hit?

MR: Our facilities are milestone-gated. Our Darmstadt laboratory is already operational, and our laser-driven

“So far, ignition has achieved a gain of four. You need 25 to 30 just to power the plant, and 100 to make it commercially attractive. We’ve got a long way to go”

neutron source, the LDRS, is under construction. The next steps are our laser development and target production facilities, the latter including deuterium-tritium fuelling, cryogenic injection and target tracking.

The Integrated Test Facility will bring the laser, the target, the plasma and the control system to Technology Readiness Level (TRL) 6-to-7, and the Fusion Pilot Plant will then demonstrate ignition and engineering breakeven, reaching at least TRL 8. From 2037 onwards, the first-of-a-kind gigawatt plant follows. Building robust European supply chains runs alongside every one of these steps.

One of the demands from the Department of Energy was that the power plant should be able to produce at least 50MW of electrical power, and the second requirement was that we need to close the fuel cycle.

That means we need to demonstrate we can produce more tritium in the power plant than we consume. Tritium doesn't occur naturally on this planet, so we have to produce it in the power plant itself.

EO: Are there any technical hurdles you still need to overcome?

MR: Yes, and we are very open about them. The central challenge is turning a single proven shot into a reliable industrial system.

That means developing diode-pumped lasers that fire efficiently at around 10Hz, mass-producing precision targets reliably and at low cost, mitigating laser plasma instabilities and cross-beam energy transfer and maturing the fuel cycle, including tritium handling.

The great advantage of laser fusion is that the laser and the reactor are physically separate, and the architecture is modular, so we can develop and de-risk the individual components in parallel rather than one after another.

EO: What improvements are needed to make laser fusion possible long-term?

MR: It comes down to moving from laboratory grade to industrial grade performance at low cost. The lasers are the most expensive part of a plant today, and the single biggest improvement is mass production, which makes them dramatically cheaper, alongside higher efficiency and sustained repetition rates.

In parallel, we need to mass manufacture precision targets, on the order of 10-per-second for a one-gigawatt plant, and to mature both the fuel cycle and full system integration.

As the lasers and targets scale, we expect the cost of electricity to fall into a genuinely competitive range, broadly comparable with today's mature renewables.

EO: So after those requirements have been achieved and fusion energy is commercially viable, will you stop there, or will you continue improving to become more and more productive?

MR: We won't be commercially attractive in terms of the cost of electricity at first, no new technologies ever are.

But this is why this is such an amazing site in Biblis. It combines two former nuclear power plants and they have these two reactor domes a perfect distance from each other for us to build our laser systems right in the middle between them.

We're not so naive to think we can just build 1,100 lasers, turn them on and we've got ignition, of course. It's just not going to happen.

We will have to undergo a learning process similar to the one the National Ignition Facility went through. The only difference is that, operating at 10Hz, it will take us 40 seconds to get 400 shots, as opposed to 10 years.

It's not quite as simple as that in reality, but you get my point.

We'll have one target area with more than 300 diagnostics where we'll identify and fix the bottlenecks until we achieve robust ignition. We can probably run for around 10 seconds (with around 100 shots) before that target chamber starts to melt.

Instead of building the next power plant, all we have to do is turn those 1,100 lasers, and turn 1,000 mirrors in the opposite direction, and fire them into the second dome.

Only this target chamber now has the breeding blanket. It has heat transformers, it has steam generators and it has a generator that actually produces the electricity and breeds the lithium to close the fuel cycle.

EO: Are there any differences between Focused Energy's path and that of other research groups or commercial enterprises?

MR: There are several. Laser fusion is the only approach with a demonstrated net energy gain, so we build on proven physics rather than on a result that's still to come.

We hold the key rights and patents for the central components: the laser, the targets and the chamber, which together form the engine of the plant.

Unlike a decades-long public research megaproject, ours is an industrial, milestone-based programme with clear evaluation criteria, a mix of public and private capital and partners embedded in the supply chain from the very start.

And we anchor deployment at Biblis, where we reuse existing infrastructure to cut both time and cost.



A rendering of Focused Energy's "world-first" laser fusion power plant in Biblis, Germany, at the site of RWE's ex-nuclear power plant

“We don’t want Germany (to become) a Natural History Museum, we want to keep industry alive and we need constant, cheap power in order to do that”

> EO: Was the existing nuclear plant infrastructure a major driver in selecting Biblis as a location?

MR: Germany shut down nuclear plants that were still in good condition, and that handed us a real location advantage. Biblis already offers the buildings, the grid connection, the surrounding infrastructure and the site and regulatory expertise of RWE.

Our ‘From Fission to Fusion’ feasibility study confirms that reusing the site substantially cuts construction time and cost.

Add the proximity to TU Darmstadt and our partners, together with a regulatory tailwind as fusion moves under radiation protection law rather than the Atomic Energy Act, and Biblis can become Europe’s flagship fusion campus.

EO: And on the other side, what are the disadvantages of having to work on a second-hand site, with infrastructure not specifically designed for your purpose?

MR: If you were to ask our optical designers and engineers, of course, they’re not too happy to have to squeeze all the lasers and beam support into an existing facility. We also have to wait for some parts to be deconstructed before we’re ready to build inside them, so there are some drawbacks. On the other hand,

the site has road access, rail access and its own harbour. In terms of the infrastructure, it’s already a perfect site.

It’s also already connected to the European grid, so there’s plenty of power. There are staff on site who are familiar with nuclear technologies and how to handle them, and the proper licences required to operate nuclear devices on site are already in place.

We commissioned an independent study and found we could be saving almost 10 years in construction time.

EO: What will the facility mean for the German economy and its European neighbours?

MR: It’s a perfect storm right now in Germany, and for the rest of Europe, in fusion. Germany decided to step out of nuclear at the same time it was forced to step out of cheap Russian gas. We’re also moving away from coal and oil, but we don’t want to turn Germany into a Natural History Museum; we want to keep industry alive and we need constant cheap power in order to do that.

We also know the world is changing. Europe has to ask itself, for every industry, ‘what will the revenue path be for the second half of the century?’ In Germany, for example, we are absolutely certain it will no longer be the development of combustion cars.

That's good for the world, but it's bad for the German economy because we've perfected combustion cars over the past hundred years, and that expertise is pretty much worthless when it comes to electric cars.

Europe has to work out 'what is a good export model that the rest of the world will buy from us?'

To do that, we need to understand what our strengths are and work on those. And in Germany, optics is one of our main strengths.

According to the Fraunhofer Institute, the optics industry is worth €74bn a year in Germany, with a 44% export rate, and that can easily rise to €200bn with a 50%-to-60% export rate by 2050.

Therefore there is a real chance to get a new industry going, based on a 21st-century technology. The optics industry could play a huge part in that, and fusion could be the incentive that kickstarts it.

Fusion has the potential to become a key, 'made in Germany' industry, with tens of thousands of skilled jobs, strong export prospects and a European supply chain that connects deep tech, the Mittelstand (German small-to-medium enterprises) and research.

Biblis can serve as a blueprint for the

rest of Europe. The risk is that Europe keeps doing the research while other regions build the value chain and capture the value. Germany can – and should – be the industrial anchor, and whoever scales now will set the global technological, regulatory and economic standards.

EO: What about the people needed to make it happen? Do you foresee the skills shortage becoming a problem?

MR: I agree that the skills shortage is a major problem, but this is an area where the glamour of fusion can help. We've raised our staff from 60 to 160 in the past year, and those are highly qualified people, too.

I'm a local patriot of Darmstadt, and even I admit it's not the most attractive of cities to ask people to move to. But we have no problems getting good people in.

Fusion is the draw. For many young, brilliant minds, fusion is a huge task that has history-making potential, and that's the attraction.

EO: How urgent is the world's need for fusion, and how big a part can it play in the future clean energy mix?

MR: The energy demand in the world is increasing dramatically. If you work

out the number of batteries it would take to power Germany for five days in November, when there's no wind and the skies are grey, the cost of those batteries would be €4trn.

And you'd have to spend €200bn every year replacing the old ones.

If you want to maintain a power grid in winter, that cost is simply intolerable for society – €200bn is half what our federal government has available all year, so it's not going to work. You need base-load power plants.

On a 30-to-40-year horizon, it is an excellent, baseload-capable complement to wind and solar, and in the longer term, abundant clean energy at very low marginal cost could even power technologies such as direct air capture, allowing us to begin correcting some of the consequences of climate change.

It would be wrong to pin all our hopes on fusion, but it would be equally wrong not to invest decisively enough for Europe to lead.

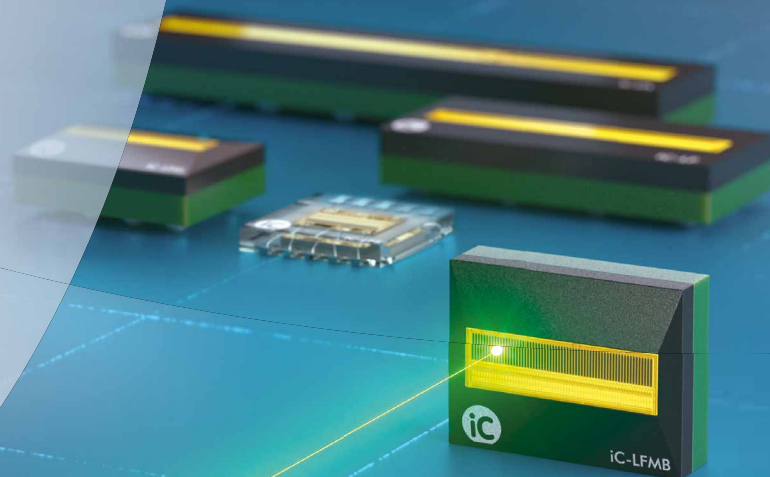
Fusion is not a short-term fix for a single climate target, and anyone who sells it that way is not being serious.

It is an infrastructure technology for the next century, in a world whose energy demands will rise sharply. **EO**



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Integration challenge facing heterogeneous optical networks

Optical networking is being split into four distinct communities, but as fibre, free-space, satellite and underwater optical systems all emerge, better communication and cross-medium integration is critical. **Paul Anthony Haigh** (right), from Queen Mary University of London, identifies the urgent integration required to get them talking the same language



On a grey North Sea morning, a wind farm is a surprisingly complicated information problem. Structural sensors on the turbine foundations are feeding data back through a subsea cable; an inspection drone is circling one of the towers, sending video over a wireless link; satellite backhaul is covering the sections of the array where cable infrastructure runs out and grid integration data is moving through fibre toward the national network. There are four physical media, with four separate engineering traditions, and one offshore energy operation that depends on all of them working together (figure 1).

Now, suppose a foundation sensor encounters an anomaly below the waterline. The subsea cable is saturated. The drone feed has priority. The satellite path is open, but the latency is high, and the data is time- and mission-critical. Which link carries what? At what priority? Negotiated how? Between systems built by whom?

Nobody has a good answer to those questions. But it's not for want of engineering talent in any of the four domains. It's because those domains were never really designed with each other in mind. They developed separately, optimised separately and now find themselves bolted together in the field through a combination of bespoke integration and a reasonable dose of hope.

The offshore wind scenario is not exotic. It is a fairly ordinary description of how energy infrastructure at sea actually operates, and versions of it appear in ocean monitoring, disaster response, maritime logistics and submarine cable maintenance every day.

Four communities, one problem

Optical fibre has had a remarkable few decades. Wavelength-division multiplexing and coherent detection pushed single-fibre capacity into ranges that would have seemed implausible to the engineers

who built the first transoceanic cable systems; free-space optical (FSO) and radio-frequency (RF) wireless matured through successive generations of mobile standards, and the economics of both have shifted dramatically; non-terrestrial networks moved from the margins toward the mainstream as low-earth orbit constellations began providing genuine global broadband coverage; and underwater communications, less visible to most of the field, but technically rich, advanced steadily to serve ocean science, offshore energy and the growing population of underwater vehicles operating on the continental shelf.

Each community has produced real, substantive results. The problem is that they have produced them largely in parallel, with limited cross-pollination. A researcher working on underwater acoustic channel modelling and a researcher designing optical inter-satellite links, for example, are both, at some level, trying to solve the same class of problem: how do you move data reliably through a medium that resists it?

But the conferences are different, the vocabulary is different and the citation networks barely overlap (Figure 2).

Spend an afternoon with the reference lists from a recent underwater communications paper and a recent satellite communication paper, and the separation is striking.

The two communities are not even arguing with each other. They're just not talking.

This matters because the applications that need connectivity to advance most don't respect those disciplinary boundaries. Submarine cable infrastructure, which carries the overwhelming majority of international data traffic, is a good example: these cables are not passive pipes. They're actively monitored systems that depend on a chain of underwater sensors, surface vessels, remotely operated vehicles and

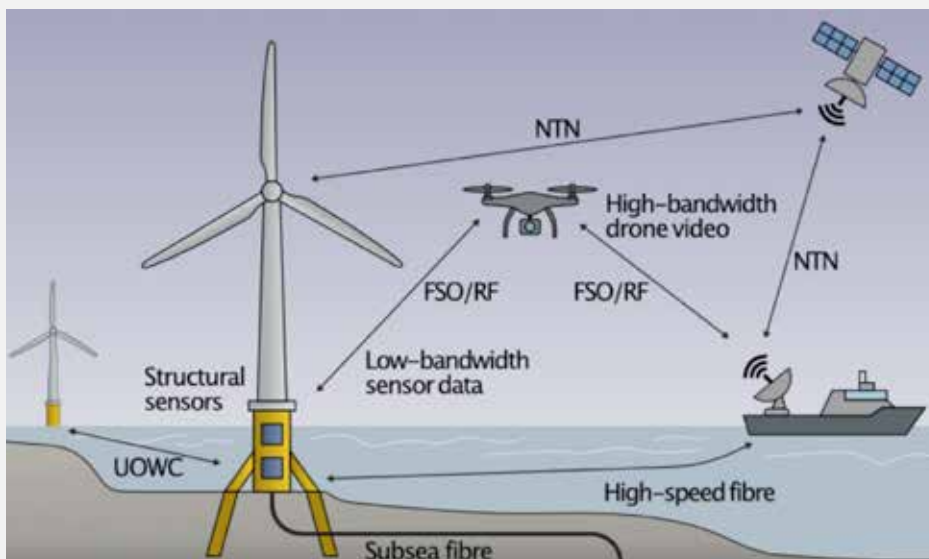


Figure 1: A heterogeneous network scenario between the four domains, including turbine, drone, satellite and subsea cable

Dr Paul Anthony Haigh

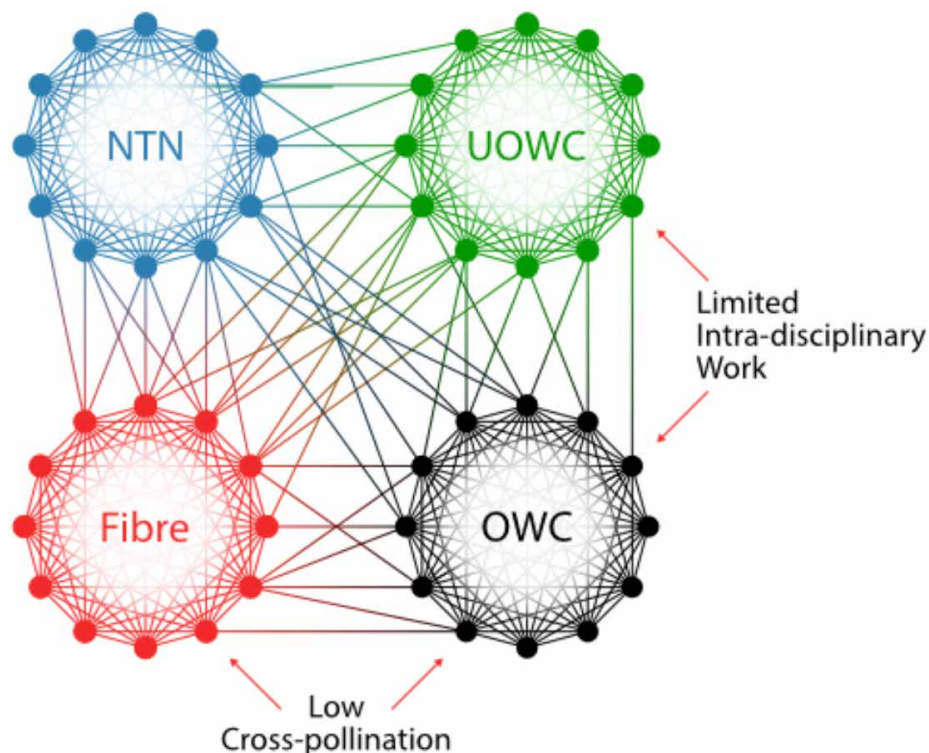


Figure 2: The four disciplinary silos are a problem for cross-pollination – NTN: non-terrestrial network; OWC: optical wireless communication; UOWC: underwater OWC; and fibre

satellite uplinks to detect faults, localise damage and coordinate repair.

Recent incidents in the Baltic and elsewhere have made clear just how vulnerable this infrastructure is, and how poorly equipped the response ecosystem is to act quickly when something goes wrong. The coordination difficulty is not primarily technical in any single domain. It comes from the seams between domains that were never engineered to fit together.

Ocean monitoring for climate research faces a version of the same problem.

So, too, does every coordinated disaster response operation that tries to pull together satellite imagery, aerial reconnaissance and maritime assets under a common communications picture. In each case, the individual technologies are capable. The integration layer is what is missing.

What must change

Calling for integration is easy; working out what it would require is harder, and the physical-layer differences between media are significant.

Optical fibre engineers spend their careers managing dispersion and non-linearity; FSO links live or die on pointing accuracy and atmospheric turbulence statistics; underwater optical channels are governed by absorption and scattering that vary with depth, water type and even the time of year as plankton blooms shift the optical properties of the water

column; acoustic underwater channels are low-bandwidth and high-latency by the standards of every other medium in this discussion, and they are subject to Doppler effects from platform motion that would be negligible in any other context; and satellite links add propagation delays and interference management challenges unlike anything faced in terrestrial networking.

At the transition points between any two of these media, the impairments compound in ways that are difficult to predict by treating each link in isolation.

A packet arriving at a satellite uplink after traversing an underwater optical path has a different statistical profile than a packet from a fibre feed, and the end-to-end behaviour of the combined system does not follow neatly from the individual link budgets.

Meanwhile, cross-medium channel characterisation, building models that describe not just propagation within a medium but the statistics of signals crossing between them, is foundational work that has barely begun.

Protocol design sits on top of that. Most transport-layer networking assumes that links are broadly similar in their latency and reliability characteristics.

The spread across a path that includes an underwater acoustic segment, a satellite hop and a terrestrial fibre connection is orders of magnitude wider than current protocol mechanisms that work well on a fibre-

“Each new wind farm is a critical energy infrastructure in a marine environment, and the connectivity architecture underneath it is, at present, improvised”

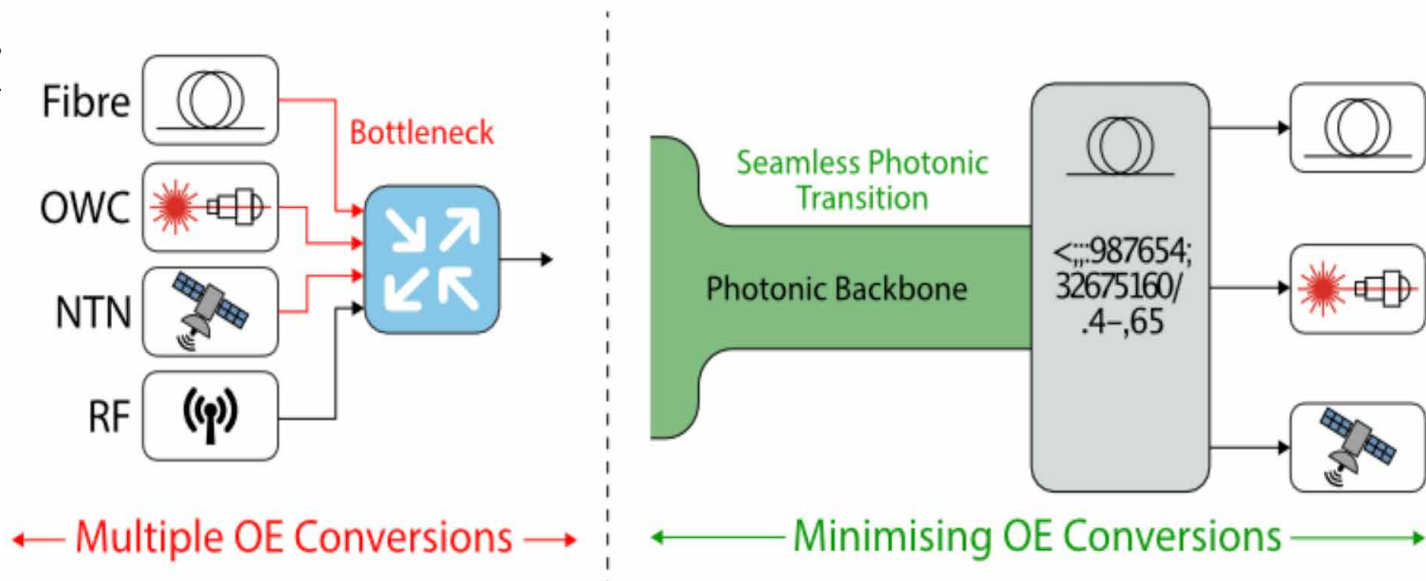


Figure 3: A photonic backbone minimises OE conversions, solving the bottleneck with seamless photonic transition

- > dominated path will behave poorly when the path includes a high-latency acoustic link, for example, and the retransmission logic that serves satellite channels well can be counterproductive in the presence of burst errors that FSO links produce in bad weather. New protocols are needed that treat medium diversity as a feature of the design space rather than an edge case.

The photonic thread

One idea that has attracted substantial global research investment, and includes key communications systems research groups, is to push optical processing as far through the network as possible, minimising the optical-to-electronic conversions that currently occur at most intermediate nodes.

Every such conversion costs energy and adds latency. In a network where data volumes are growing, and energy efficiency is becoming a primary design constraint rather than an afterthought, eliminating unnecessary conversions represents both an elegant engineering approach and a practical necessity (Figure 3).

For a multi-medium network, the photonic backbone concept is attractive for another reason. Fibre, FSO and inter-satellite FSO links can, in principle, form a continuous optical path from the seafloor surface interface all the way to orbit, with the signal remaining in the optical domain throughout. The challenges are substantial: atmospheric turbulence correction for FSO links, pointing and acquisition for satellite optical terminals and the integration of widely different aperture sizes and power regimes along the same path. But the fundamental physics is cooperative in a way that the interface between optical and radio frequency or acoustic domains is not.

That interface remains the harder

problem. Underwater acoustic links, which dominate communication below the optical attenuation depth in anything other than exceptionally clear water, do not connect naturally to a photonic backbone. Nor do the radio-frequency channels that still handle most of the access layer in non-terrestrial networks. The design of efficient, low-loss bridges between the photonic domain and these others, and the protocol and network-layer work needed to make those bridges transparent to applications, are where some of the most interesting unsolved problems in this space sit.

The timing question

None of this is purely a problem for the future. The offshore wind buildout across international waters is happening now, and floating wind technology is opening ocean areas that fixed foundations could not reach. Each new farm is a critical energy infrastructure in a marine environment, and the connectivity architecture underneath it is, at present, improvised.

Ocean monitoring programmes are deploying sensor networks that researchers expect to run for decades, and the data relay architecture they are built on will shape what's scientifically possible for a long time. Getting the integration work done before those systems become entrenched is far easier than retrofitting convergence into mature, divergent infrastructure later.

But there is a broader historical point here. The internet did not emerge from a single unified network. It emerged from a profusion of incompatible networks that were eventually given a common addressing and routing layer, one that made all the underlying networks capable of cooperating without making them identical. The situation in multi-medium

connectivity is not the same, but the logic rhymes. Fibre, FSO, wireless, satellite and underwater links are not going to converge on a single physical technology. The question is whether the field develops the common abstractions, interface standards and orchestration frameworks that would let them function as one system when an application needs them to.

That work requires the four communities to start treating each other's problems as their own. It requires channel modellers to care about the transitions between media, not just the propagation within them; it requires protocol designers to build for a latency range that spans acoustic and fibre in the same path; it requires photonics researchers to think seriously about the interfaces where the optical domain ends; and it requires global funding and institutional structures that reward collaboration across disciplinary lines that have been treated as fixed for a long time.

The offshore wind farm still waits for an answer to that routing question. And so, for that matter, is the submarine cable repair ship, trying to coordinate with a satellite ground station and a remotely operated vehicle at three in the morning. The connectivity problem that spans sea, air, space and fibre is not going to solve itself within any single community. It needs a research agenda that treats all four as one **EO**.



Paul Anthony Haigh is an Associate Professor at Queen Mary University of London, where his research group works on optical wireless communications and heterogeneous network systems.



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Chroma's Customer Service: Past, present and future

As automated platforms fail to resolve complex support requests, Chroma Technology explains why the company prioritises technical expertise and human connection over AI

Customer service plays a pivotal role in the customer experience just about anywhere you shop, from your local corner store all the way to the Fortune 500. Customers everywhere are looking for support in their purchasing journey. In fact, 69% of consumers still prefer to use phone support for certain issues, citing the need for a human touch on complex problems. As time marches on, customer service has become an overlooked function.

Now businesses can delegate customer service to automated platforms and AI agents to save time and increase the number of resolved cases. The maths might look appealing on paper, since self-service costs roughly \$1.84 per contact compared with \$13.50 for agent-assisted support, but only 14% of those self-service interactions actually resolve the customer's issue. Their intentions may be in the right place, but an important piece is missing: customers are more than a statistical highlight. They're real people with real problems that should be handled with empathy and care, which is something only humans can provide.

Chroma Technology has always embodied this philosophy. Our customer service team has always put its customers first and made sure that a real person answers the phone or responds to an email. Since day one, we've made serving our customers a priority by empowering our team with the knowledge and autonomy to truly support them. While AI and automation continue to reshape the customer service industry, we believe that our customers' questions are best answered by real people.

Where it all began

Chroma's commitment to people-first service goes back to the company's earliest days. In the early 2000s, when Chroma was a 35-person company still operating out of an old cotton mill, sales and applications worked side-by-side in a single office. There was no automated phone tree and no chatbot standing between customers and the people who could

Chroma



Mavis Ellingwood (left) has been a Customer Service Representative since 2010; Sarah McClellan started in the same role since in 2000 and has been Team Lead since 2022

actually help them. Everybody, including the founders, would answer the phones. Paul Millman, a founder, lived to answer the phone from day one until his retirement six years ago, and that mentality remains today.

Getting a real human on the line, rather than routing people through automated systems, was simply how things were done from the very start. That instinct shaped the team for the next two-and-a-half decades, even as the company grew and customer service became its own dedicated department staffed with technical experts. Long before some of today's team members ever set foot in the building, Chroma had already built a reputation for award-winning customer service, one centred on putting the customer first and helping advance the science behind what customers were trying to accomplish, rather than chasing the bottom line.

Where we stand today

Today, Chroma's customer service team has grown into a small, but mighty,

group of technical experts who answer the same main line that has always connected customers directly to real people. The job has become far more complex than just picking up the phone. It now includes everything from pricing and availability to export compliance, payment troubleshooting, and working through technical specifications with the engineering team. What hasn't changed is the philosophy behind it.

Mavis Ellingwood, a valued Customer Service Representative since 2010, explains: "We sincerely care about the customer. We see them as people, not as a number, not as a payout... it's not just a job. It's far more than that to me."

That care is backed by real flexibility. The team is empowered to make judgment calls to genuinely solve customer problems – all without jumping through layers of approval.

Sarah McClellan, a valued Customer Service Representative since 2000 and Team Lead since 2022, describes that freedom as a defining part of the job: "We have a lot of flexibility as to how we go

Chroma



In the early 2000s, Chroma was a 35-person company operating out of an old cotton mill

“We’re always going to be trying to have a human answer a phone”

about doing things,” she says, and that autonomy makes both the team and the customers happier, which, in turn, makes for better service and leaves customers feeling heard. It’s this combination of technical expertise and genuine autonomy that customers notice, and that breeds customer loyalty based on the value Chroma provides. Our Net Promoter Score isn’t world class by accident.

Where we’re headed

Looking ahead, Chroma’s customer service team isn’t interested in chasing the industry trend toward full automation, but that doesn’t mean standing still. The team plans to keep evolving alongside new tools and technology, just as it always has, so that even more time can be spent with customers and less time on repetitive behind-the-scenes work.

Mavis envisions a future where the team plays an even bigger role in feeding customer insights back into the rest of the organisation, helping marketing, sales and engineering understand what customers are actually trying to accomplish.

“What I would like to see is that it does become more of being recognised for what it really is,” she says, “being more involved in the growth” of the company itself.

Sarah is just as enthusiastic about future innovations but is firm about what should never change.

“I would actually really like to say that our high priorities aren’t going to change,” she says. “We’re always going to be trying to have a human answer a phone when somebody calls.” As she puts it, while the rest of the world moves toward automation, “people actually appreciate a human being,” and that’s exactly what Chroma intends to keep providing.

The bottom line

From a phone line answered by anyone who could grab it first to a team of dedicated technical experts, Chroma’s customer service has changed in scale and complexity, but never in priorities. Putting the customer first, making sure a real person answers the phone, and giving our team the autonomy to solve problems their own way are not things we plan to change, no matter how the rest of the industry evolves.

As automation reshapes the rest of the industry, Chroma is doubling down on the one thing that technology still can’t replicate: a real person who genuinely cares about solving your problem. For us, Customer Service isn’t a job description; it is a way of life. **EO**

‘Open-source PDKs close the gap’ between idea and fabrication

Cornerstone believes its open-source model PDKs will accelerate silicon photonics development by removing traditional IP-based barriers. PDK Manager **Emre Kaplan** (right) tells **James Wormald** how greater transparency, collaboration and shared fabrication data could speed up innovation across the industry, from post-doc researchers to more established players



Electro Optics: Can you explain what a PDK is and why they're so important for bridging the gap between experimental design and real-world fabrication?

Emre Kaplan: It's a great starting point because we often assume everyone knows the term PDK. It stands for Process Design Kit, and it's an interface between a foundry and a designer. Foundries make the basic building blocks of a system available to designers, we call them basic fundamental photonic devices, so they don't need to redesign every individual component in a system.

Instead of having to go through a lengthy design and simulation process for each component, PDKs allow designers to focus on circuit-level design and innovation. One part of it is that they have access to these basic building blocks, which are common components that they can use directly, and the second is that they have a design manual, provided to them by a foundry, on how the chips are fabricated.

That means they can tell what the fabrication limitations are before and during the design phase.

EO: Cornerstone has been working on what you've described as a "world-first" open-source PDK initiative. What's so revolutionary about it, compared with existing approaches?

EK: It's an ambitious statement, right? Yes, as far as I know, Professor Lukas Chrostowski from the University of British

Columbia made the first open-source PDK, but that was on e-beam lithography and silicon technologies only. Where we differ is that our PDKs offer e-beam lithography, as well as deep-UV (DUV) lithography services. The difference is that e-beam is good for conducting research, but the writing time of patterns is very long, so it's not really scalable. When you want to move into mass manufacturing, e-beam tools are the limiting factor.

Instead, DUV lithography involves processing silicon technologies on multiple prototyping chips, with up to 200mm-sized wafers, and can pattern them all instantly, so it's really good for scalability.

In terms of scalable lithography, yes, we can say we are the first foundry to do that, by providing 8" DUV lithography for open-source photonics.

The second aspect we bring is that we try to cover a broad range of the wavelength spectrum. If you have just one platform such as in silicon-on-insulator, you will only be able to target telecom applications, but our platforms cover visible light up to mid-IR, so they can be used for quantum applications, sensing applications and for greenhouse-gas monitoring.

These kinds of applications require a large range of wavelengths, so we offer eight different PDKs.

They are all truly open source, and they address the different technologies being integrated into photonics systems.

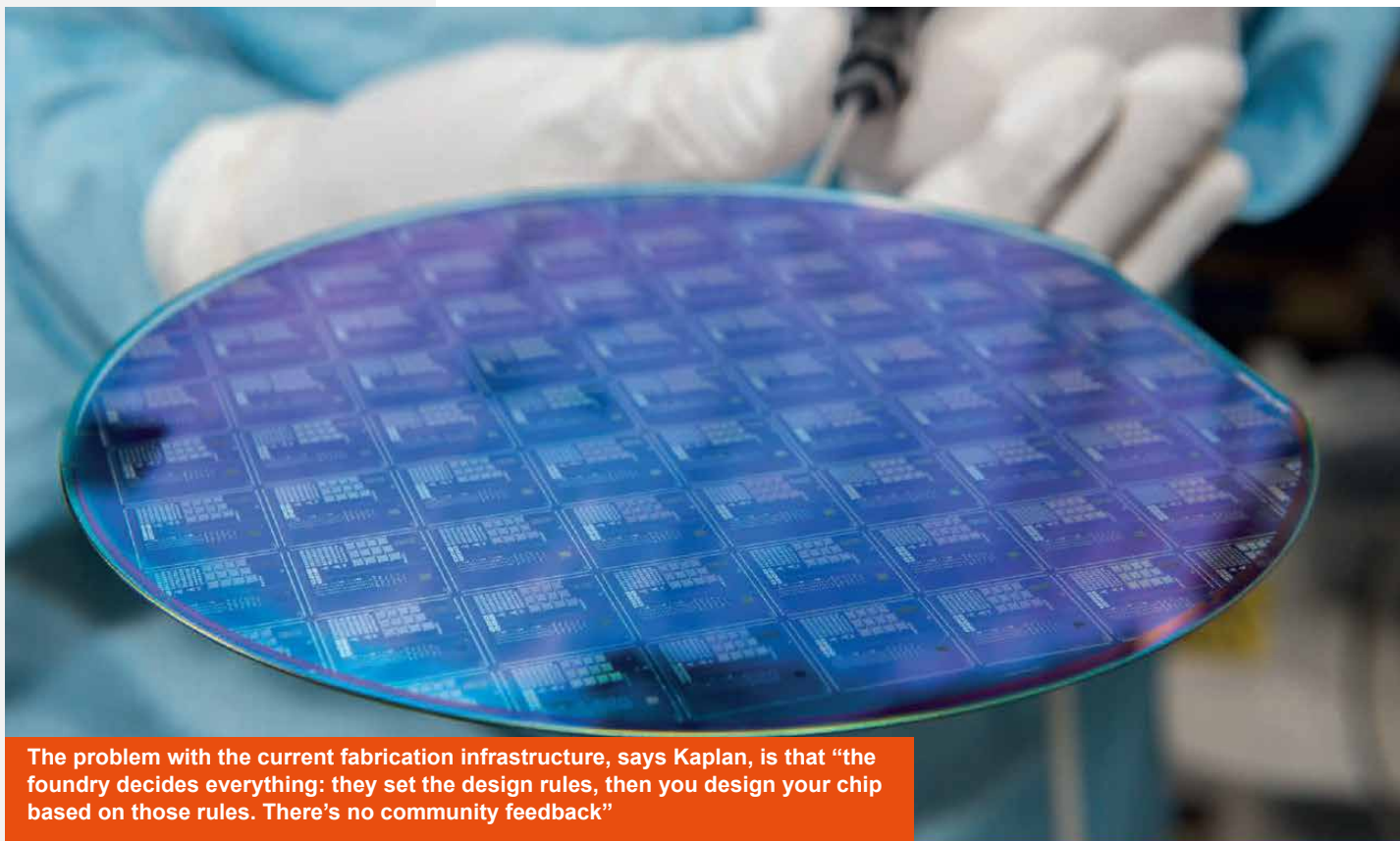
EO: What's your reasoning for going down the open-source route? Are there some limitations to traditional IP-protected PDKs or is this more of a democratising act?

EK: We weren't initially dreaming that big. The idea was originally just to promote silicon-integrated technologies to everyone, so our main objective is to make the technology accessible and visible in the community. It's not going to completely democratise the entire field, this is just one side of it. (It's helpful for) design and layout to have component test results or fabrication tolerance figures to hand, and the information can be easily shared openly.

As the foundries become more interested in the open-source approach, the capabilities of the technologies will also increase, but the building block PDKs are the IP of the foundries, and they are well protected under licensing rules. That's why it will depend on how the entire community reacts to the open source idea.

EO: How has the community reacted to the platform so far?

EK: People from academia love the idea. People such as researchers, PhD students and postdocs. And start-ups also like it because they get easy access to technologies without any NDAs or democratic barriers put in their way. So we got some positive early contributions when we launched the open platform



The problem with the current fabrication infrastructure, says Kaplan, is that “the foundry decides everything: they set the design rules, then you design your chip based on those rules. There’s no community feedback”

last year. Organisations such as the University of Sheffield and CSA Catapult in the UK contributed to the open platform on GitHub, then the Tyndall National Institute and the University of Pavia were also involved.

However, the point where we are now is not satisfactory. We need to reach out to more people, we need to get more contributions. We’ve had a lot of positive feedback from researchers saying they are willing to share their building blocks in the future, but we haven’t had as many external contributions as we’d like so far.

We’ll also be promoting the open platform to bachelor’s and master’s degree students. We run fabrication rounds for first-time users twice a year, where students can interact with PICs, design components and even contribute to the open platform during their studies.

As we don’t require an NDA, we can also use open-source PDKs in training sessions, and software companies such as Luceda Photonics and GDSFactory use our PDKs in their software packaging systems and for their training programmes. That’s because they’re accessible and available in the public domain.

EO: So established companies are using them as well as academia and start-ups? Which sectors do you think are gaining the most benefit?

EK: The initial idea was to promote the activity within academia in the UK, but I think now we’re at the stage where

we can target beyond that. Start-ups, spin-outs, academic research groups, researchers and postdocs, these are definitely still the main targets because they provide services for research anyway. They can build photonic circuits based on the work of others. Open-source is a very collaborative approach, and it can be used by research and academia to boost their activity.

But I think there are still opportunities for big players as well. You might be a giant in the field of electronics, for example. Of course, if you want to try to adopt integrated photonics (IP) technologies, then we can offer rapid prototyping, so you can test your idea very quickly and see if PICs can be a solution to a certain problem.

So it’s not just the big companies already in the field that will find it useful, but maybe some other companies from other fields will be interested as well. Quantum companies, for example, and those that provide sensing systems. They might be based on electronic systems, but they can use photonics technologies, as long as it can outperform the current products on the market.

Even big companies that exist as foundries, they all use IP-protected PDKs, of course, but they can make part of the technology public, while still keeping the most advanced processes under protection. There’s nothing wrong with that, of course, but once you’ve shown designers your capabilities, you

“You can learn from the mistakes of others, instead of having to make your own first”



“DUV lithography involves processing silicon technologies on multiple prototyping chips with up to 200mm-sized wafers,” says Kaplan, “and (you) can pattern them all instantly, so it’s really good for scalability”

> let them decide which platform is the best fit for their application. If you’re a start-up or a researcher, you need to go to an individual foundry and sign an NDA to get the PDK and then make the assessment, and it will take time. From my experience, even signing an NDA can take a month. Open-source PDKs close that gap. If you have an idea and you want to test it really quickly. You can use an open-source PDK and you can look at the components and what you can do with them, then you have all this EDA integration to design your layout. It makes your development cycle very short, so you can make more iterations within a short time frame.

EO: What’s the perception of open-source platforms like? Are there concerns from industry about the quality or reliability of content available in open frameworks?

EK: So because it’s an open-source platform, as well as the fact that we’re a research foundry coming from academia, it can trigger this kind of perception in people. And it’s actually partially true. But as long as the devices are being fabricated as designed, the quality of fabrication is maintained.

But fabrication quality in integrated photonics is not a straightforward problem to solve; there is always

deviation. Some of them are predictable, some aren’t, but because we’re open-source, we collect all the data and provide it to everyone. What you can do is make sure the fabrication design is considerate of these tolerances, then when the simulations converge with the test results you have quite a robust, well-maintained and high-quality PDK.

Of course, we offer eight different platforms, and not all of them have the same maturity level, so some platforms have more components or are more popular than others, and that means they accumulate more know-how. That’s why it’s questioned if a foundry can be open-source and high-quality, but we need to change the perception. I believe we can be open-source and still be better at optimisation. That’s because we can get feedback from the community.

You don’t need to use your own equipment, your own staff or your own testing resources, but you can still get feedback from designers. This makes it quicker to develop open-source PDKs, and makes them higher quality, too.

Of course, it’s still all about the data. You need more data to mimic fabrication variations and boost PIC performance. One thing we’ll do in the future is not only share layout designs, but also the measurements that come directly from

the cleanroom, so you can correlate design layouts with fabricated physical dimensions and test results.

It means you can create this fabrication-aware design approach. It’s quite a hot topic in integrated photonics.

EO: We would have thought an open-source design platform may suffer from ‘too many cooks’, but you say it improves both quality and speed?

EK: I believe the approach will result in higher quality PICs, yes. Everyone can contribute in open-source, of course, so you need some kind of a control system that decides which building blocks are useful and which aren’t. So we need to encourage contributors to support their building blocks with data, be it test data, simulation data or published papers.

Not every component will be of the highest spec, of course.

We are working on technology readiness levels (TRLs) at the moment. I was in Amsterdam for the PIXEurope Pilot Line project where we tried to address this terminology, (asking) ‘what is a PDK?’ And ‘how do we deal with maturity levels?’ We decided to follow TRL levels as defined by the EU, but they are mostly defined for microelectronics, so not entirely compatible with integrated photonics. It’s an ongoing question for

the community, 'how to align TRLs to photonic PDKs?'

This is why we're making the PDKs using standard criteria, but we are also assigning TRLs and calling it a component development index. That's why you'll immediately know how major any component in our PDK is. It may only be a simulation component or it may be one that's been fabricated and tested multiple times and at a higher TRL.

This is how we plan to set the standards, and then define quality levels against those standards. We won't just say 'we have really good PDKs', we'll say which parameters this quality level is set against.

This is a long-term commitment for us.

EO: So what are the barriers that are still blocking the path towards a more collaborative and democratic use of silicon photonics?

EK: The main bottleneck is still fabrication. We provide the building blocks in the design layouts, but you still need to find a foundry to fabricate them.

At the moment, it's a Cornerstone foundry, the technology is manufacturable within our cleanroom, but I believe it should be more widespread than that and more international. So, it will depend on if we can attract some interest from established foundries.

If we can get more contributions from established foundries to the open platform, then we will see a rapid increase, but the main barrier is always on the fabrication side.

As long as you fabricate more samples, get the data and integrate into the PDK, then you have really robust, well-established PDKs to offer. But to get there, you need multiple iterations.

Most of the time, you also need to spend money on fabrication and cleanroom maintenance, so the main barrier we need to overcome is getting more data from the fabrication side, plus making open-source photonics part of the industry's mindset.

There are still challenges ahead, but we need to see how people react first. How much they get involved in contributing to the open-source PDK repositories. Hopefully, this platform will not only support Cornerstone technologies, but that other foundries will become actively involved as well.

EO: So, there are still tweaks that need to be made to improve the process, but I guess that's to be expected with any first-of-its-kind system that hasn't been seen before.

EK: Absolutely. We're trying to create a kind of ecosystem where users can

interact with foundries. In the current scheme, the foundry decides everything: they set the design rules, then you design your chip according to those rules.

There's no community feedback. If you have a problem, the only entity you have to deal with is the foundry itself.

With the open-source approach, there's a much more dynamic environment where designers can feed back to foundries. They can create a building block that outperforms the existing one, and they can tell the foundry about it.

I wouldn't be offended. I'd be happy to have this contribution and put it in the PDK.

Foundries deal with very different technology platforms, and progress is not always the same in each one. You may make really fast progress in singular technology layers like silicon-on-insulator, for example, but you might not have that much time for silicon nitride or germanium technologies.

Designers are trying new things all the time, so they can often guide foundries or support them with data.

Then someone else can see their components and build their own iteration starting from that point, rather than starting from scratch.

This is the whole idea of the open-source foundry: to make the entire community more interactive.

First comes the interaction between the foundry and the designers, but then comes the interaction between the designers themselves.

The idea behind it is that you can fit and fix it yourself, and you can learn from someone else's mistakes instead of having to make your own first. **EO**



Dr A Emre Kaplan is a Senior Enterprise Fellow in the Optoelectronics Research Centre (ORC) at the University of Southampton.

After receiving his MSc degree in Electronics Engineering from the University of Bologna in 2016, and his PhD from the University of Ferrara in the field of Integrated Photonics in 2020, Kaplan subsequently moved back to Bologna as a Research Fellow at the university.

After winning a Research Fellowship from the University of Pavia in 2021 he worked with the Photonics Group until September 2022.

Dr Kaplan is currently working on the Process Design Kit development of Cornerstone's technology platforms.

“It makes the development cycle very short, so you can make more iterations in a shorter time frame”

Multimode lasers challenge an old assumption in advanced microscopy

For decades, precision microscopy has favored single-mode lasers despite demanding operational challenges and high cost. New highly integrated multimode laser systems, including Lumencor's CELESTA and ZIVA Light Engines, are prompting researchers to reconsider that assumption by combining power, stability, and spectral control in compact, practical platforms

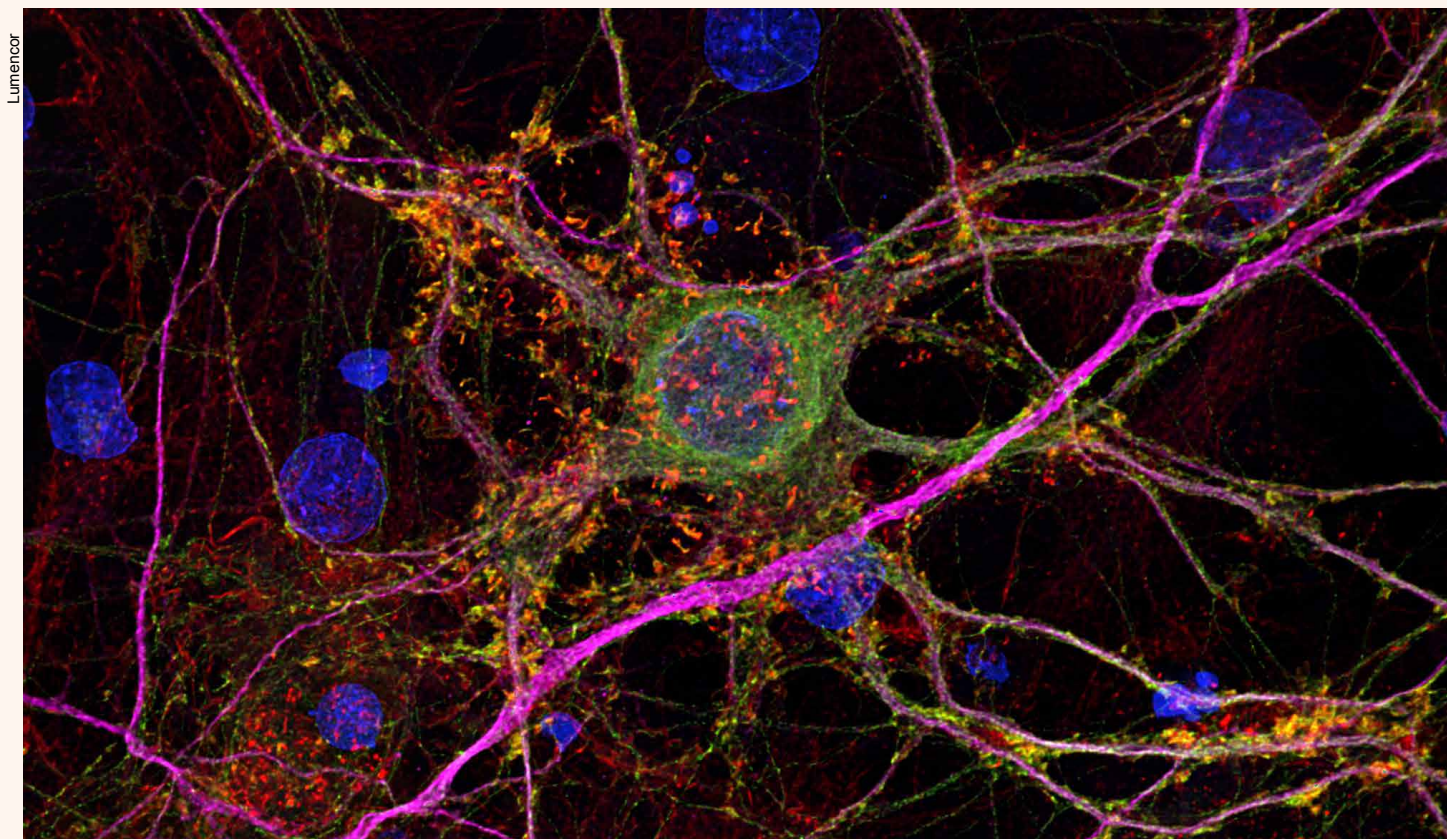
In advanced fluorescence microscopy, single-mode lasers have long held a privileged position. Their narrow spectral bandwidth, spatial coherence, and stable beam profiles made them the default choice for confocal and super-resolution imaging. But as researchers push imaging systems to capture faster, deeper, and more quantitative data, the

criteria for illumination are changing.

Multimode lasers were once viewed mainly as tools for widefield imaging, where optical power often mattered more than beam quality. More demanding methods were assumed to require single-mode laser sources. That distinction is becoming less rigid as optical engineering improves the performance

and usability of integrated laser systems.

The shift comes as microscopy itself becomes more ambitious. Laboratories now use spinning disk confocal systems alongside super-resolution methods such as STORM (stochastic optical reconstruction microscopy), SIM (structured illumination microscopy), and MERFISH (multiplexed error-robust



Cultured cardiomyocyte spheroids imaged with a Yokogawa CSU-W1 spinning disk confocal module and ZIVA's 577 nm laser. The setup delivered gentle, uniform illumination across 200 timepoints at 100 ms exposure, resolving a sample that could not be visualized on the core facility's laser scanning confocal instrument. Video-rate acquisition captured tissue volume and sustained cellular function during photonic interrogation, supporting studies of therapies for cardiovascular disease

“Rather than asking whether single-mode or multimode lasers are categorically better, researchers are asking which source best matches the experiment”

fluorescence in situ hybridization). These techniques expose biological structures and processes in greater detail, but they also place new demands on illumination: the laser light must be bright, stable, fast, spectrally precise, and practically easy enough to use with little to no technical training.

All-important stability

For quantitative imaging, stability is not a convenience; it is a requirement. Researchers need consistent light output across wavelengths so that comparisons remain meaningful across samples, timepoints, and experiments. Modern laser light engines are built and tested with that reliability in mind. Ideal illuminators provide precisely the same amount of light for each and every pulse of a multi-point experiment and every image throughout a video recording.

Spinning disk confocal microscopy shows why the conversation is changing. Yokogawa CSU systems use thousands of pinholes and parallel optical paths to acquire images rapidly while reducing photobleaching and phototoxicity. To perform well, they require intense, uniform illumination across the field of view. Lumencor's ZIVA Light Engine was designed for direct illumination of these systems, supporting high-content, live-sample imaging while delivering greater optical power and field flatness at the sample plane than historic single-mode laser solutions, at a fraction of the price.

Super-resolution methods add another layer of demand. SoRa (super-resolution via optical reassignment) preserves much of the speed of spinning disk microscopy while improving resolution, and STORM enables visualization of structures on the nanometer scale. These workflows require high-power,

precisely controlled illumination across multiple wavelengths. Lumencor's CELESTA and ZIVA Light Engines are designed to support such confocal and super-resolution applications without the complexity of traditional open-bench laser systems.

Performance, or service?

Cost and usability are also part of the story. Research laboratories must weigh performance against space, service requirements, and long-term operating costs. Compact, integrated Light Engines such as CELESTA and ZIVA combine multiple lasers and associated optics in a single unit, reducing footprint, simplifying operation, enabling rapid switching, and supporting long operating lifetimes.

The result is a more application-specific view of illumination. Rather than asking whether single-mode or multimode lasers are categorically better, researchers are asking which source best matches the experiment. That reframing has opened the door for multimode laser systems to support a wider range of precision imaging techniques while improving cost, usability, and operational efficiency.

As microscopy continues to evolve, illumination is becoming part of a broader technology shift. Lumencor's CELESTA and ZIVA Light Engines show how well-engineered multimode laser systems can support advanced applications including spinning disk confocal microscopy, SoRa, STORM, SIM, TIRF (total internal reflection fluorescence microscopy), and MERFISH. For laboratories seeking high-performance imaging without unnecessary complexity, these systems offer a practical alternative to long-standing assumptions about what precision microscopy requires. **EO**

How hybrid photodiode sensor could help address \$750bn food waste problem



Up to a third of food grown for human consumption is wasted due to single-pass harvest timing, but with the help of combined silicon/gallium antimonide detectors, P100 honouree **Abdel Ruvalcaba-Perez** (right) believes a hybrid multispectral sensor array smaller than a fingernail could change the landscape

Roughly a third of everything grown for human consumption is never eaten. Across the global supply chain, crop losses add up to approximately a billion tonnes a year, at an estimated cost of \$750bn (£557bn).

A large share of that waste has nothing to do with pests, weather or spoilage in transit – it is due to timing.

Most fields continue to be harvested in a single pass, on a single day, regardless of whether any given piece of fruit is under-ripe, perfectly ready or already past its best.

A team led by P100 honouree Abdel Ruvalcaba-Perez from Friedrich Schiller University Jena, ams OSRAM Group and the Fraunhofer Institute for Applied Optics and Precision Engineering (IOF) believe part of the answer lies in a small hybrid optical sensor that can watch fruit ripen in real time, without ever cutting into it.

Their proof-of-concept broadband multispectral sensor array (BMSA), described in *npj Nanophotonics* (a Nature-branded journal), replaces the destructive chemical tests and expensive laboratory equipment such as hyperspectral cameras or spectrometer solutions currently used to judge ripeness.

The idea is not to build a better laboratory instrument, but to get a working sensor, smaller than a fingernail, onto every piece of crop-touching equipment, including harvesting machinery, drones and sorting lines. As a result, ripeness stops being a single end-of-season decision and becomes something that can be tracked, week-by-week, from the moment a fruit starts to form.

A sensor built to be both cheap and broad

The BMSA sensor's trick lies in combining two different semiconductor technologies, rather than pushing either one further than it can go. The sensor array combines silicon

(Si) and gallium antimonide (GaSb)-based photodiodes in a single optical package. Si provides sensitivity through the visible and near-infrared, while the GaSb detector extends the response through the short-wave and extended short-wave infrared. Together, the platform covers 400–2,300nm, a range broad enough to follow both surface pigments and internal constituents.

Each photodiode is paired with a dielectric interference filter. Rather than reconstructing every wavelength in a continuous spectrum, the array measures 19 carefully selected bands. The combined active detector footprint is approximately 2.02mm². Miniature incandescent lamps provide broadband illumination, allowing the two detector materials to operate as one sensing system.

This hybrid architecture is important because no single detector material offers the required sensitivity across the entire range. It also gives the system a direct path towards miniaturisation: the spectral selection is performed at the filter-detector interface, without the gratings, scanning mechanisms or large optical trains associated with conventional hyperspectral instruments.

As a result, the price point of the BMSA sensor is estimated to be substantially lower than traditional solutions, allowing mass integration at every step of harvesting.

Extending the response to 2300nm is particularly valuable for agriculture because the strongest water-related features lie beyond the range of many silicon-only devices. In fact, five molecular groups: carotenoids, anthocyanins, chlorophylls and O-H and C-H overtones were considered during the BMSA design, covering the most changeable characteristics during the growing process.

It is also technically demanding: detector responsivity, filter transmission and source irradiance differ substantially across the

spectrum. The two arrays must therefore be treated as complementary parts of one instrument rather than as interchangeable channels. In the proof-of-concept analysis, the GaSb response was balanced against the silicon response before the selected bands were converted into detector counts. This preserves the relative spectral patterns while making the broadband output easier to interpret as a unified measurement.

Using scattering as a built-in reference

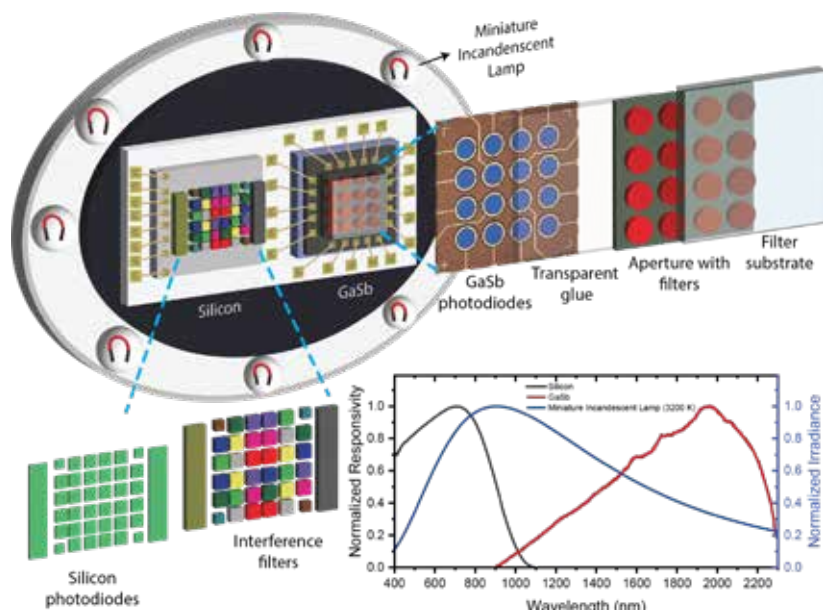
A compact sensor still needs to distinguish biological change from measurement variability. Fruit curvature, probe distance, illumination and surface condition can all alter the signal. Instead of relying only on external calibration, the group identified a comparatively stable optical feature within the fruit itself.

Between approximately 750nm and 840nm, healthy apple tissue exhibits a near-infrared plateau. Absorption from pigments and water is relatively weak in this interval, and the detected light is dominated by multiple scattering at cellular interfaces and intercellular air-water boundaries. Reflectance at 800nm was therefore selected as an internal normalisation reference.

Every other channel can be interpreted as relative to this high-scattering band. Normalisation enhances seasonal contrast and supports comparisons between measurements collected at different times. It also connects the sensing strategy to tissue condition: when the microscopic structure begins to break down during advanced ripening, the plateau itself changes, and that disruption becomes diagnostically useful.

Tracking Gala apple season ripening through multispectral signatures

Raw BMSA counts collected over 18 weeks were normalised to the response of channel



Broadband multispectral sensor array architecture: Silicon and gallium antimonide (GaSb) photodiode arrays are combined with interference filters to provide spectral sensitivity from the visible to the extended short-wave infrared

10, located within the 750nm-840nm near-infrared (NIR) plateau where scattering dominates photon transport in the fruit skin and cortex.

Translating spectra into ripening markers

The 19-channel responses were used to calculate a set of spectral indices. Established visible indices followed the carotenoid-to-chlorophyll balance, anthocyanin development and chlorophyll loss. Additional indices were introduced for starch-sensitive behaviour between 1,450 and 1,770nm and for water-related absorption around 1,920nm.

Across an 18-week Gala apple season, these indicators traced distinct stages of development. Chlorophyll declined, while carotenoid and anthocyanin contributions increased later in the season. The starch index reached a maximum around week 12 and then decreased, reflecting the transition from starch accumulation to degradation.

The water-related index showed a pronounced change in the same part of the season before stabilising.

More than a visual transition during the season, the resulting indices describe separate processes occurring on different timescales. The value of broadband sensing is therefore not simply that it sees more wavelengths, but that it can separate several physiological mechanisms that collectively determine harvest quality.

Beyond the apple orchard

When the spectral characterisation and ripeness markers were extended from Gala to Pirol and Gravensteiner apples, similar pigment and starch-related trends were visible, but the timing and post-harvest

behaviour varied. This is an important result before deployment, because a useful agricultural sensor should not assume that every cultivar ripens identically; it should provide comparable measurements while preserving real biological differences.

The same approach was then explored in other crops. *Citrus japonica* (kumquat) and *ananas nanus* (miniature pineapple) were monitored before harvest, while Hass avocados and Cavendish bananas were followed in the post-harvesting stage. In avocados and bananas, samples approaching over-ripeness showed strong changes across the GaSb channels. Tissue degradation disrupts the ordered scattering environment within the fruit, increasing the contrast after normalisation and providing a route to identify senescence rather than colour alone.

This multi-crop evaluation does not imply that one fixed index will immediately solve ripeness assessment for every species. Each crop has its own anatomy, pigments and commercial maturity criteria. It does show, however, that common broadband architecture can supply the optical information from which crop-specific decisions can be built.

From the lab bench to the packing line

The sensor's simplified design and small footprint make it a plausible fit for hardware already being tested on farms: harvesting robots, drones and fixed installations in greenhouses, packing lines or retail cold storage.

There's also a role for the sensor alongside machine-learning models trained across multiple growing seasons, which would maximise its capabilities and enable live decision-making during the harvesting season.

None of that solves food waste on its own. But a third of the world's harvest is currently lost partly because growers are forced to guess, then act on that guess all at once, across an entire field.

A sensor cheap enough to place on every piece of equipment already moving through an orchard, reading a signal the fruit was providing all along, is a step toward replacing a guess with actual metrics. **EO**



This article is based on research performed by Abdel K Ruvalcaba-Perez from the Institute of Applied Physics, Abbe Center of Photonics at Friedrich Schiller University Jena, Fernando J. Castaño and Gunter Siess from the Technology R&D department of ams OSRAM, Volker Böhm from the Institute of Nutritional Sciences at Friedrich Schiller University Jena and Andreas Tünnermann from the Fraunhofer Institute for Applied Optics and Precision Engineering IOF

“A sensor cheap enough to place on every piece of equipment already moving through an orchard, reading a signal the fruit was providing all along, is a step toward replacing a guess with actual metrics”

‘Orders of magnitude faster’ LPUs could replace GPU clusters

Boeing is backing LightSolver to replace energy-hungry GPU clusters with room-temperature laser processing units by 2027. **James Wormald** talks to LightSolver CEO and Co-Founder **Ruti Ben-Shlomi** (right), a Photonics100 honouree, about scaling physics-native architectures for engineering



Electro Optics: Tell us about the project with Boeing. How did it come about? Who made the first move?

Ruti Ben-Shlomi: We established the company in 2020 and have now spent six years developing the IP for this new computing paradigm.

Early on, we engaged with several major industry players that were investing heavily in traditional computing, while we focused on identifying the fundamental bottlenecks that come with the use of classical GPUs and CPUs and HPC systems.

One of the most significant challenges is simulation which demands enormous computational resources. To better understand these limitations and their real-world impact, we began working closely with companies across a range of industries.

We were already collaborating with national laboratories and HPC centres to support the adoption of this new computing paradigm, but it was equally important to work with Fortune100 companies, such as Boeing, to understand the challenges their engineering teams face.

By integrating those insights into our platform and tailoring solutions to real-world use cases, we could deliver a meaningful competitive advantage.

We were actively presenting our technology at industry conferences, and it was after one of those events that we began discussions with Boeing. We initially worked with the team responsible for evaluating emerging computing technologies, including quantum computing, and we were able to demonstrate the advantages of our approach from the onset.

Our path to commercialisation is relatively short. We are on track to deploy the first laser processing unit (LPU) capable of replacing clusters of GPUs by 2027. Boeing saw the potential early and chose to support its development, helping ensure the platform meets the requirements of its engineering teams.

The use case we focused on is a computer-assisted engineering (CAE)

simulation involving degradation-based structural effects.

These degradation mechanisms influence long-term material performance and asset lifespan, making accurate simulation essential for design improvements and effective maintenance planning. The LPU performs these computations orders of magnitude faster than current HPC systems. By dramatically accelerating simulations, it shortens the validation cycle and reduces overall computational overhead.

EO: You say LightSolver's LPU is capable of solving PDEs (partial differential equations) far quicker than GPUs since it uses physical laser dynamics, but how does it work? What are the technical differences between LPUs and GPUs, and are there any other practical advantages, as well as speed?

RB-S: The LPU operates entirely with lasers. Because lasers can be coupled, they interfere with one another and simultaneously explore a large configuration space.

As they propagate back and forth between mirrors inside the processing unit, their interference naturally mimics the physical phenomena underlying the PDE-based problems being solved.

Since the processing unit contains no electronic components, these calculations are completed in the order of microseconds.

“Our computing method leverages the physical behaviour of lasers, described by laser rate equations, to simulate other physical phenomena, governed by partial differential equations.

This includes problems such as heat propagation through materials, or fluid dynamics governed by the Navier-Stokes equations, supersonic flow, electromagnetic wave propagation and seismic modelling. In general, the approach is well suited to a broad class of physics-based problems described by partial differential equations.”

EO: With companies such as Boeing taking notice, the technology must be fairly well developed. Tell us about the journey up until this point and some of the challenges you've faced.

RB-S: When you're developing an entirely new computing paradigm, a significant part of the research is identifying where it delivers the greatest advantage and establishing the right performance metrics for comparison with existing processors. The industry partners we're working with today rely on a wide range of simulation software, all of which now runs on GPU-based systems.

These simulations can be implemented using a wide range of specialised algorithms, software tools, and on various GPU architectures.

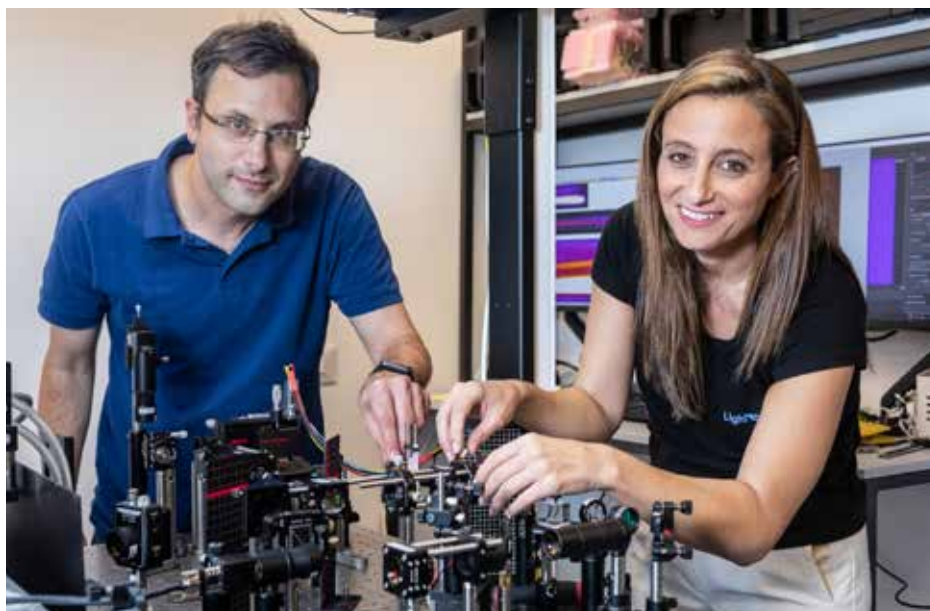
Our first step was to identify the right problem to solve, followed by extensive benchmarking to demonstrate that our solution outperformed the industry's established GPU-based standard. Across all of our projects, we work closely with design partners to benchmark our platform against commercial solutions and validate its performance in real-world applications.

EO: So if you're working with people who are used to running on GPUs, how easy is it for them to integrate LPUs into their existing HPC stack instead?

RB-S: That is exactly the type of collaboration we're pursuing with US National Labs. They are helping us to develop the software stack and build out libraries of application types that the LPU can target. They're also supporting integration of the LPU into heterogeneous HPC stacks, including hybrid workflows alongside GPUs, CPUs and at scale within large HPC orchestrations.

EO: What targets have you set for yourselves regarding these projects with Boeing and National Labs?

RB-S: We've successfully demonstrated the advantages of our solution in



LightSolver CTO Chene Tradonsky with CEO, Ruti Ben-Shlomi

engineering simulation workloads. To give you a sense of scale, high-end engineering simulations represent a multi-trillion dollar class of global industry activity when accounting for the broader ecosystems it supports across aerospace, automotive, energy and defence. Within that, Department of Defense (Department of War) programmes alone account for billions of dollars in annual computational spend. We are now focused on further developing the LPU and integrating feedback from production environments of engineering teams in real operational settings.

EO: How far off are more practical LPU applications, as opposed to those in experimental set-ups?

RB-S: LPUs are capable of replacing clusters of GPUs, which is the core advantage they were designed to deliver. In our collaboration with Boeing, the LPU is being applied to degradation-based structural simulation. More broadly, it can be used to solve a wide range of physics-based differential equation problems, and we plan to expand into these applications by 2027. This is why we're extending into additional aerospace use cases, and we are also engaged in collaborations across energy, logistics and manufacturing.

EO: LPUs sound pretty groundbreaking, but is the supply chain mature enough to facilitate large-scale production?

RB-S: LPUs are built from off-the-shelf optical components that are commercially available. We don't rely on exotic parts that could introduce supply chain constraints, which significantly reduces the manufacturing risks. Unlike quantum computing approaches, the LPU does not require cleanroom conditions or complex alignment, calibration or stabilisation systems. It operates and can be assembled

under standard ambient conditions at room temperature. In that sense, the system is relatively straightforward to manufacture and produce at scale.

EO: You've described the breakthrough as part of a shift toward "physics-native computing". What does that journey look like over the next five or 10 years?

RB-S: The next five to 10 years will focus on deploying LPUs in data centres and expanding our collaborations with cloud providers. In parallel, we'll broaden the user community around the platform.

Because the LPU is highly efficient at modelling physical systems and can be engineered into a compact, energy-efficient form factor, we also play a role in the emerging physical AI landscape. This includes physics-based perception tasks, such as modelling friction, inertia and contact dynamics, which are central to enabling robots to perform real-world physical operations. We believe this positions LightSolver to become a key computing platform for the emerging humanoid robotics market.

EO: You spoke about expanding into other industries alongside aerospace, such as energy, logistics and manufacturing. What makes those sectors ripe for LPUs? And for those that aren't ready, what's holding them back?

RB-S: Our current prototype is built on a Python-based interface, which makes it highly accessible for users. This also makes it straightforward to extend into aerospace or other verticals, since the underlying problem classes are broadly consistent across industries.

Any engineer running simulation workloads today through a COMSOL or Synopsys tool would be able to execute those same workloads on an LPU. **EO**

"(LightSolver) can provide solutions orders of magnitude quicker than current HPC systems"

Product Picks

A curated selection of the most eye-catching photonics products to hit the market in recent weeks

To submit your next new product release for inclusion, please send product details and images to james.wormald@europascience.com



Luxinar Aionis femtosecond laser

Aionis 515-50-Yb is a femtosecond laser that has up to 50W of average power, pulse durations below 350fs and pulse energies of up to 100μJ. The system operates at 515nm, which manufacturer Luxinar says allows it to provide tighter beam focusing than 1030nm systems, and also to support the production of smaller features. By combining high power with ultrashort pulses and high energy, Luxinar says Aionis is designed to increase throughput, while also limiting thermal effects and the risk of microcracking during precision processing. Aionis, which is part of Luxinar's Pulsecore solid-state laser series, is designed for applications that require repeatability and process stability, such as those in semiconductor manufacturing and glass – and other brittle materials – processing.



Edmund Optics Point Source Microscope

Edmund Optics' Point Source Microscope (PSM) is a portable, USB-powered instrument that combines a full-field video microscope and autostigmatic microscope with an autocollimator, offering optical alignment, inspection and measurement in one place, says the company. The manufacturer states that the PSM's sensitivity is close to interferometer levels, which allows it to align components using optical features rather than mechanical references. Designed to support centering and focusing along the true optical axis, to potentially allow less stringent mechanical tolerances for optics and mounts, PSM's measurement functions include radius of curvature and lens orientation assessment, while the device can also be operated purely as an autocollimator.



Gentec UP100 laser power detector

UP100 is a thermopile laser power detector designed to measure large-diameter, low-power laser beams. With a 100mm aperture, Gentec says UP100 is capable of measuring power from 100mW to 50W, and single-shot laser energies up to 700J, allowing for the characterisation of high-energy, low-repetition-rate sources such as excimer lasers. UP100 has a spectral range from 1193nm to 20μm, and incorporates Gentec's XNR Anticipation technology to accelerate its measurement response, says the company. The detector has a 17mm-thick profile.



Focuslight Pitch Error Measurement System

A pitch error measurement system has been launched by Focuslight to automate the inspection of V-grooves, fibre arrays (FAs) and MT connectors used in high-density optical interconnects. The system features $3\sigma < 0.1\mu\text{m}$ measurement repeatability and $0.001\mu\text{m}$ resolution, with measurement cycles less than one second per channel, says the manufacturer. It supports single-mode, multimode and polarisation-maintaining fibres, with minimum pitches of $40\mu\text{m}$ (128-channel inspection) for V-groove and FA applications and $250\mu\text{m}$ (16-channel inspection) for MT connectors. Designed specifically for V-groove alignment verification, FAU inspection, connector inspection and optical assembly process development, the system features automated functions such as autofocus, tilt compensation, measurement and report generation, and is supported by CSV or PDF outputs, SPC analysis and MES connectivity.



Solinide Photonics LumiCOMB optical frequency comb generator

LumiCOMB is a 2U optical frequency comb generator from Solinide Photonics, based on the company's ultra-low-loss silicon nitride (SiN) photonic integrated circuit platform. The turnkey instrument uses a microresonator to generate a broadband, phase-coherent comb of evenly spaced optical frequencies from a single source. It is capable of producing a fully-locked soliton comb directly from standby, says Solinide, and achieves 69% optical conversion efficiency for CW-driven soliton microcombs. Specified with up to 24 usable lines above -5dBm in the O-band at 200GHz spacing, and outputs provided through a single polarisation-maintaining fibre with FC/APC termination. LumiCOMB is designed for multiple uses including AI data centres.



HunterLab Vista L2

Vista L2 is a transmission colour and haze spectrophotometer for transparent and translucent liquids and solids. It extends spectral measurement to 710nm, allowing colour, measured as absorbance, to be distinguished from haze associated with light scattering. The range supports chlorophyll measurements at 630, 670 and 710nm in accordance with AOCS Cc 13d-55. L2 retains the platform's transmission geometry and full-spectrum LED illumination, while adding 32GB of onboard storage, an HDMI output and integrated wavelength verification.



Aerotech LaserTurn 280 laser machining motion platform

A motion platform for laser processing cylindrical medical devices such as stents and vascular implants, Aerotech's LaserTurn280 is based on the company's PRO280LM linear stage design. Available with three rotary-stage configurations, Aerotech says the platform can accommodate tubes from 0.3 to 30mm in diameter, has 300mm of linear travel with a max speed of 1,000mm/s and features calibration accuracy of $\pm 1\mu\text{m}$ linear motion and $\pm 30\mu\text{rad}$ rotary motion, with bidirectional repeatability specified at $\pm 0.4\mu\text{m}$ and $\pm 0.15\mu\text{rad}$ respectively. Using ironless linear motors and non-contact optical encoders for both wet and dry cutting, Aerotech says LaserTurn280, used alongside the company's Automation1 controller, supports Position Synchronised Output for laser-to-motion synchronisation and Enhanced Tracking Control for more complex contours.

From innovation to scale: Exploring photonics opportunities in Taiwan and China



**By Carlos Lee,
Director General, EPIC**

Over the past month I have had the opportunity to attend three photonics and semiconductor exhibitions in Asia: LASER Taiwan, SEMICON Taiwan and CIOE in Shenzhen, China. The timings could hardly be more relevant as AI is creating an unprecedented demand for optical technologies.

AI systems require enormous amounts of data to move between GPUs, servers and data centres, at extremely high speeds and with low latency and power consumption. As electrical interconnects increasingly approach their physical and energy-efficiency limits, photonics is becoming essential to connect the AI infrastructure of the future.

The result is rapidly growing demand for lasers, optical transceivers, photonic integrated circuits, optical engines, co-packaged and near package optics and other advanced packaging solutions.

Recent acquisitions provide a powerful illustration of the technological strength of European photonics. Switzerland's Polariton Technologies was acquired by Marvell, bringing its advanced plasmonics-based modulation technology into Marvell's optical roadmap for next-generation connectivity. Italy's PhotonPath was

acquired by Ciena, while Germany's aiXscale Photonics was acquired by Astera Labs to strengthen photonic scale-up connectivity for AI infrastructure.

These transactions demonstrate that European companies can develop highly differentiated technologies that become strategically valuable to global semiconductor and connectivity leaders.

Asia has exceptional capabilities and experience in manufacturing and industrialisation. Taiwan and Shenzhen, in particular, benefit from dense, mature ecosystems covering components, electronics, semiconductors, assembly, testing, equipment and system integration.

They also bring experienced manufacturing talent, large-volume production capabilities and proximity to many of the world's largest technology users and manufacturers. This combination can significantly accelerate the transition from European innovation and prototypes to competitive products at scale.

Europe, however, is also developing important capabilities across the value chain. For instance, companies such as SMART Photonics have advanced InP foundry capabilities, while PHIX in the Netherlands provides sophisticated

photonic packaging and assembly, from prototyping through scalable production.

The opportunity is, therefore, not only about moving manufacturing from one region to another.

It is about connecting complementary strengths: European innovation, specialised technologies and IP with Asian manufacturing scale, supply chains, market access and industrial expertise.

This is why I regularly travel to Asia: to explore opportunities, establish and strengthen trusted and reliable partnerships for our members, and identify distributors and industrial partners interested in working with European photonics companies.

The AI revolution is creating a once-in-a-generation opportunity for photonics. Europe has many of the technologies. Asia has much of the scale and manufacturing ecosystem.

Bringing these strengths together could be a powerful way to accelerate innovation, strengthen competitiveness and build the next generation of global photonics value chains.

My focus on Asia should not be interpreted as prioritising Asia over the United States. The US remains one of the most important markets and technology ecosystems for European photonics companies, and many EPIC members already have strong relationships and ongoing business discussions there.

Events such as OFC provide an excellent platform for European companies to connect with US and global customers, partners and technology leaders.

In comparison, engaging with Asia can sometimes require a greater investment in understanding local ecosystems, building relationships and identifying the most suitable partners.

This is why I spend significant time in Asia: not because I rank these markets differently, but because I believe I can add particular value by helping European companies navigate an ecosystem that may be more difficult for them to access independently. **EO**



The China International Optoelectronic Exposition (CIOE) 2026 took place from 8-to-10 September at the Shenzhen World Exhibition and Convention Center

Ultra Compact UV-Vis-NIR Spectrometers

Bullet-Series micro Czerny-Turner cavity spectrometers combine collimating and focussing in a single curved mirror along with low reflection internal coatings.

They provide the sensitivity, stray light and resolution of larger models in a compact and rugged package with low power consumption, so are ideal for portable instruments.

SilverBullet (SB) models featuring 1024-pixel high speed CMOS sensors operate from 180nm to 1100nm.

RedBullet (RB) spectrometers cover 900nm to 1700nm with a choice of 128- or 256-px InGaAs sensors. SB and RB can be optimised for sensitivity and resolution with a choice of grating, slit width and operating range.

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Scaling precision glass microstructures with ultrafast lasers

EPIC Photonics Technologies Programme Manager **Jérémy Picot-Clément** talks to **Nicoletta Casanova** (right), CEO and President at FEMTOPRINT, about the Swiss-based contract manufacturer of glass microsystems and its use of ultrafast femtosecond lasers



FEMTOPRINT

Jérémy Picot-Clément: What's the background to you founding FEMTOPRINT as CEO?

Nicoletta Casanova: In 1994, after graduating in Civil Engineering from ETH Zurich, I became Technical Director of a materials testing laboratory in Lugano. At the same time, I was working with a PhD student, Daniele Inaudi, on a collaborative research project with EPFL, the Swiss Federal Institute of Technology in Lausanne.

We were developing optical fibre sensors for structural health monitoring of bridges, dams and other civil infrastructures, and we quickly recognised the commercial potential of the technology.

In 1996, Daniele and I founded SMARTEC to bring the fibre-optic sensing technology we had developed to market.

Over the following 10 years, we grew the company to around 15 employees,

expanded into oil & gas and industrial monitoring and became one of the world's leading specialists in fibre-optic structural health monitoring.

In 2006, we merged with Roctest, a Canadian public company, to continue expanding our products and access new markets. Six years later, the Roctest Group was acquired by the US company Nova Metrix.

That marked the happy end of a truly meaningful collaboration with Daniele and Roctest. My initial plan was to take a sabbatical. But two weeks later, I was invited by a European project consortium to evaluate a completely new 3D laser printing technology for manufacturing glass microsystems.

The technology and its potential applications were entirely new to me, but I was fascinated – not only by the technology itself, but also by the

passionate team behind it. The consortium was looking for someone to take the technology forward commercially, and I decided to compete for the rights to do so. I won. And in 2013, I founded FEMTOPRINT.

JPC: How has the company developed since then?

NC: We started with three employees and a prototype 3D printer in approximately 100m² of laboratory space in Muzzano, Switzerland, just outside Lugano.

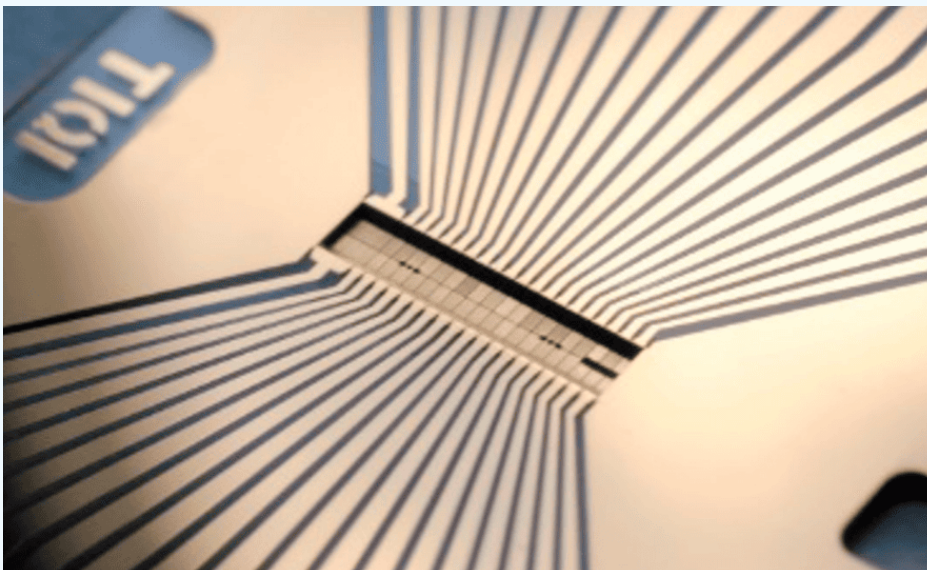
Our original business plan was to sell high-precision systems for prototyping 3D-printed glass microstructures using ultrafast femtosecond lasers. But, after about three months, we completely changed the business model. Instead of selling machines, we repositioned FEMTOPRINT as a contract development and manufacturing organisation, offering design, prototyping and production services. This allowed us to work closely with customers and, more importantly, to understand what they actually needed.

We started with applications including microfluidic devices for diagnostics, implantable medical components and precision components for watchmaking.

Over time, we expanded our production capabilities for serial manufacturing, achieved ISO 13485 certification for medical devices and in 2019 opened a dedicated Business Unit in Neuchâtel to support customers in photonics, quantum technologies, micro-optics but also micro-mechanics.

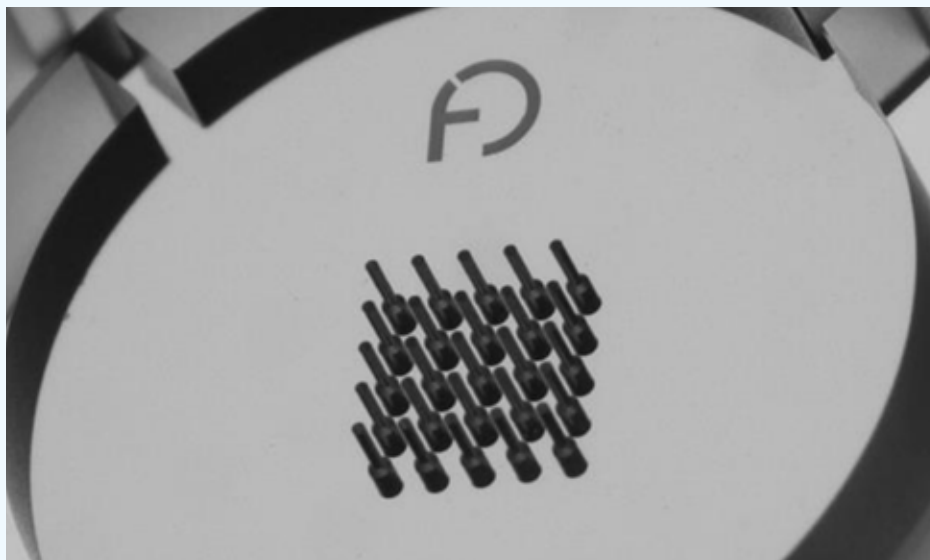
By 2023, we had grown to almost 40 employees, achieved ISO 9001 certification and evolved into a full-service CDMO serving the watchmaking, life sciences, medical, aerospace, photonics and quantum sectors.

In 2024, we moved into a new 1,800m² headquarters and manufacturing facility in Agno, Switzerland. The brand new site was designed to support our transition to



FEMTOPRINT

"Glass has the potential to transform many fields, including quantum computing, photonic integrated circuits, co-packaged optics and technologies related to artificial intelligence," said Nicoletta Casanova



FEMTOPRINT

“We started with three employees and a prototype 3D printer”

“We’ve moved from being a company focused mainly on prototyping and small production runs to one that develops products and is increasingly capable of large-scale manufacturing,” said Nicoletta Casanova

industrial-scale production and continued international expansion.

JPC: And your main challenges?

NC: After the merger of SMARTEC and Roctest, I gained experience managing operations across Lugano, Paris and Montreal. This meant I already knew that building a successful company requires a great deal of energy, commitment and perseverance.

With FEMTOPRINT, however, the situation was different: I initially knew neither the technology nor the market.

The first challenge was credibility. We were using femtosecond laser pulses to produce complex three-dimensional glass microdevices with highly free-form geometries. This was completely new, and it took time to explain the technology and convince people of glass’s advantages.

We were also a small company building everything from the ground up, with a very young team. Our CTO, Andrea Lovera, had just completed his PhD when we started meeting customers in watchmaking and at large medical technology companies. They were, understandably, cautious when we told them we could manufacture highly precise glass components using a brand new technology.

But something interesting also happened: some customers began imagining new applications enabled by our technology that had never even occurred to us. Very early on, one customer asked us to manufacture a glass microcatheter. We thought we probably couldn’t do it. But we tried, and a week later we delivered it.

Since then, customers have continued to challenge us. But they have also trusted us. That trust has pushed us beyond the boundaries of what we initially thought was technologically possible.

JPC: What’s your approach to people management?

NC: I have always considered it important to take care of the people I work with and to help them grow. I actually don’t particularly like being the centre of attention. I enjoy supporting others, and I like encouraging the people around me to step into the spotlight. I want them to experience recognition and success.

When I recruit people, I look for a mix of personalities and abilities. But within that mix, I want people who are aligned with the company’s values: people who are passionate about what they do, respectful of others, willing to collaborate and courageous enough to try new things and challenge themselves.

A company is ultimately made of people. And I believe that giving people the opportunity to grow is one of the most rewarding parts of being a leader.

JPC: How do you see FEMTOPRINT’s future development?

NC: The past two years have been challenging, partly because of the geopolitical situation. But since around August last year, we have seen the market start to accelerate again.

We believe the next three years could bring significant change. Glass has the potential to transform many fields, including quantum computing, photonic integrated circuits, co-packaged optics and technologies related to artificial intelligence, as well as life sciences and medical technology.

In life sciences, for example, I co-founded AxCellerate in 2023 as a spin-off from FEMTOPRINT, together with partners from the European NEUROCHIP consortium. The idea is to use FEMTOPRINT’s glass microfluidic chips

to culture stem cells and grow human-derived brain organoids in a controlled environment, helping to evaluate new drugs for toxicity, functionality and other biological responses.

FEMTOPRINT, itself, is also evolving. We have moved from being a company focused mainly on prototyping and small production runs to one that develops products and is increasingly capable of large-scale manufacturing.

Our ambition is to serve not only the markets in which we are already active, but also large international customers whose production requirements are significantly higher.

We are also considering establishing a presence in Asia to be closer to our customers there.

We already have a presence in the United States and are looking at how we can strengthen it further to provide even better support in that market.

JPC: What’s your advice to someone starting a company?

NC: I have a saying that I really believe in: your life becomes an extraordinary journey if you do something every day that scares you. Every time you do something that takes you outside your comfort zone, your perception of fear changes. And the next day, you are ready to try something more.

Second, find an excellent mentor. I would not be where I am today without Hans Gerber, who gave me the opportunity to create and develop SMARTEC at a time when I was considering selling our fibre-optic technology to his company.

Third, if you find what you are doing boring, it is probably time to evolve. You need to be creative and find ways to have fun, because that energy is your fuel.

Fourth, while it is great to start new projects, the key is to stay focused. Never lose sight of your star. Keep putting your heart into the project until you reach your goal.

And finally, always do something that pushes you beyond what feels comfortable. If everything is easy, comfortable and under control, you are probably not growing. There should always be another challenge waiting for you. **EO**



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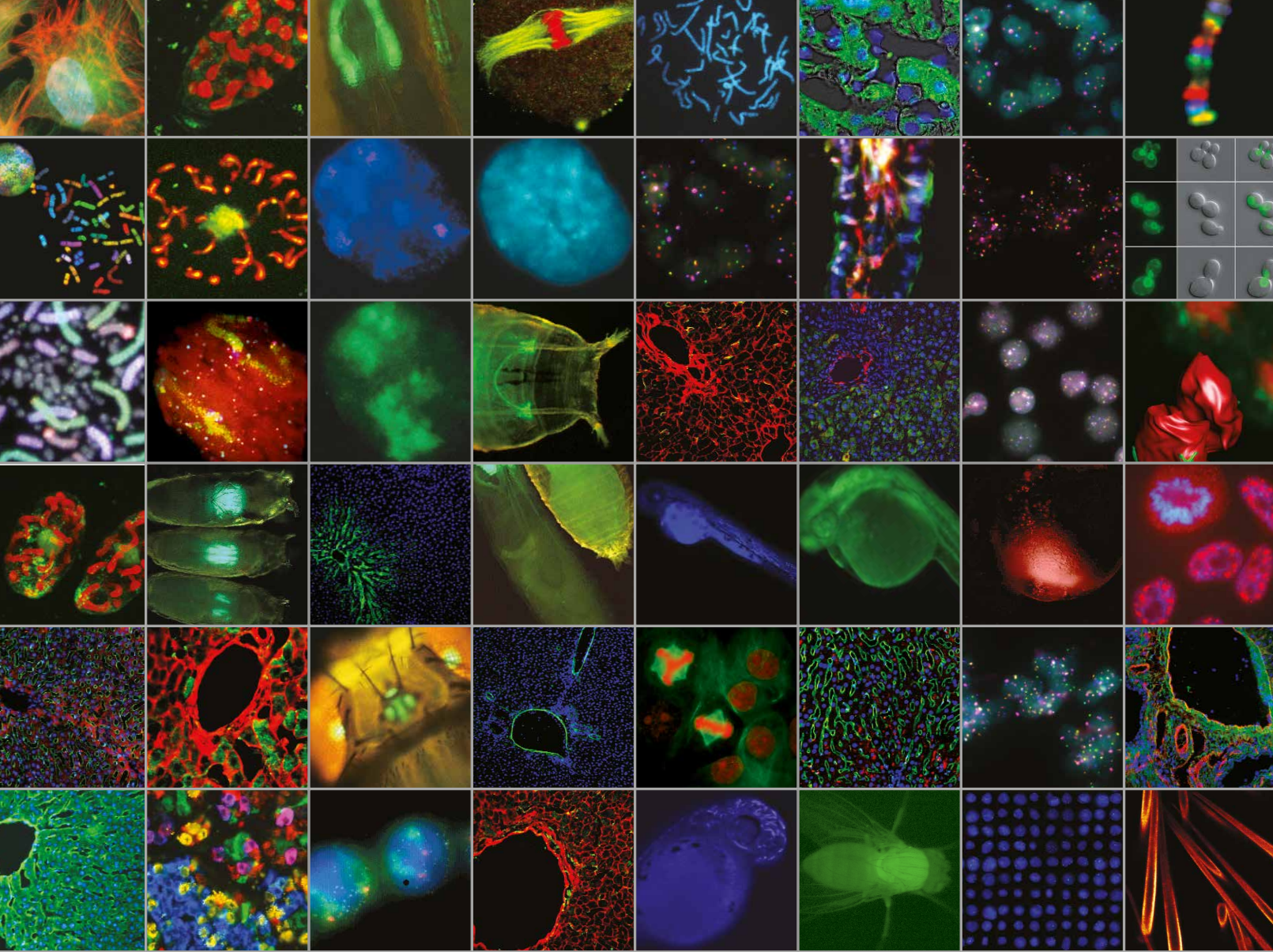
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