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Sought-after skills

Last month I ventured north to Glasgow for the annual general meeting of the European Photonics Industry Consortium (EPIC), where guests were treated to a traditional Scottish feast featuring haggis, whiskey and bagpipes.

But it wasn’t all fine dining. The event included many panel discussions, one of which focused on the challenges European photonics firms face in hiring and retaining skilled engineers. The days when people will work for decades for the same company are gone, said Orion Engineering’s René Louwers, so firms need to think beyond salary and offer staff interesting projects and entrepreneurial opportunities. Read more on the report on page 14.

This theme was also present in an interview with Thomas Zettler, CEO and co-founder of LayTec, on page 18. The company sells metrology equipment to both industry and academia, and even though selling to universities isn’t as profitable, Zettler noted that keeping strong relationships here is a good way to recruit. The company provides training for universities and works with nearly every PhD student generation at those institutions, so has excellent access to talent.

Also in this issue we spotlight display technologies such as micro-LEDs (page 22), look at additive manufacturing in the optics industry (page 20), and the latest trends and developments in the optical mirror field (page 30).

@electrooptics
Photonics needs to become a ‘pervasive discipline at all levels of education and professional training’ to meet Europe’s social, economic and environmental challenges, according to a new report handed over to the European Commission.

The ‘Photonics21 Multiannual Strategic Roadmap 2021–2027’, created in preparation of the new EU funding programme, Horizon Europe, outlines factors hindering photonics’ potential. While the global market has reached €600 billion, Photonics21 estimates only 20 per cent of potential power and benefits of light technologies have been unlocked.

More than 1,700 photonics bodies were consulted, and the report was given to the European Commission during Photonic21’s photonics public private partnership (PPP) annual meeting, in Brussels, in March.

Advancing areas like disease diagnosis and environment conservation relies on defining skills needed for the future photonics workforce, delivering appropriate education and training, plus strong academia-industry links to ensure rapid commercialisation of innovations.

‘An important area for the future of photonics is the education and training of the next generation of professionals,’ the report stated. ‘They will need to be provided with the necessary skills to successfully and innovatively exploit the great potentials that photonics technologies have to offer.’

Innovative approaches will be needed to attract students towards STEM disciplines and photonics studies, it was noted, and academic and vocational training in photonics must be a priority both in STEM curricula and in other subject fields – with educational and training material continuously upgraded and disseminated.

The report highlighted that digital skills should be part of all photonics programmes, and that entrepreneurial and innovation mindsets should be stimulated to maximise impact of newly discovered technologies.

Moreover, the mobility of students and those working in the sector should be encouraged, since the required skillset is often highly specialised, with educational and industrial needs not often aligned geographically.

‘To enable this in a sustainable way, it is necessary to establish a pan-European network of institutions devoted explicitly to photonics outreach to all areas of society, including students, citizens and industry,’ the roadmap said.

To ensure research supports industry needs, lifelong learning programmes should be set-up by academia to target industry needs, mainly in the case of SMEs, ‘since they often lack internal resources for training.’ In addition, photonics programmes should target companies that are non-specialists, but that could benefit from using photonics technologies.

The report highlighted the need for research to be directed to applications that ensure innovations get out of the lab and benefit society.
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**European microtechnology sector outlines Brexit fears**

Members of Europe’s microtechnology sector are concerned that Brexit impacts, such as investment delays and higher levels of bureaucracy, could affect their businesses.

This is according to a recent survey conducted by the IVAM Microtechnology Network, an industry association representing organisations in the fields of microtechnology, nanotechnology, advanced materials, MEMS and photonics, which consulted 3,243 companies and research institutes to produce the report.

Compared to a similar IVAM survey from 2016, published just before the Brexit vote, expectations – especially for British industry – have declined since 2016, mainly due to the conditions of Britain’s withdrawal being so uncertain.

Almost 60 per cent of IVAM’s members anticipate a negative impact on their own business, compared to 36 per cent in 2016.

Capital investment in the UK has already declined due to the Brexit vote, according to various economic reports. This was reflected in the survey, with more than 80 per cent of participants stating that Brexit is having, and will continue to have, a negative impact on UK investment.

With the framework conditions for foreign trade relations not yet established, funding decisions and investments are being put on hold. Even if an agreement between the UK and the EU were to be reached soon, certain damage to business would not be averted, a survey participant from the UK commented.

Trade relations between the UK and European Union will likely be regulated more strongly after Brexit. Britain’s independence is expected to put a higher bureaucratic load on companies both there and in the EU. In 2016, a negative impact of Brexit on regulations was predicted mostly for UK industry, but respondents now expect industry in EU countries to face more bureaucracy.

While trade negotiations between the UK and the EU have reached a dead end, only a third of survey respondents expect a deal that could give Britain some benefits of EU membership.

Regarding agreements between the UK and non-European countries, the industry is more optimistic. Those who thought the UK would be able to negotiate favourable trade agreements outside the EU were at little less than 14 per cent in 2016; now it is just over 30 per cent.

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**Microlight3D gains 2D microprinting expertise with acquisition**

Microlight3D, a manufacturer of 3D microprinting systems, has bought French firm Smart Force Technologies (SFT) to extend its product portfolio to include 2D microprinting.

The acquisition could benefit researchers working with microfluidics by developing combined 2D-3D microprinting systems.

With such a system, researchers would be able to print microfluidic channels, as well as produce micro-features directly inside those channels, all using a single piece of equipment.

Smart Force Technologies is a manufacturer of a maskless lithography system for micro-scale 2D-printing. It is a spin-off from LTM, a French research centre focused on miniaturising micro- and nano-electronics devices.

Microlight3D’s microprinting technology is based on two-photon polymerisation with a resolution down to 0.2µm. It can print 10µm structures inside microfluidic channels, which are typically 100 to 200µm in diameter, for instance. The addition of SFT gives Microlight3D capacity to address new needs of customers in microfluidics, microoptics, microsensors and microelectronics.

Denis Barbier, CEO of Microlight3D, said: ‘We [Microlight3D] gain expertise in high-resolution 2D-printing that, combined with our 3D microprinting know-how, will lead us to develop new micro-fabrication systems. These future 2D-3D microprinting systems will respond to customer needs for faster, larger and more complex printing capabilities.

‘Microlight3D is now in a stronger position to support a range of customer developments in the life sciences and increasingly in industrial applications.’

Using a single piece of equipment to print microfluidic channels and structures in the channels would improve accuracy and create more sophisticated devices.

Julien Cordiero, CEO and co-founder of SFT, added: ‘By adding our 2D microstructuring technology to Microlight3D’s portfolio, it means that customers who are seeking new ways to solve design challenges can greatly benefit from the quality and efficiency of sourcing from a single supplier.’

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**Eureka Network opens €2m call for advanced manufacturing projects**

The Eureka Network in Photonics, a joint initiative between Innovate UK and the funding authorities of the Photonics 21 Mirror Group, has announced €2 million of funding to produce industrial photonics technologies for advanced manufacturing.

The funded projects, according to the network, will last no longer than three years, and will investigate photonics technologies including: laser machining; additive manufacturing; selective laser sintering; photonic curing; optical process control; 3D optical sensing and imaging; lidar; and photo-, stereo- or laser-based lithography.

“The participating funding bodies... intend to fund joint-research and development in the area of photonics,” said the network. ‘Applicants are expected to undertake research aiming at marketable products, services or technologies with high market potential in the participating countries.’

The countries of the Eureka Network in Photonics are: Austria, France, Germany, Israel, Poland, Switzerland and the UK.

The call for project proposals opened on 25 March, with the submission deadline 25 July. Selection of the funded projects takes place on 29 October, with an intention to start the projects between January and June 2020.

Funded projects will receive between €750,000 and €2 million.

UK organisations eligible for this funding will need to involve at least one UK-based SME, and must also collaborate with at least one separate organisation from another country of the Eureka Network in Photonics.

These organisations must apply for the UK funding via Innovate UK by 15 July, in addition to filling out a Eureka project application form by the main 25 July deadline.
Coherent CEO John Ambroseo to retire

John Ambroseo has announced he will retire as CEO of laser manufacturer Coherent by April 2021, after nearly 17 years in the position.

Coherent has entered into a transition services agreement with Ambroseo, who is also president of the company.

‘Throughout my nearly 17 years as CEO of Coherent, I always try to take the long view on the markets, technologies and the company,’ said Ambroseo. ‘I believe this approach allows us to make better decisions benefitting all stakeholders, but this also requires a trade-off between professional and personal priorities.

‘Having considered this, I want to shift my long-term attention to my family and philanthropic pursuits. As a result, I have worked with my fellow directors on the board on how to best manage a leadership transition, which I am fully committed to making as smooth as possible.

‘Until a transition occurs, I remain fully focused on both our customers and the company.’

The governance and nominating committee of the board of directors will start looking for Ambroseo’s successor.

IN BRIEF

Photonics21 has published a market research study on nanoscale quantum optics. The study focuses on the market potential of quantum communication, quantum key distribution, quantum random number generator, quantum sensing, atomic sensors, as well as sensors based on nitrogen vacancy centres.

Hübner Photonics has opened an office in the United States. This is an expansion of the current Cobolt office, which will be renamed.

The European Photonics Industry Consortium has signed a memorandum of understanding with the Ethernet Alliance, to cooperate on the endorsement of standards and technology roadmaps.

NKT Photonics has strengthened its presence in the United States with a facility in Boston. The site will be the company’s headquarters for US-based sales, and will accommodate single-frequency fibre laser production, as well as an application and service laboratory.
Female engineers needed for role model initiative

The American Association for the Advancement of Science has launched a programme to give women in science, technology, engineering and mathematics (STEM) careers the opportunity to share their stories and serve as high-profile role models for middle school girls.

Participants in the programme will connect with students (aged 11 to 13) in person and through various media, including popular YouTube channels and TV shows. It is open to US-based women who represent a diversity of STEM professions, including both academic and private-sector researchers and scientists working across different sectors. Applications opened on 1 April.

The Ambassadors programme is part of IF/THEN, a $25 million initiative of Lyda Hill Philanthropies and various science, education and entertainment organisations, which aims to boost females’ interest in STEM careers by changing the narrative around them.

Having a fictional or non-fictional STEM role model increases the proportion of girls interested in getting a job in the sector to 52 per cent from 32 per cent, according to a 2018 Microsoft survey. A 2018 research report by Lyda Hill Philanthropies and the Geena Davis Institute on Gender in Media, however, found that just 37 per cent of STEM professionals portrayed in media are women.

More specific to the photonics field, having women figures to look up to is an important way of improving the uptake of women – which make up just 21 per cent of the photonics community – into the sector, according to SPIE data.

Writing for Electro Optics, Daniela Marin, an engineering student at University of Colombia in the US, said that role models and mentors are vital for raising awareness, and interest in, optics and photonics courses. ‘I always had the blurred figure of a male cross my mind when I thought of an engineer, or I thought of my eye doctor when I thought of optics,’ Marin commented.

‘At college, I was fortunate to have been exposed to eclectic themes associated with optics through my mentor... who taught me more than just the fundamentals of optics, [such as] what research was like, how to find opportunities, and gave advice when I felt unsure.’

Getting photonics into earlier stages of education was referred to in the latest European photonics roadmap, which was handed over to the European Commission last week by Photonics21 in preparation for the new EU framework programme, Horizon Europe.

IF/THEN aims to inspire young girls’ interest in STEM fields by highlighting real-world STEM applications and their importance in daily life. Coalition members include partners such as Girl Scouts of the USA, National Geographic, Massachusetts Institute of Technology, and the World Wildlife Fund.

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EPIC delegation to Israel

The EPIC delegation to Tel Aviv and Haifa was composed of five company visits and four receptions, which brought together about 30 local industry leaders and experts. The delegation took place in conjunction with the Optical Engineering and Science in Israel (OASIS) conference and exhibition that takes place every two years. OASIS features 55 exhibiting companies and 1,200 participants, of which 10 per cent come from abroad. The EPIC delegation trips are a great way to learn about a geographical market.

EPIC has 12 members in Israel, ranging from a distributor, a defence system integrator, a research organisation, and numerous suppliers along the manufacturing and components value chain. This is just a small fraction but representative of the overall photonics ecosystem in Israel.

According to the local cluster, there are more than 350 companies, and also a strong academic base with more than 500 researchers in seven universities. Just as in Europe, most of the companies are SMEs, a typical feature of the photonics ecosystem. The industry is also an important generator of income and employment. The total industrial revenue is more than $5 billion, of which 90 per cent is export.

The sector employs more than 20,000 employees, of which 5,000 are in R&D. There is a strong infrastructure for research, development, production, assembly and testing, and the recently established Advanced National Photonics Centre focuses on speciality fibres, epitaxial growth, and at a later stage, also optical materials.

The main markets for photonics in Israel are by order of importance: metrology, medical, defence, communication, components and security. The research topics cover the full breadth of high-power lasers, optical networks, fibre sensors, nano-photonics, quantum physics, ultrafast phenomenon, optical materials, chemical sensors, spectroscopy, non-linear optics, plasmonic beams, electron optics, integrated photonics, multispectral imaging and more.

Though the culture is very different from Europe, I found Israel very attractive and interesting, both on a personal level and in the scope of EPIC and the members. But clearly I am not the only one to think so, given the vast amount of multinational companies with a presence in the country. To name a few R&D centres from multinationals: Applied Materials, Spectra Physics, KLA Tencor, Flir, GE Healthcare, HP (Indigo division), and Zeiss.

“The total industrial revenue [in Israel] is more than $5 billion, of which 90 per cent is export”

If you would like to learn more, please contact EPIC or the association of photonic companies in Israel. This photonics cluster, under the umbrella of the Association of the Hi-Tech industries in Israel, was founded in 2018, at which occasion EPIC was present and signed a collaborative memorandum of understanding. As with most clusters, the mission is to bring together all entities making up the photonics ecosystem in the country, to enable growth in photonics companies and the national economy. EPIC is very much looking forward to continuing with this very positive partnership.

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Photo-acoustic PIC sensors lower cost on gas analysis

Leti, a research institute of the French Alternative Energies and Atomic Energy Commission (CEA), has developed prototype opto-acoustic sensors that are more energy-efficient and cheaper than existing systems, offering a more accessible solution for monitoring toxic gas emissions.

The centimetre-sized sensors are based on mid-infrared photonic integrated circuits (MIR PICs). These silicon PICs, created by integrating optical circuits onto millimetre-size silicon chips, make extremely robust miniature systems, in which discrete components are replaced by on-chip equivalents. This makes them easier to use and reduces their cost dramatically, by a factor of at least 10.

Developed by the European Commission’s Redfinch project headed by CEA-Leti, the prototype photo-acoustic sensors were fabricated on a CMOS line in a miniaturised silicon photo-acoustic cell, which allows extreme integration.

In demonstrations, the sensors match the performance of bulky commercial gas-sensing systems commonly available today, which could make gas emission analysis systems cheaper and more accessible, helping to ensure factories and plants adhere to emission regulations.

The sensors consume less than 10W in continuous operation. They can be operated in a slow pulse-burst mode for infrastructure monitoring, and when leaks are detected, the pulse frequency of the sensor automatically increases. This keeps average power consumption very low, so the sensors can be battery-operated for more than a year, or powered by renewable sources such as solar cells.

“This allows the detection and concentration measurement of a wide range of gases, liquids and biomolecules,” Coutard said. “This is crucial for applications such as health monitoring and diagnosis, detection of biological compounds and monitoring of toxic gases.”

Mathieu Carras, CEO of MirSense, an EU-funded project that helped with the development, said: ‘Our mission is to democratise QCL usage; MirSense is ready to produce these integrated QCL-based components and do a similar job on electronics and software to bring the value of this technology to the market.’

The research was presented at Photonics West ’19, where it won a best paper award.

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Two research projects based on photonics have begun that could lead to early detection and better treatment of cancer.

The European Space Agency and the UK Space Agency have prioritised €1.2 million of funding to develop an x-ray machine to spot early signs of cancer, while the UK Centre for Process Innovation (CPI) is collaborating on a photonics project to advance cancer treatment using phototherapeutic methods.

X-ray images are not normally clear enough to detect the early signs of cancer. But engineers from UK firm Adaptix have used technology developed for space science to produce 3D scans that generate much clearer images.

The device employs x-ray optics deployed on spacecraft such as the European Space Agency’s (ESA) XMM-Newton mission, which launched in 1999 and is observing stars at x-ray wavelengths.

The machine is also small and portable enough to be used in GPs’ surgeries, rather than the patient having to visit a hospital to get a scan.

Tony Young, national clinical director for innovation at NHS England, said: ‘Using stargazing technology to spot cancer is exactly the type of advanced innovation that could improve care for patients by speeding up diagnosis and helping to deliver our [NHS’s] long-term plan, which will save half a million lives.’

Adaptix was nurtured at ESA’s business incubation centre in Harwell, UK.

Mark Evans, chief executive of Adaptix, said: ‘Working with ESA’s business incubation centre, hosted by the Rutherford Appleton Laboratory in Harwell, has given us access to fantastic facilities and leading minds. ESA’s focus on commercialising space-heritage technology to create tangible benefits for the EU population and the UK economy has helped us to create 33 high-value UK jobs in research and development and, increasingly, in manufacturing.’

Meanwhile, a collaborative project between the UK Centre for Process Innovation (CPI) and molecular biology firm LightOx is advancing light-based cancer treatment.

CPI’s healthcare photonics team used optical analysis techniques to help LightOx develop its fluorescent probes. Durham University also produced a prototype light delivery system to allow LightOx to validate its new compounds.

LightOx is now in the process of developing its products for clinical applications.

LightOx’s probes are smaller than any other commercially available product for these applications, meaning they bypass the traditional problems associated with fluorescent probes. They are taken up into cell easily and provide minimal disruption to cell activity prior to light activation, fundamentally changing the way in which these therapies can be delivered to patients.

The technology is also able to target therapeutic action to particular body sites using a simple delivery system, which kills selected cells and tissues without damaging healthy cells, minimising side-effects for patients.

The collaboration between CPI and LightOx forms part of the Spotlight programme, which itself is a partnership between CPI and Durham University, funded by the European Regional Development Fund.

The project comes shortly after CPI’s new National Healthcare Photonics Centre in County Durham was opened.

The centre will support scale-up and commercialisation of med-tech products by acting as a hub for businesses of all sizes and academic partners to work on methods of diagnosing disease, imaging systems and light-based treatments.
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Talking talent

Jessica Rowbury reports from EPIC’s AGM, where the ongoing struggle to recruit skilled engineers was discussed.

Hiring and retaining talented personnel continues to be a major challenge for the European photonics industry, according to panellists at a recent EPIC event.

The April annual meeting in Glasgow welcomed more than 220 photonics industry leaders from 25 countries, to discuss key business challenges, meet with customers and form partnerships. During a recruitment session, Carlos Lee, director general of the European Photonics Industry Consortium, asked attendees who faced difficulties hiring and retaining skilled staff to raise their hand. Almost everybody in the room did so.

Paul Ryckaert, CEO of Belgian infrared camera maker Xenics, highlighted a common problem for growing photonics companies – making the transition from being very scientific to commercial.

‘Moving from scientific to commercial, we suddenly needed a lot of people,’ he commented. ‘We had a lot of brilliant scientists, but they were not business thinking. We weren’t asking the question: “Do our activities add value to the customer?”’

‘Part of transitioning from a scientific to commercial company was stimulating business culture throughout the company.’

Being innovative
Attracting skilled personnel – particularly fresh graduates – means having the right branding and story, which creates a corporate identity that’s unique and therefore stands out, said Benno Oderkerk, director and founder of Avantes, and EPIC president. ‘We see this as very important for attracting young people.’

René Louwers, director of recruitment company Orion Engineering, added that offering exciting opportunities is important for attracting – and retaining – talent.

‘The days when people will work for 40 years for the same company are over. Highly-skilled engineers won’t leave for a higher salary, but for

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more interesting projects. As a company, keeping innovation high is crucial,’ he said.

However, it is easy to want to go overboard and offer too much, said Xenics’ Ryckaert. Keeping a good balance is key, he noted: ‘For example, offer freedom for entrepreneurship but within limits, and be careful of irrational salary escalation.’

Finding the right people requires careful preparation before the hiring process starts, Ryckaert pointed out, which includes defining role profiles and priorities. And, being willing to spend the time and resources that’s required is essential. ‘Recruitment costs a lot of money, but the cost of not getting it right is a multiple of this investment,’ he said.

In time, this process will get easier and less time- and cost-intensive, as having a critical mass of the ‘right people’ will help to attract new people, Ryckaert added.

Attracting talent to Europe

According to Chris Thiel, of recruitment firm Insight Technology Search, and Robert van Tankeren, from TMC Physics, Brexit is having an effect on the job market.

‘The amount of people applying for jobs in the UK from the EU has dropped considerably,’ van Tankeren said. ‘This makes it even harder for UK companies at the moment.’

However, Thiel believes this is only temporary: ‘It’s just the uncertainty that is affecting things – because nobody is sure what the final outcome of Brexit will be, and how it will affect movement in the EU. Once the deal is completed – whether it’s “hard” or “soft” Brexit – I believe people will start looking for positions in the UK again, because at least there will be certainty.’

In terms of attracting people from Asia, who a member of the audience noted find the US more attractive for technical careers, touting the benefits of working and living in Europe is important.

‘The EU has a lot to offer – it is world-leading in many areas,’ said Louwers. Frank Wolfs, CEO of ProFound Corporate Recruitment, added: ‘Worldwide research shows quality of life in the corporate European world is better than Silicon Valley or Asia.’

Higher job security was also mentioned as being an attractive benefit, in addition to an easier visa process. According to Thiel, in the last 12 months with the Trump administration, there has been a huge slowdown in visa approvals. ‘People have had to wait 8 to 12 months to get a visa after a job offer, which means that job offers are then retracted. Acquiring a visa is much simpler and faster in Europe,’ he said.

The importance of diversity

One factor that was notably absent from the discussion was how the European photonics industry could attract and retain more women into optics and photonics careers. According to figures from SPIE, the international society for optics and photonics, women make up just 21 per cent of the photonics workforce. Therefore, attracting more women to this field could significantly increase the talent pool.

Writing for Electro Optics earlier this year, Professor Anita Mahadevan-Jansen, director of the Vanderbilt Biophotonics Centre at Vanderbilt University in Nashville, said: ‘The optics and photonics community is not exempt from the challenges that all STEM disciplines are facing when it comes to equity, diversity and inclusion. While the community does not prevent people from diverse backgrounds from participating in the myriad of events, until recently little was done to encourage and support them. Concerted and coordinated effort is needed to make diversity part of the very fabric of our community.’

Katie Schwartz, optical research engineer at Edmund Optics, said that the photonics industry has an opportunity to differentiate itself from other fields by working to increase diversity.

‘[The photonics industry] falls very much in line with other STEM fields with regards to attitudes, the pay gap, and representation. I think that if there was any community or industry that would appreciate the need to have confidence in aggregate data, and not personal observations, it seems that one rooted in science would be the most likely. To me, this presents an incredible opportunity to differentiate ourselves as an industry. There is a rising concern about a global shortage of optics and photonics talent in industry. Imagine all the untapped talent we could gain and retain by having a reputation as an inclusive and progressive industry,’ she said in an article for Electro Optics.

Another way of increasing the talent pool, according to Thiel during the panel discussion, is to look at adjacent industries – such as the semiconductor sector – for skilled engineers who could adapt and would be interested in working in the optics industry.
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How did LayTec begin?
LayTec will celebrate its 20th anniversary later this year. We started as a metrology company in 1999 and quickly became a leader in the field of in-situ metrology for LED and laser production. We started by providing metrology equipment for the compound semiconductor industry, but now our products are used in several sectors: electronics, display, optoelectronics, photovoltaic, silicon-based semiconductor, and industries that are a combination of mass-production and research, as well as universities and research institutes.

In the early years, LayTec focused entirely on the academic research market, but year by year we developed into a company providing metrology for industry, as well as academia. It is this balance between industry and academia that guides the direction of the company, because one definition of an entrepreneurial organisation is that it recognises when there are changes in the market. It is a good investment to continue business with universities and research institutes, because they are indicators of new developments in material science and device structures.

We would like to continue this industry-academia balance. Even though selling metrology equipment to academic customers is usually not as profitable, this is a good investment for LayTec’s future. We won’t stop making a product simply because there is not yet a big industry market behind it.

The other advantage of doing business with academic customers is that it’s a good way to recruit. We provide training for universities and work with nearly every PhD student generation at these institutes. The universities and PhD students know us, and we sometimes know the person applying for a position at LayTec, and will know whether they will fit into our company philosophy and climate.

Another important part of doing business with both universities and industry is that many PhD students, when they graduate, will work in a similar field. Because they know our research metrology systems, it’s then easier for them to use the industry-type metrology systems later on in their careers.

How are staff organised at LayTec?
All our employees are technology people, because we are a high-tech company. Roughly one third of staff are involved in R&D projects; one third are close to the customer, which is not just marketing but is also about service and application engineering – to work together with the customer to make the product as profitable as possible, and to reach a return on investment as early as possible. Then the remaining third is involved in organisation, manufacturing and quality testing.

How large is the company?
LayTec, singly, is an SME, but we are part of a group of companies under the holding company Nynomic. Nynomic is made up of: Avantes, LayTec, m-u-t, tec5, APOS and Spectral Engines. These companies are all involved in optical measurements based on spectroscopy. As a group of metrology companies, we are not an SME anymore.

The merger with Nynomic in 2017 happened in order to improve our capabilities to organise our future and not be driven by the market. Of course, we have
to learn from and adjust to the market, but being part of a larger group means we have early information about the market, and allows us to respond early to new needs.

The merger came about, initially, because I knew some of the CEOs from the Nynomic group and, in private talks, I got my first impression of how Nynomic works. Then we had discussions with all the CEOs, and visited the companies in the group and the key shareholders to learn what they think about the future of the group. After going through this process, we decided that it’s a good idea for our owners, employees and customers to be a part of the group.

There are several advantages to being part of Nynomic, one of which is the improved supply chain of components for use in our metrology systems. The basic idea of joining Nynomic was to create an entity that continues to be successful over the next decades. And one must think early as to the developments that might take place in the next 10 years. In order to avoid a situation where you must make fundamental decisions about the future of the company in just a few years, or even a few months, we started early and watched the market – and discussed internally who would make a good partner. We tried to make the best decision for the future of the employees and the business – Nynomic was a good fit for us.

Big companies are often successful, because they dominate the market and can operate efficiently at a large scale, but they sometimes fail in innovation. The structure of Nynomic, made up of sister companies that are free to develop in their markets, is a good compromise. I think LayTec’s chances of providing ongoing high-performance solutions for our markets have increased by joining Nynomic and to share the synergies of this high-tech group of companies.

We signed the contract in 2017 and 2018 was a very successful first year in the group. It’s really a nice development for our products and sales figures. So far, all the team is highly motivated to use the advantages within the group. The companies within Nynomic work in different fields and don’t typically compete in the same markets. At first sight you might think tec5 and LayTec may be competing, but if you look closely at the expertise and strengths of both, each serve different applications, markets and needs. There are companies in the group that supply bespoke systems, such as LayTec, and others that are more focused on general production of systems.

**What did you look for in a partner?**

We looked for a partner that is not a risk to our long-term success. So, partners only driven by financial performance, and optimising the procedures for the next quarter results – these are the kind of investors we excluded. We also looked at firms that want to strengthen the European industry. Nynomic, as a European firm, therefore had several advantages in comparison to non-European companies located in high-tech regions somewhere else.

Another consideration was that a large part of Nynomic’s shares are still owned by the founders – this adds even more stability for the long term.

**How do you promote entrepreneurial spirit?**

In principle, our relationship with Nynomic is a merger, but LayTec remains a brand and keeps its name. There are no major changes in the organisation, except some synergies that really help us.

And it is a perfect environment for employees, because their opinions matter; it’s not like someone from the outside will come in and tell them what to do. We grow as a group.

It is also important to be transparent about the general business situation, in good times and bad. Every employee at LayTec is informed once a month about what the company is doing: the key projects; why we are focusing resources on certain projects and why we invest less in others; what the expectation in the market is for photovoltaic and compound semiconductors; and other factors. Therefore, if the management decides to move in a certain direction, it is easier for the employees to understand the reasons behind this.

This is one way of promoting an entrepreneurial spirit within a large percentage of our employees. Another way is by learning and training via projects with customers.

Entrepreneurial spirit at LayTec has many facets.

One of our employees left and founded his own software company, and we remain in close contact with him. We also invested in a German start-up metrology company and still collaborate with this company. And some young and gifted engineers, who got their first job with us out of university, moved on to seek larger companies, but then came back – bringing with them new knowledge.

Finally, we also developed products for large-area deposition through founding and growing a start-up subsidiary, the technology for which was then reintegrated back into LayTec after eight years. **EO**
Additive manufacturing is no longer confined to R&D labs or niche applications. It is now very much a mainstream manufacturing approach and is transforming the way products are made and designed across a wide range of industries. Hugely complex components that traditionally have been impossible, or extremely expensive, to make have become straightforward to produce when additive manufacturing (AM) is used. Prototypes can be created quickly and cheaply in hours, from a digital 3D design.

The ability to easily incorporate intricate structures enables the creation of parts that have the same strength but greatly reduced weight when compared to traditionally-manufactured predecessors. 

What does it mean for optics? 3D printed metal and polymer parts are already successfully used in sectors such as aerospace, automotive and healthcare, but what about optics and photonics? What does AM mean for our industry and what might the future hold? It is not yet possible to print a high-precision glass optic, but there are many other ways AM is being used throughout the industry.

At multiple points during the manufacture of a lens it needs to be held in place. For custom components, sometimes creating tooling and fixtures can take weeks. With AM the necessary parts can be created in hours, shortening the lead time substantially. This also applies in research and development where custom holders, mounts and housing can be designed and made quickly and cheaply.

This new flexibility at the prototyping stage allows engineers to quickly trial different design iterations and arrive at the optimal solution much quicker than they otherwise would have. This is one of the areas that AM excels at across all industries – and optics and photonics is no different. The ability to quickly prove an idea, or demonstrate its feasibility to a customer, manager or investor with something functional, or even just a physical representation, is extremely powerful.

What about using AM methods to make optical components? There are several...
companies that are already printing optics from UV curable polymers. While the precision, homogeneity and small range of available material properties makes them less suitable for use in high-precision applications, they work really well for things like illumination, and in some cases low magnification imaging. The possibility of printing any optic on demand in a matter of hours is a fascinating thought, and if this technology continues to improve, it will undoubtedly have a huge effect on optical design and manufacturing.

Consider freeform optics, for example. Printing a lens layer by layer makes a freeform design just as easy to manufacture as a rotationally symmetric one. Designers will have unparalleled flexibility to explore new designs that just weren’t possible before.

This flexibility would also make compact, lightweight assemblies much easier to design and manufacture – a huge advantage for size and weight-sensitive applications in fields such as autonomous vehicles or aerospace. Just as we have already seen in other areas, the biggest advantage will be the ability to quickly produce a custom design directly from a digital file. This is extremely powerful and will help to rapidly accelerate the product development cycle. Traditional optics take a relatively long time to manufacture and one-off custom prototypes are often prohibitively expensive, particularly for small companies. 3D printed optics would make this so much more accessible, and likely lead to an explosion in optical innovation.

The challenges ahead
There are many exciting possibilities, but there is still a long way to go and it seems unlikely that AM will replace traditional methods anytime soon. The surface figure irregularity and surface flatness are critical for precision optics, and that isn’t quite there yet with additive methods. In addition, optical polymers are not able to offer the same range of transmission, refractive index or dispersion as glass substrates at the moment. Until these fundamental material science issues are solved, glass and traditional methods are likely to remain the industry standard, certainly at high precision.

Another issue is high-volume production. 3D printing is great for quickly generating single pieces with high levels of complexity, but it is a serial process. For producing multiple parts quickly, traditional high-volume manufacturing is still going to be considerably faster and more cost-effective.

“Until these fundamental material science issues are solved, glass and traditional methods are likely to remain the industry standard, certainly at high precision”

Additive manufacturing is affecting the optics industry. 3D printed fixtures and tooling are already capable of shortening lead times. As the precision with metals and polymers continues to improve, 3D printed optomechanics are likely to become a lot more common place. It is an engine of growth, too – high-energy lasers and the precision optics that go with them are critical parts of many different AM methods. With large amounts of investment being made in this area across a huge range of industries, this is likely to be a growing market for optics for a long time.

The technology and materials for the direct printing of optical components are still in their infancy – but with advances being made all the time, who knows where we will be in 20 years? The possibilities are exciting – the potential benefits huge. Being aware of recent developments in this area is going to be crucial for companies that want to stay competitive in optics and photonics.
TV technologies push for resolution evolution

3D technology is just one of the innovations emerging in the large display market, as Andy Extance assesses the prospects for LCD, OLED and microLEDs in the fight for a share of this very competitive space.

“Samsung is developing a blue OLED backplane directing the light to the appropriate pixelated quantum dot film”

Dimenco incorporates 3D display technology into Simulated Reality, which it calls a natural user experience, interacting with 3D objects in a virtual environment, without the need of any headwear or wearables.
Delmdahl said that UVBlade helps with this through its gentle lift-off process, enabled by homogeneous energy distribution and stable beam and energy density.

**Flexible solutions**

UVBlade’s potential in microLED manufacturing builds on its usage for laser lift-off in OLED displays, where it helps produce devices on flexible backplanes. Delmdahl highlighted the 77-inch wide, transparent, flexible OLED screen demonstrated at the DisplayWeek conference in Los Angeles, California, in 2018. ‘Technically, and also economically, lift-off separating such large displays from their giant motherglass panels requires record line lengths of 1,200mm,’ Delmdahl said. ‘Coherent is the only company which has realised, shipped and installed a 1,200mm line-length UVBlade system to support the flexible OLED TV market.’

This illustrates how OLED technology is shifting from displays on glass to rigid plastic, which is thinner, more robust, and can be curved or fully flexible, Das highlighted. ‘This may prove a big boost in turning round the flatlining, or declining, tablet and smartphone market and allowing display makers to capture more profit margins, since it is not yet a commodity,’ Das said.

Such continued innovations are largely being pushed by suppliers, Das observed. ‘Margins on LCDs have fallen due to competition from Chinese-based panel makers,’ he said. ‘It’s innovate or die – as many Japanese companies have learnt.

Huge LCD investment in China meant those in Korea and Japan lost margin and ended up, in some cases, leaving the display business. It resulted in huge innovation in OLEDs. Chinese display makers are also hot on OLEDs and other technology, and will be quite formidable competition, but for now the Koreans are in the lead.’

Such innovation is slowly improving OLED for TV’s biggest problem today, which is cost, Das added. ‘Printing potentially promises very large area displays beyond the current panel sizes today, restricted by conventional non-printing processes,’ he said.

One leading OLED printing player is Newark, California-headquartered inkjet tool producer Kateeva. Inkjet printing is already used to deposit and pattern a key
encapsulation layer in OLED smartphones, explained Steven Van Slyke, Kateeva’s chief technology officer. ‘All the flexible and foldable smartphones in existence use this technology, and Kateeva has provided essentially all of these tools,’ he said. ‘It is expected that this same technology will be used for TV-sized displays in the future.’

OLED manufacturers are also inkjet printing the emitters in red-green-blue (RGB) full colour displays. That differs from the white-red-green-blue (WRGB) format, which relies on combining an unpatterned white emitter with colour filters to produce the red, green and blue. Kateeva has demonstrated inkjet printing for 210 pixel per inch (ppi) RGB displays. ‘A 55-inch TV with 8K resolution is about 160ppi,’ Van Slyke underlined. Kateeva is providing R&D tools to China and Korea for RGB printing development to enable ‘top emitting’ OLEDs, in which the emitters are in front of their control circuitry.

Top emission fits RGB formats better, partly because WRGB colour filters cause issues. They must either be patterned on top of the OLEDs’ encapsulation layers, or on a separate piece of glass aligned and laminated to the OLED substrate, Van Slyke explained. The latter is an undesirable additional process step and use of materials. Also, top-emitting OLEDs create micro-cavities in their material stack, between their semi-transparent top cathode and reflective anode. This cavity’s optical properties favour wavelength ranges that mean pure white emission is not feasible. With inkjet printed RGB displays, each pixel’s colour can be designed to take advantage of the micro-cavity, Van Slyke said.

Quantum leap

Inkjet printing is also helping enhance both OLED and LCD technology using quantum dot colour filters (QDCFs). Such filters could sit in front of a blue LED-based backlight, with an LCD modulating the blue light reaching the QD film, Van Slyke said. Alternatively, Samsung is developing a blue OLED backplane directing the light to the appropriate pixelated QD film. ‘In this case, the blue OLED emitter is unpatterned, so it is scaleable to large mother glasses,’ Van Slyke said. ‘Likewise, the QDCF layer deposition by inkjet printing is also scaleable to large substrate areas. This approach is receiving much attention recently, and is in the advanced development stage. So far, it looks promising as a competitive display technology.’

Abishek Srivastava, from the Hong Kong University of Science and Technology (HKUST) and his colleagues are working on similar quantum dot enhancement film technology. Rather than quantum dots, HKUST is developing quantum rod-based films, aligning them with liquid crystal molecules, giving polarised emission. This doubles emission efficiency from around 4 to 8 per cent, Srivastava explained, and spans wider colour space. Whereas the commercial cutting edge for colour is around 90 per cent of the recommended specifications known as BT.2020, the HKUST team achieved 96 per cent. ‘I think that’s the best case reported for any LCD until now,’ Srivastava underlined.

LCD producers have been improving display parameters continuously, Das stressed. A good example is in one of their previous biggest shortcomings, viewing angles, which have improved steadily over the last 15 years. With market shares declining, remaining LCD producers are looking to eke out such benefits for as long as possible, he added. One innovation is making LCDs flexible, as the company FlexEnable is doing. ‘Large LCDs for TVs will be here for some time, small displays are more rapidly moving to OLED,’ he pointed out.

HKUST has been working with Hsinchu, Taiwan-headquartered display giant AU Optronics (AUO) on another potential LCD innovation. Field sequential colour (FSC) eliminates colour filters, which take up space and absorb 70 per cent of
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Ferroelectric liquid crystals (FLCDs) meet the driving voltage and electro-optical response requirements needed for FSCs, Srivastava explained. FLCDs were invented in 1975, but until now they have been very sensitive to mechanical shock. ‘If you touch the screen, the optical contrast drops straight away,’ Srivastava said. HKUST scientists discovered that the ferroelectric liquid crystal material’s elastic energy was not previously balanced with the anchoring energy of the alignment layer needed to orient the liquid crystals. They have developed new materials that improve that energy balance, enabling very high contrasts and robustness against mechanical shocks.

Another dimension
Among the best LCD technologies today is the low-cost, two domain in-plane switching (IPS) used in Apple devices, Srivastava said, offering much better viewing angles than conventional LCDs. FLCDs should be better still, he added, and also outperform OLED. ‘OLED or any other kind of display needs subpixels to show full colour images,’ Srivastava explained. ‘But field sequential displays only need one pixel to show three colours, and because this requires very small driving voltages, we can go up to 2,000ppi resolution without problems. We’re trying to make 2,500ppi.’ The team’s partner company is evaluating the technology’s commercial use, Srivastava added. That might seem excessive, but high resolutions will help attempts to bring displays into the third dimension.

Dimenco, based in Veldhoven, Netherlands, produces glasses-free 3D displays by applying a lenticular lens on top of a display, explained Huub Van Kuringen, process development engineer at Dimenco. ‘The lenticular lens divides the pixels over the eyes of the user, which creates a 3D perception,’ she explained. ‘An eye-tracker is used to see the best 3D from all positions, and with current high-resolution displays, the resolution for both eyes is good as well. For our 2D-3D switchable displays we use liquid crystals, which can turn the lenticular lens on and off.’

Such approaches have been explored since the 1990s, but suffered from crosstalk between component images being shown to viewers. The issue arises in the polyimide (PI) alignment layers. ‘PI is a well-performing alignment material on planar surfaces,’ Van Kuringen explained. ‘But on non-planar surfaces, such as lenticular lenses, the PI layer deteriorates the optical quality of the lens structure. This results in cross-talk ghost-images. Recently, we have replaced the PI layer of the lenticular lens with nano-grooves. These nano-grooves align the liquid crystals very well. Thanks to the small dimensions and irregularity of the nano-grooves, they do not scatter light or cause interference, and the optical quality of the lens has been improved significantly.’ Dimenco reduces crosstalk to less than one per cent, for a ‘natural and pleasant viewing experience’.

In principle, any 2D display can be used to make a 3D display, explained Silvino Presa, head of optics at Dimenco. ‘However, not all of them will result in the same quality,’ he added. ‘High resolution displays are better, because the bonding of the lens will reduce the number of pixels. Our switchable lenses work with linearly polarised light, which is emitted by all LCDs and also some other display technologies.’

Such advances show how, across all display technologies, intense competition for consumer spending is driving optical innovation. In what could be considered a case of ‘survival of the prettiest’, the resulting visual delights will be valued by all but the most cynical viewers. EO
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Displays are being integrated in more devices than ever. Nowadays displays are used in cars, phones, tablets, laptops, watches, household appliances, etc.

LCD has been the dominant display technology for many years, during which time the technology matured and reached its limits with respect to resolution, brightness, contrast, colour saturation and speed. There have been multiple display technologies aiming to replace LCD, of which only a few seem capable to actually challenge it. And now, nearing the end of this decade, OLED technology is on its way to push LCD aside.

Major mobile phone and tablet manufacturers are already using OLED displays in their top-tier product lines because of their superior contrast and colour saturation. These properties give manufacturers a competitive advantage, but they also create challenges when measuring these displays in their existing measurement systems. These measurements need to be done to calibrate every display accurately, so colour performance is constant for each device.

Need for highly sensitive and accurate colorimeters

The colorimeters used for LCD technology performed very well for many years in mass production environments.

However, when re-using these systems for OLED display technology, they will be relatively slow. The internal sensors need a minimum amount of light for accurate measurements, and the deep OLED black levels offer less light to measure. This results in longer measurement times, during which more light is collected to compensate. Sensor technology and electronics will need to improve so measurement time can be shortened for measuring the black level of OLED displays.

Furthermore, re-used systems may be less accurate on OLED displays as well because the emitted light has other spectral characteristics than LCDs. Within the colorimeter, the transmissive filters that create the XYZ tristimulus functions have spectral imperfections and will need to improve to make the colour measurement more accurate.

To optimise tact times while still maintaining high measurement accuracy in mass production environments, the OLED display and device manufacturers need more sensitive and more accurate measurement equipment.

Introducing the Admesy Hyperion colorimeter

Admesy has developed the Hyperion colorimeter which integrates custom-designed optical filters, state-of-the-art electronics and sensors in a compact robust housing. The Hyperion is the perfect choice for manufacturers that need fast and accurate OLED display measurements for their products.

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**Electro Optics**

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Keely Portway looks at some of the latest developments in optical mirrors – including a trend for larger sizes – and how the technology may develop further.

Optical mirrors are used in a range of industries, such as astronomy, life sciences, metrology, semiconductor and solar. Demand for these components in these markets is steadily increasing, as Patrick Sasso, product line engineer at Edmund Optics, explained: ‘The markets for optical mirrors are demanding products faster,’ he said. ‘Customers want exactly the mirror that they need, which seemingly fits a very customised solution phase, and they want it right away. We call it the Amazon effect.’

Looking at the mirrors in terms of functionality, customer demand is also driving development, with high reflectivity a popular request. Sasso continued: ‘Customers are asking for reflectivities of 99.999 (recurring). It becomes an issue with, not even can we manufacture it, but can we measure it? Do we have the metrology capabilities to actually go ahead and measure something that highly reflective? Some new technologies have been coming out, including our cavity ringdown system. That gives us the ability to measure reflectivities to those kinds of extremes and higher. We are excited to start understanding how we can generate products to sell to customers that utilise that technology.’

Sasso explained that for ultrafast laser mirrors, the key objective is to keep making pulses faster. Tony Karam, laser optics project manager at the company is key to that goal. ‘Ultrafast lasers are growing,’ he said, ‘that’s why they’ve been out there for a couple of decades, but mainly been focused on research labs and academic or university labs. This type of mirror is very advantageous for pulse compression, anything below 30 femtoseconds and this mirror works great.’

Now, however, said Karam, these mirrors are being used more frequently in industrial settings. ‘That creates a lot of opportunities for smaller companies and smaller start-ups to invest and start working on ultra-fast laser technology,’ he explained.

Laser Components has seen a focus on more complex mirror coatings

“Ultrafast lasers are being used in a variety of micromachining applications”

in stock with same-day shipping. We see a lot of movement there – a start-up company, instead of having to invest in an entire coating run that costs tens of thousands of dollars, can buy two or six of them right off the shelf.’

Other new applications for ultra-fast laser mirrors, said Karam, include medical applications like ophthalmology, multi-photon microscopy and, more recently, micro machining. Karam continued: ‘Now, ultrafast lasers are being used in a variety of micromachining applications because they provide a lot of precise features with no more or less thermal defects during the micro-machining process, so this is one of the growing areas.’

Extreme ultraviolet (EUV) optics technology has seen a move into different wavelength areas for mirrors, as Gary Pajer, senior product line manager, explained: ‘The first developments through EUV were
Laser Components has seen a focus on more complex mirror coatings. Thienel believes that, as people become more aware of the industry progressing in terms of capability, the demand on spectral performance has changed. ‘For example,’ he said, ‘it’s common for us now to see structures with a number of layers, so this is where ion beam sputtering (IBS) technology really comes into its own. Because of the very high energy of the coating it produces very compact layers with low moisture. It very much reduces the volatility of the coating and eliminates any thermal drift or spectral changes with environmental conditions of the optic. We’ve put a lot of focus on higher-complexity mirror coatings, not just a single wavelength, or a single-wavelength band mirror,’ Thienel noted.

A new dimension

In terms of applications, these complex coatings would be useful in practices related to scanning, microscopy, imaging or interferometry. ‘Basically, anything where there is going to be multiple light sources at different wavelengths,’ said Thienel, ‘and the user would wish to manipulate the set-up, such that different wavelengths might be directed either fully, or partially, in different directions to different detectors, let’s say. This is why you’d have a very high reflectivity, a certain wavelength to direct that light to one detector – you might have a partial reflectivity of a defined amount, for instance. You could have just five per cent of the intensity of one wavelength transmitted through for some kind of beam diagnostic, like a sample of that beam, while the other 95 per cent is reflected along with the higher reflectivity beam as well.’

Thienel believes that, as people become more aware of the industry progressing in terms of capability, the demand on spectral performance has changed. ‘For example,’ he said, ‘it’s common for us now to see a partial reflectivity of a defined amount, for instance. You could have just five per cent of the intensity of one wavelength transmitted through for some kind of beam diagnostic, like a sample of that beam, while the other 95 per cent is reflected along with the higher reflectivity beam as well.’

When it comes to wavelengths, as Sam Thienel, technical sales engineer at Laser Components, explained: ‘A focus area at the moment is more complex mirror coatings, namely mirror coatings with multiple wavelength peaks and possibly multiple wavelength functions. There could be, for instance, a mirror with a specified wavelength or wavelength frame with incredibly high reflectivity, a wavelength with a partial reflectivity and a high transmission at another band as well. That could be over a broad wavelength range.

‘That becomes quite a complex coating structure with a number of layers, so this is where ion beam sputtering (IBS) technology really comes into its own. Because of the very high energy of the coating it produces very compact layers with low moisture. It very much reduces the volatility of the coating and eliminates any thermal drift or spectral changes with environmental conditions of the optic. We’ve put a lot of focus on higher-complexity mirror coatings, not just a single wavelength, or a single-wavelength band mirror,’ Thienel noted.

A different wavelength

One of the long-lead-time items that slows people down, according to Pajer, is the EUV optic – and Edmund has noted a move into a new wavelength, with 13.5nm. ‘This is way outside the range of wavelengths that Edmund traditionally works in,’ he said.

‘Additional research in that area came with the development of lithography. 13.5nm is the wavelength that has been chosen for the next generation of lithographic equipment, and that has spawned parasitic research industry and science at 13.5nm.

‘Even though people are doing research in areas other than lithography,’ Pajer continued, ‘they’re still using 13.5nm because there’s a lot of development and technology in that area. Our first offerings are mirrors at 13.5nm.’

Some of these areas outside lithography include imaging and micro-machining. ‘Those are probably the main areas,’ confirmed Pajer. ‘It’s also a connection to ultrafast technology, because some of the same sources using ultra dot pulse are used for EUV radiation. There is interest in other wavelengths and it’s worth exploring those as well, but the most demand at the moment is 13.5nm.’

Coating has also seen new developments
requests for particularly high-performance multiple mirrors. A customer will request and expect, for instance, a mirror with very high transmission at one wavelength, and a very high reflectivity at another.'

Another increased push is for higher laser damage thresholds. 'I imagine this will have been brought up a number of times, it is something that is at the forefront of a lot of people’s minds at the moment,’ he said. 'Likewise, with us, we are constantly developing new coating methods, and investing in testing and trialling of new coatings as well. We’ve recently done tests for nanosecond and femtosecond pulses for 355nm and 2µm and have achieved some promising results there.’

Thinking big
In terms of growth areas, Laser Components has seen a notable rise in demand for larger optical mirrors. ‘Fairly recently we have developed the ability to coat substrates to a maximum diameter of 390mm, and a lot of our focus has been on the development of significantly larger laser mirrors,’ he revealed.

Most of the applications for mirrors of this size usually fall under astronomy applications, and, more increasingly, defence applications.

Having a large mirror like that does present its own challenges, continued Thienel. ‘One of these would be getting a decent coating homogeneity over such a large area in the substrate, which is something we have had significant improvements on, and some very good feedback as well. Similarly, in such a large substrate, achieving a good flatness after coating is somewhat of a challenge, as well as being able to model and predict accurately what that flatness will be after applying a certain coating.’

When a coating is applied, it applies a stress across a surface of a substrate. That stress curls the substrate up at the edges, creating a distortion in the front of the mirror surface. ‘What you get is something called reflective wavefront distortion,’ he said.

‘For applications such as imaging or interferometry, you require a very flat wavefront from the reflective beam, and what you get is distortion in any kind of imaging application, if the flatness is compromised in any way. It is actually more critical in transmissive optics, such as windows, but certainly flatness for mirror-coated optics is important as well, so it’s something we’ve been focusing on.’

Direct approach
Crystalline Mirror Solutions has also witnessed the increasing trend for larger mirrors, as Garrett Cole, co-founder, explained: ‘The defence market seems to be really growing. This application demands very damage-tolerant optics, very low optical loss because the powers are extremely high, and we don’t want parasitic absorption or scatter – even a really tiny fraction of light getting scattered out. Optical loss, scatter absorption has to be low. This is mainly for US entry but I see it a little bit in Europe too.’

According to Cole, this market is still growing. ‘It’s the most common request we get now, and the other interesting area is continued development of space-based optics.

‘Now we have space qualification ongoing in Europe and the US and that’s another growing process. In general, it’s scaling the optics bigger and bigger, so we’ve made up to 200mm diameter demonstration parts and the target is to get to 400mm. That’s extremely challenging.’

On the flipside, one area previously predicted to experience high growth and not moving quite as quickly as anticipated is low-loss mid-infrared (IR) mirrors. ‘We have had a couple of customers come online,’ said Cole, ‘but the growth has been slower than we anticipated.’

The numbers game
This is largely attributed to numbers. ‘[Mid-IR components are] more expensive,’ stated Cole. ‘That always makes things a little more challenging, as cost in this space has a huge impact on the final decision to make the purchase, and there are not always high-quality optics out there. But they can be incredibly cheap because they’re made by evaporation – these very cheap manufacturing processes. Even if the performance isn’t great, they are just so low cost that it can be very hard to compete with. That has been an interesting development because everybody keeps touting that mid-IR is going to be the future, and there are some bright spots, but it is so much slower than everybody had hoped.’

Overall, however, said Cole, things seem positive. ‘We’re continuing to push the mid-IR. For us it’s more of a marketing issue, getting it out there as to why it is beneficial. Like I said, the growth is perhaps slower than I would like, but it is still growth.’

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The emphasis on low optical loss and scatter absorption is becoming increasingly important.

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The annual meeting of the Photonics Public Private Partnership (PPP) was held in Brussels on 27 and 28 March. The PPP is a joint effort between the European technology platform Photonics21 and the European Commission. EOS was represented at this meeting by its executive director, Elina Koistinen, and president elect, Gilles Pauliat.

The highlight of the meeting was the official announcement of the new multiannual strategic roadmap for 2021 to 2027 (available for download at www.photonics21.org). This roadmap gives specific focus points and priorities for funding. It links directly to Horizon Europe, the European Union’s ninth framework programme, covering the same period, until 2027.

Proposals for call topics have been discussed and now planned, and the Photonics21 community is working hard to maintain the priority status of photonics in new funding plans.

Optics and photonics societies meet
Several optics and photonics societies met on 3 February in San Francisco during the SPIE Photonics West congress. EOS, represented by Thomas Südmeyer, chair of the EOS scientific advisory committee, joined the meeting and discussions with the other key players in the field.

The societies discussed global issues around optics and photonics, and opportunities for co-operation. Three areas were identified for deeper collaboration between the societies:

- International Day of Light and outreach resources; anti-harassment policies; and national reports and initiatives.
- The issue of photonics being diluted in Europe was one of the discussion points, and a united message and communication will be created, joining forces worldwide to promote photonics as a key enabling technology. The societies will meet again in June and develop activities on the topics.

Upcoming EOS events

- **EOS Optical Technologies**, 24 to 26 June, Munich, Germany. Includes conferences on manufacturing, tolerancing, testing optical systems and optofluidics. Register by 31 May as early bird: www.conftool.com/wpc2019
- **EOS Topical Meeting on Diffractive Optics**: 16 to 19 September, Jena, Germany. Submit an abstract: www.conftool.com/do2019
- **Integrated Optics**: 26 to 28 November, Joensuu, Finland.
A team of engineers at Tufts University in the United States has produced a series of 3D-printed metamaterials with novel optical properties that cannot be produced using conventional processes. The technique has been used to create metamaterial embedded geometrical optics (MEGO) devices such as a moth-eye- like lens that can absorb electromagnetic signals from any direction at selected wavelengths, in addition to an optical parabolic mirror with both reflecting and filtering functionalities.

The research was released on 8 April in Microsystems & Nanoengineering, published by Springer Nature.

Metamaterials extend the capabilities of conventional materials in devices by making use of geometric features arranged in repeating patterns at scales smaller than the wavelengths of energy being detected or influenced. New developments in 3D printing technology are making it possible to create many more shapes and patterns of metamaterials, and at ever smaller scales. In the study, researchers at the Nano Lab at Tufts describe a hybrid fabrication approach using 3D printing, metal coating and etching to create metamaterials with complex geometries and novel functionalities for wavelengths in the microwave range.

For example, they developed devices such as parabolic reflectors that selectively absorb and transmit certain frequencies. Such concepts could simplify optical devices by combining the functions of reflection and filtering into one unit. “The ability to consolidate functions using metamaterials could be incredibly useful,” said Sameer Sonkusale, professor of electrical and computer engineering at Tufts University’s School of Engineering and corresponding author.

“It’s possible that we could use these materials to reduce the size of spectrometers and other optical measuring devices so they can be designed for portable field study.”

Combining 3D printing with metal-coating and wet-etching processes enables metamaterial geometrical optics with unique properties.
The geometry of a moth’s eye provides inspiration for a 3D-printed antenna that absorbs specific microwave frequencies from any direction.

The author of the study, ‘It’s possible that we could use these materials to reduce the size of spectrometers and other optical measuring devices so they can be designed for portable field study.’

The products of combining optical/electronic patterning with 3D fabrication of the underlying substrate are referred to by the authors as metamaterials embedded with geometric optics (MEGOs). Other shapes, sizes, and orientations of patterned 3D printing can be conceived to create MEGOs that absorb, enhance, reflect or bend waves in ways that would be difficult to achieve with conventional fabrication methods.

There are a number of technologies now available for 3D printing, and the current study uses stereolithography, which focuses light to polymerise photo-curable resins into the desired shapes. Other 3D printing technologies, such as two photon polymerisation, can provide printing resolution down to 200nm, which enables the fabrication of even finer metamaterials that can detect and manipulate electromagnetic signals of even smaller wavelengths – potentially including visible light.

‘The full potential of 3D printing for MEGOs has not yet been realised,’ said Aydin Sadeqi, graduate student in Sankusale’s lab at Tufts University School of Engineering and lead author of the study. ‘There is much more we can do with the current technology, and a vast potential as 3D printing inevitably evolves.’

Ophir Optronics Solutions has released chalcogenide glass coatings for high-performance IR athermal systems. Chalcogenide infrared glasses have increased in popularity recently as they enable simple athermal system design. Transparent in the infrared spectrum, these glasses are a mix of a few elements, close to the metalloid line in the periodic table. When shaped into optical components, finding appropriate optical coatings is challenging, as chalcogenide behaves differently than popular crystals. Lower T-glass causes the glass to lose its shape at a lower temperature, and thermal shock sensitivity is also limiting. The coating process temperature must be lowered, making it hard to achieve good adhesion and environmental durability.

Ophir Optronics Solutions has developed adhesion materials that hold the coatings to this special substrate. Laser Components now relies on online broadband monitoring during optical coating processes, and a diode spectrometer is used to monitor
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The Cronus combines a transmissive-grating based spectrophotometer with a tri-stimulus colorimeter. This unique combination offers both accurate spectral measurements and fast colorimeter measurements in one device. All devices are available in various optical configurations, varying from a fixed lens or cosine corrector, to fibre attached accessories. www.admesy.com/products-1

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coating layer thickness must be determined and met. Typically, there are three methods of monitoring this; measuring a witness sample, monitoring the behaviour of a quartz crystal, or simply using a timer. These methods are not sufficient to meet the growing demands on today’s laser optics.

Broadband monitoring is used in Laser Components’ IAD and IBS coatings. An empty hole in the substrate holder lets through unfiltered light from the BBM lamp, and an area without a hole gives a dark current. These reference values are compared with the incoming signal through a reference window, allowing the current layer thickness to be determined with an absolute accuracy of ±0.5nm.

Iridian designs and manufactures custom optical filter and coating solutions from 300nm to 10µm for applications including tele/datacom, spectroscopy, 3D cinema, sensing and detection, lidar, satellite earth observation and communications, astronomy, among others.

The company’s energetic sputtering coating technology and proprietary design, monitoring, and control software produces filters with high wavelength selectivity (single or multiple band-pass or notch filters, edge pass filters, and so on) to exacting quality standards for performance, durability, and reliability.

Crystalline Mirror Solutions (CMS) produces ultra-high reflectivity supermirrors made by substrate transfer and direct bonding. These semiconductor-based interference coatings set new standards for applications spanning defence, astronomy, and high power laser systems, and are employed in the world’s most stable interferometers for metrology, while providing significant performance advantages for laser machining and mid-infrared cavity-enhanced spectroscopy systems. EO
**PRODUCT UPDATE**

**LATEST PRODUCT UPDATE**

**LENSES AND OPTICS**

**Techspec multi-element tube system**

Edmund Optics’ new Techspec multi-element tube system is a highly-versatile optical system, with mix-and-match components, making it ideal for prototyping and creating uncommon optical designs. The Techspec multi-element tube system works by combining multi-element outer tubes with multi-element inner simple and pair optic mounts to create a complete system. The outer tubes have M29 threads running down their entire length; inner single and pair optic mounts have M29 threads along their outer diameters, allowing them to be placed anywhere on an outer tube. This design allows optical spacing to be infinitely adjustable along the optical axis. To ease adjustment, Edmund Optics thus introduced a custom-designed multi-element tube tensioner wrench, which has a hollow bore to allow a pass-through during adjustment. The system can be customised further by using multi-element spacer ring and spacer tubes to securely define optical spacing, multi-element inner aperture to control internal beam diameter, and additional multi-element tube system accessories to connect systems together, or expand systems’ capabilities. [www.edmundoptics.com](http://www.edmundoptics.com)

**SPECTROSCOPY**

**Spectrometer wavelength calibration sources**

Ocean Optics has released a new line of spectrometer wavelength calibration sources for convenient, reliable spectrometer calibration. The (-2) model series of calibration sources spans UV to NIR wavelengths, allowing users to maximise spectrometer performance and maintain the integrity of their results. Each wavelength calibration source has an embedded, rechargeable battery for use without an external power supply; offers remote on/off operation to avoid disturbing experiment setups; and uses indicator LEDs to provide quick confirmation of battery charge and lamp activation. Routine spectrometer wavelength calibration is essential to correct for baseline drift and other spectral phenomena inherent to all spectrometers. Each (-2) series model produces known atomic emission lines for performing spectrometer wavelength calibration.

Options include mercury-argon (253-1,700 nm), krypton (427-893nm), neon (540-754nm), argon (696-1,704nm) and xenon (916-1,984nm) gas-discharge emission sources. With more wavelength options and emission lines to utilise, users can more readily choose a source, or combination of sources, to match analytical wavelengths of interest in the measurement range. [www.oceanoptics.com](http://www.oceanoptics.com)

**NanoRam-1064 handheld Raman analyser**

B&W Tek has introduced the NanoRam-1064, a handheld Raman analyser for non-destructive identification of raw materials and the latest addition to the company’s handheld Raman product line. The NanoRam-1064 uses Raman technology for non-destructive identification and verification of raw materials such as APIs, intermediates and excipients. NanoRam-1064 can identify more samples as it minimises fluorescence, which makes it an ideal tool to identify coloured samples, natural products and to differentiate between different grades of cellulose, polysorbate and Opadry.

The handheld system has an intuitive workflow that can be operated by nontechnical users to expedite materials through incoming inspection including be it in the warehouse, loading dock, or lab. The NanoRam-1064 is operated using the NOS-1064 embedded software, which comes equipped with on-board method and library validation, on-board instrument calibration, library and method development and data storage/transfer. The software is paired with the NID EX software package, which is designed for use on PCs and allows end users to generate reports, review data and access the audit trail for instrument operations. [www.bwtek.com](http://www.bwtek.com)

**LEDS AND ILLUMINATION**

**NanoScanOP 400 nanospositioning piezo objective scanner**

The NanoScanOP 400 provides the fast step and settle time and incorporates capacitive feedback sensors, providing excellent positioning accuracy and resolution. Compatible with most microscopes and objective lenses, the system has settings optimised for different objective sizes, weights and performance requirements. The user simply selects the best setting for their application. Features of the system include: 400µm closed loop travel range (450µm open loop); connectors with built in stage calibration provide plug and play electronics, which can be interchanged, minimising system down times; made from stainless steel – providing greater mechanical stiffness (faster) and temperature stability (lowest drift); the stage is a flexure guided system – the friction-free flexures are designed to provide high stiffness and to minimise off axis motions, giving high repeatability and faster cycle times. Applications include: optical sectioning producing 3D images; autofocus systems for time-lapse imaging; high content screening; surface analysis; semiconductor wafer inspection; and scanning interferometry. [www.prior.com](http://www.prior.com)

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FiberLight L3 UV LED light source
Heraeus Noblelight has released FiberLight L3, a broadband UV LED light source module for analytical measurement instruments combing the benefits of LED technology with broadband UV spectral output.

Broadband spectral output is desirable for optical analytical instruments because it provides the flexibility to perform both qualitative and quantitative analysis with one instrument. FiberLight L3 will find immediate application in instruments used for environmental monitoring such as air and water quality, and soil monitoring, and also for protein purification.

OEMs, such as those manufacturing UV-spectrophotometers, flash chromatography can integrate the FiberLight L3 more easily into their analytical instruments due to its small form factor and lower optical setup costs. As a result, analytical instrument OEMs can develop new portable and handheld instruments more quickly and deliver their instruments to a broader range of customers.

The FiberLight L3 uses a single UV-LED chip and phosphors to produce the broadband output, overcoming many disadvantages of previous approaches that used multi-chip UV LED arrays.

FiberLight L3 provides broadband UV spectral output from 250 to 490nm and a lifetime of more than 5,000 hours. Power consumption is less than 1.5W with excellent optical stability. The module incorporates the optical fibre coupling and can operate in pulsing or continuous modes.

www.heraeus.com/
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**LASER SYSTEMS**

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Metasurface light steering to disrupt lidar market

A new lidar technology based on metamaterials has entered the field, offering higher reliability, lower cost and longer range.

Lumotive, a technology start-up funded by Microsoft founder Bill Gates, has introduced a beam-steering technology that it claims will significantly improve the performance, reliability and cost of lidar systems for the emerging self-driving car industry.

The start-up’s new system is based on liquid crystal metasurfaces (LCMs), which, according to Lumotive, gives unprecedented range, resolution and frame rate. The technology also benefits from the economics of semiconductor manufacturing to keep production costs down.

The system will initially be used to target the robo-taxi market, and will be available to select customers for beta testing in the third quarter of 2019.

Lidar, which measures the round-trip flight time of light pulses scattering from nearby objects to build up a map of its surroundings, has emerged as a key 3D sensing technology for autonomous driving systems. The technology can locate objects accurately to within a few inches at ranges of hundreds of yards.

Currently, most lidar systems rely on mechanical scanning, which Lumotive has said not only limits the performance of existing systems, but also suffers from poor reliability, cost and form factor. Past lidar solutions have included bulky spinning assemblies, while newer breeds make use of MEMS mirrors or optical phased arrays. Lumotive believe both of these recent approaches lack performance, because of the small optical aperture of MEMS mirrors and the low efficiency of phased arrays. In contrast, the start-up’s beam-steering technology uses liquid crystal metasurfaces, semiconductor chips that steer laser pulses based on the light-bending principles of metamaterials. This is a first for lidar, according to the firm.

‘The LCM chip is the holy grail of lidar, finally enabling beam steering using a semiconductor chip but efficiently and over a large optical aperture that’s hundreds of times larger than a MEMS mirror or an optical phased array,’ said Lumotive co-founder and CTO, Dr Gleb Akselrod. ‘Our large aperture is like having a bigger telescope, allowing us to see dramatically farther than other systems.’

The system’s optical aperture is 25 x 25mm, delivering long range. It also has a 120-degree field of view with high angular resolution and fast random-access beam steering, all with no moving parts.

‘Lumotive’s solution is ideal for automakers and tier-ones seeking safer, yet more cost-effective, perception solutions for their vehicles,’ commented Lumotive co-founder and CEO, Dr William Colleran. ‘LCMs deliver the combination of performance and commercial viability that will finally eliminate barriers to adoption of lidar for both ADAS and autonomous vehicles.’

In addition to its cost and performance advantages, Lumotive’s LCMs can be integrated into small form-factor systems, making it appealing for other applications in industrial and consumer sectors.

Professor David Smith, of Duke University in Durham, North Carolina, a pioneer in metamaterials research, said: ‘Lumotive’s beam-steering technology is the culmination of years of fundamental research into controlling electromagnetic waves using artificially structured metasurfaces. In the past, these concepts have been applied to radio waves, but Lumotive is the first to develop dynamically tunable metamaterials for optics. Their development is a tremendous advance in metamaterials research, as well as a breakthrough technology that addresses pressing and unmet needs in lidar and other optical systems.’

Market opportunity

Although lidar systems will enhance perception in diverse markets, including for robots, drones and industrial automation, most observers see lidar’s largest near-term application in automotive markets.

‘The lidar markets dedicated to advanced driver assistance systems and robotic car applications are showing significant growth between 2018 and 2024, from $721 million to $6.3 billion,’ said Dr Alexis Debray, technology and market analyst at market research firm Yole Développement. ‘At Yole, we estimate the CAGR will reach almost 45 per cent during this period. We expect strong growth of lidar in the transportation segment for both robotic vehicles and ADAS applications. A Gates-funded start-up like Lumotive, with unique metamaterials-based technology, is well-positioned to serve this growing market.’

The amount of investment in lidar is significant. Innoviz Technologies has recently raised $132 million in series C funding to accelerate production of its solid-state lidar, while semiconductor-based lidar firm Ouster raised $60 million in further funding. Innoviz’s new funding total now amounts to $214 million, while Ouster’s total amounts to $89 million. Both firms received awards at the Consumer Electronics Show at the start of the year.

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