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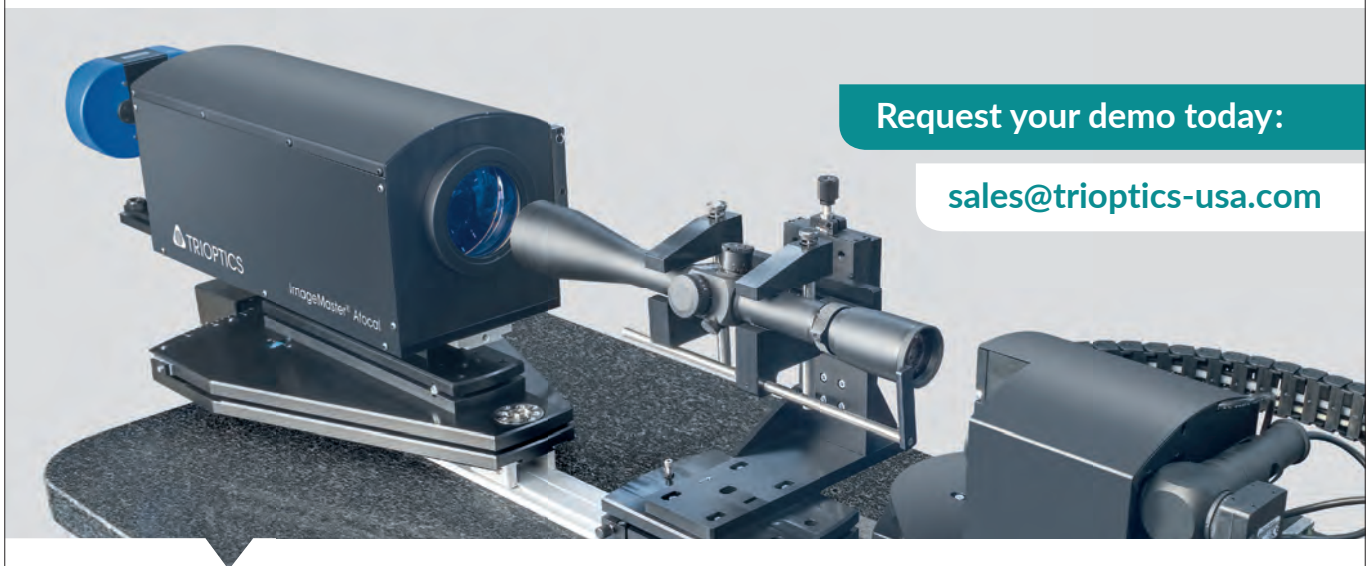
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# Lockheed backs optical interconnects with Ayar Labs investment

*Strategic funding intended to help accelerate commercialization of new high-speed photonic links.*

Ayar Labs, a Silicon Valley startup with the stated aim of “enabling the next phase of Moore’s law through optical connectivity”, says it has received strategic investment from the venture wing of the giant US military contractor Lockheed Martin.

Without disclosing the precise amount invested, Ayar said that the additional money will be used to accelerate the commercialization of its patented monolithic in-package optical I/O (MIPO) technology.

Aimed at applications demanding high bandwidth, low latency and power-efficient short reach interconnects, the target markets include artificial intelligence, high-performance computing, and digital beam-forming for radar.

## DARPA project spin-out

News of the Lockheed support comes after earlier investments by Intel Capital and the chip manufacturer Global Foundries. Ayar also lists Founders Fund and Playground Capital as investors, while last April it secured a \$3 million term loan from Silicon Valley Bank.

Set up in 2015, Ayar emerged from a decade-long collaboration between researchers at MIT, UC Berkeley, and Colorado University in Boulder, with funding from the US Defense Advanced Research Projects Agency (DARPA) via its “POEM” development effort.

Short for “photonically optimized embedded microprocessors”, its aim was to demonstrate photonic technologies that could be integrated within embedded microprocessors to provide seamless, energy-efficient, high-capacity communications within and between microprocessors and DRAM memory chips.

The abstract for the DARPA program stated: “It is envisioned that POEM technology will be especially useful to military platforms where extreme performance coupled with low size, weight, and power is a necessity (e.g. UAVs, and satellites).”

Via that program, what became Ayar Labs created technology that is said to overcome power/performance scaling challenges of

semiconductors, as well as the interconnect bandwidth bottleneck between devices.

## Vertical grating couplers

The company has previously described efforts to commercialize its “TeraPHY” optical I/O chiplets and “SuperNova” multi-wavelength lasers. A technical presentation from last August described the silicon photonics technology that forms the basis of Ayar’s approach, combined with evanescent coupling between adjacent waveguides.

TeraPHY also uses vertical grating couplers to get light on and off the chip, and couple it into optical fiber, and micro-ring modulators and detectors to convert data to and from the electrical and optical domains.

According to the same presentation, the compact size of those micro-ring devices, which are monolithically integrated with CMOS transistors, leads to large bandwidth density and high energy efficiency - with clocking, drivers, transimpedance amplifiers (TIAs), and control circuitry all integrated on same chip as the optical devices.

Back in 2015, the POEM development team reported in the journal *Nature* that they had built an electronic-photonics system on a single chip that integrated more than 70 million transistors and 850 photonic components to provide logic, memory, and interconnect functions.

Since then, the company has used that base technology in a number of engineering demonstrations, delivering a bandwidth density of more than 500 Gb/s per square millimeter of chiplet area.

It means that each TeraPHY chiplet - measuring less than 10 mm by 6 mm - can support ten tiny transceiver elements that couple directly to an optical fiber array, something that the company believes will offer a 1000-fold improvement in interconnect bandwidth density, alongside an order-of-magnitude reduction in power consumption.

The approach also supports the use of in-package optics, which Ayar says will “fundamentally break the traditional bandwidth-distance trade-off and

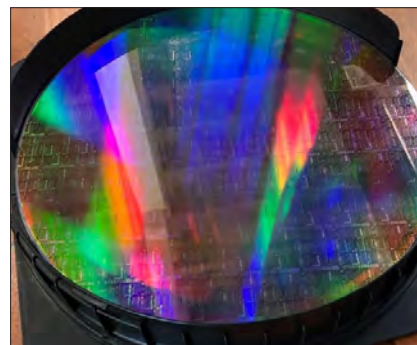


Photo: Ayar Labs.

*A wafer with fabricated “TeraPHY” chiplets: the Ayar Labs photonic interconnect technology is produced in collaboration with semiconductor giants Intel and GlobalFoundries.*

support new high-performance computer architectures”.

## Moving to market

Late last year the company indicated its move towards production scaling when it hired former Xilinx and Rambus senior engineer Ken Chang as its new senior VP of engineering. CEO Charles Wuischpard said at the time:

“Ken has decades of experience in bringing high speed I/O products to market as well as leading and growing world class engineering organizations. He joins Ayar Labs at a seminal moment as the industry prepares to transition to in-package optical I/O to meet growing workload demands and maintain Moore’s law scaling.”

Commenting on the new Lockheed support, Wuischpard added: “Working with key system integrators like Lockheed Martin, who really understand the value of our solution and how to design it into future complex systems, is incredibly important. In that sense, we view this relationship as more than funding alone, but as an important long-term working relationship as well.”

Chris Moran, executive director and general manager at Lockheed Martin Ventures, said: “We are very excited to add Ayar Labs to our investment portfolio and look forward to working with them and gaining access to their in-package optical interconnect that could provide business and technical value across our business units.”

Having publicly unveiled the TeraPHY chiplet technology at last year’s Supercomputing 2019 conference, Ayar says it is now working with select semiconductor manufacturers, OEM systems builders, and end users on sampling and co-design partnerships this year.

The technology is also being used in DARPA’s “Photonics in Package for Extreme Scalability” (PIPES) development project. Co-packaged with Intel’s electronics, the chiplets are being made by Global Foundries.

<https://optics.org/news/11/1/109>

# FLIR restructures again as commercial sales fall

**Thermal imaging giant also reports a jump in orders for coronavirus-related screening.**

FLIR Systems has embarked on another restructuring effort, after deciding to discontinue a number of its consumer product lines and to sell its "Raymarine" electronics business for maritime applications.

Those moves were revealed by company CEO Jim Cannon as he announced the Arlington-headquartered firm's latest financial results on February 27.

At \$489 million, sales in the closing quarter of 2019 were up 9 per cent year-on-year - although that increase was entirely due to recent acquisitions including the likes of New England Optical Systems, Aeryon Labs, and Endeavor Robotics.

The latter two acquisitions contributed to a 23 per cent year-on-year jump for quarterly sales into government and military applications, which stood at \$211 million.

## Commercial consolidation

In contrast, FLIR's commercial business unit saw its quarterly sales shrink by more than 10 per cent, to \$85.5 million. Although FLIR's total sales rose 6 per cent to \$1.88

billion in 2019, the annual figure for the commercial division was also down 10 per cent, and Cannon's latest restructuring plan will see it consolidated within FLIR's industrial business unit.

"These actions to simplify and reshape the company's product portfolio and organizational structure will support its efforts to focus on key strategic priorities, improve operational efficiencies, and position FLIR for long-term, sustainable growth," stated the firm.

Describing 2020 as a "year of evolution" for the company, the CEO told an investor conference call that he had initiated a new cost-reduction and portfolio rationalization scheme called "Project Be Ready".

US Army veteran Cannon, who introduced the concept of the "FLIR Method" shortly after taking the helm at the company back in 2017, added during the conference call:

"Project Be Ready aims to reduce costs and simplify our product portfolio to better align our resources with higher growth opportunities." With regard to the Raymarine division, which is focused on

maritime electronics rather than thermal imaging, Cannon said that FLIR was already engaged with several prospective buyers of the business.

## ADAS and temperature screening

Alongside a growing focus on unmanned aerial vehicle sensing, FLIR is aiming to strengthen its position as a critical supplier of sensors for advanced driver assistance systems (ADAS) and future autonomous vehicles.

Cannon pointed to recent developments including a deal with major auto parts supplier Veoneer to provide thermal cores for "Level 4" autonomous vehicles, and thermal cameras for new robotaxis, as evidence of FLIR's growing influence in the high-profile field.

"We expect ADAS-fueled technology such as thermal-augmented autonomous emergency braking to be integrated as a standard safety feature in the future," added the CEO. "Key to our ADAS success is FLIR's more than 15 years of automotive experience - and the fact that we can claim the only automotive-qualified thermal sensor that's been deployed on over 700,000 vehicles today."

Aside from that, FLIR also witnessed a boost in demand for its thermal imaging equipment for firefighting applications in Australia in late 2019, while more recently the outbreak of the Covid-19 virus has prompted a strong uptick in orders for screening body temperatures.

"We are proud that FLIR thermal imaging cameras are one of the tools being used in Asia as the first step to help indicate higher-than-average skin surface temperatures a key symptom of the coronavirus," noted FLIR's CFO Carole Lowe, while stressing that thermal imaging kit is not able to detect or diagnose an infection.

"We have sold cameras since the early 2000s for performing temperature screening relating to several widespread viruses such as SARS, avian bird flu, and others," she added.

• Following the February 27 financial update, FLIR's stock price slumped by around 20 per cent on the Nasdaq. Despite the coronavirus-related volatility currently afflicting Wall Street, the company's valuation has remained steady since then, and after closing at just over \$45 on March 3, the stock price translated to a market capitalization in the region of \$5.5 billion.

<https://optics.org/news/11/1/94>



Photo: FLIR Systems.

In February FLIR released its new "A8580" series of thermal imaging cameras for scientific applications. The company says that the 1.3 megapixel, entry-level cooled camera is aimed at a wide range of industrial, military, science, and product research and development applications. The product series includes four mid-wave infrared (MWIR) models and a long-wave (LWIR) version, as well as compatibility with a telephoto lens.

# Koito invests \$50M in lidar firm Cepton

Top-tier provider of car parts wants to develop headlamps with built-in lidar sensors.

Silicon Valley lidar firm Cepton Technologies says that it expects this year to be a “transformational” one, thanks to a new \$50 million injection of funding that should enable it to ramp up development activity.

One of dozens of competing players looking to benefit from the auto industry’s desire to use advanced sensor technology in vehicles for driver assistance and, eventually, autonomous driving, the company has attracted the bulk of the funding from the Japanese car parts giant Koito.

While Cepton says that other investors took part in what it has designated to be a series C funding round, Tokyo-listed Koito announced that it had made a \$50 million investment.

“This brings Cepton’s total funding to nearly \$100 million, providing a strong foundation to substantially ramp up its research and development efforts, expand its footprint in the automotive market, and support major customers worldwide,” noted the San Jose firm, adding that Koito will obtain non-exclusive rights to manufacture and sell Cepton’s lidar sensor design for an automotive application, using key components supplied by Cepton.

## Lidar for ADAS

Cepton says it will use the proceeds to accelerate development and deployment of its advanced lidar technology in ADAS (advanced driver assistance systems) applications, as well as for autonomous vehicles, and other fast-growing areas such as smart cities, intelligent transportation systems, and security.

“For ADAS and autonomous driving vehicles, high-accuracy sensors such as lidar sensors, cameras, and millimeter-wave radars are essential to monitor surroundings,” pointed out Koito in its own release announcing the deal. “Along with development of lighting technologies to support driver and mechanical visibility, Koito is working to develop various sensors.”

Its \$50 million Cepton stake represents one of those efforts, with the Japanese firm pointing to long-range sensor capability and a wide field of view as two of the key selling points of the technology.

While Cepton has not revealed specific



Cepton’s “Heliu” product is said to combine the San Jose firm’s lidar technology with edge computing and groundbreaking perception software to provide real-time object detection, tracking, classification and more.

Image: Cepton Technologies.

details of that technology, it does say that the scanning techniques employed are different from conventional ones that rely on mechanical rotation or scanning mirrors.

A patent application from 2016 assigned to Cepton that names co-founder and CEO Jun Pei as one of the inventors suggests that the approach uses laser pulses and is based on time-of-flight (ToF) technology.

## All-chip FMCW lidar

Although the ToF approach is generally able to take advantage of existing and relatively low-cost optics and photonics technologies, several companies are now working on coherent optical systems that instead deploy frequency-modulated continuous-wave (FMCW) light.

FMCW is more complex from a component point of view - for example demanding an extremely narrow-linewidth laser source - but its proponents believe that it offers a far superior performance compared with ToF.

One of those proponents is Intel, some of whose developmental work was detailed in a presentation at February’s SPIE Photonics West event in San Francisco.

Speaking during a conference on silicon photonics technologies, Jonathan Doylend from the Santa Clara chip giant explained that by using a frequency-chirped laser signal it was possible to generate direct velocity measurements thanks to the Doppler effect.

Doylend pointed out that, unlike ToF systems, it means the FMCW approach allows immediate discrimination between stationary and moving objects, and can tell which direction those objects are moving in. “That’s the big motivation for FMCW lidar,” he added.

## Hybrid laser

Doylend told delegates that by building on the advances made in silicon photonics for optical communications, Intel was working to combine its hybrid indium phosphide-silicon laser technology with a variety of photonic components including amplifiers and beam splitters, in a bid to develop an all-chip FMCW lidar system suitable for mass production and integration with cars.

Other companies known to be working on the FMCW approach include the Bozeman, Montana, firm Blackmore, which was acquired by Amazon affiliate Aurora Innovations last year, as well as Insight Lidar, a subsidiary of Insight Photonic Solutions inspired by the company’s earlier work in optical coherence tomography (OCT), plus the Californian startups SiLC Technologies and Aeva, and Australia’s Baraja.

Meanwhile Pei is hopeful that the latest investment from Koito will prove to be a game-changer for his company.

“Since Cepton was founded in 2016, we have made great strides in advancing the state-of-the-art in lidar technology and bringing the benefits of lidar-based solutions to a variety of markets,” he claimed.

“With this latest investment round, the year 2020 is poised to be truly transformational for Cepton’s future. Combining Koito’s world leadership in automotive lighting and their world-class quality, reliability and manufacturing with Cepton’s award-winning lidar solutions presents a tremendous opportunity to make deep inroads into the automotive market.”

<https://optics.org/news/11/1/61>

# Lumentum predicts further growth in 3D sensing

Quarterly revenue rise driven by telecoms but company expects to take a hit from coronavirus disruption.

Lumentum reported improved results for the second quarter of fiscal 2020, although the effects of the coronavirus outbreak in Asia are expected to negatively impact revenues in the current Q3.

Net GAAP revenue for Q2 was \$457.8 million, up slightly from \$449.9 million in the preceding quarter and also up from \$373.7 million for the equivalent quarter of fiscal 2019.

"The themes of the prior quarter - strong customer demand, an improving financial model due to increasing levels of new and innovative products and increasing scale and acquisition synergies - drove new record revenue, gross margin and operating margin in the second quarter," said Alan Lowe, President and CEO.

"Adding to these themes in calendar year 2020, we are seeing telecom transport demand strengthening, and we expect a strong expansion of the market for world-facing 3D sensing lasers."

The largest driver of sequential and

year-over-year growth was telecom and datacom products, while quarterly revenue from the company's lasers business was \$48.4 million, almost unchanged from one year ago and up from \$33.8 million in Q1. Lumentum commented that it had now repaid in full the term loan that it took on in connection with the acquisition of Oclaro in 2018.

Speaking to analysts, Lowe confirmed that Lumentum foresees growth for 3D sensing lasers in smartphones for biometric security purposes, with similar technology likely to make its way into other sectors too.

"We expect 3D sensing to be incorporated in more consumer products in both user and world-facing applications, including computational photography and augmented and virtual reality," he said. "Our R&D teams are working with a broad range of customers on their future generations of 3D sensing needs, including new products coming later this year and next, as well as for

products several years away. We are well-positioned to grow in this market."

## Coronavirus affecting quarterly guidance

Lowe also highlighted Lumentum's PicoBlade 3 ultrafast laser for micro-machining applications, addressing OLED display processing, 5G antenna fabrication, and advanced via hole drilling and printed circuit boards. "These applications are all expected to see significant market growth in the coming years," he commented.

Events in China were a constant topic of the conversation with analysts, however. In May 2019 Lumentum halted shipments to Huawei Technologies, one of the first American companies to align with export restrictions imposed by the US government, although as Lowe noted Huawei are a major smartphone supplier and therefore a major customer for 3D sensing lasers. Huawei's involvement in the UK's forthcoming 5G telecoms network is a further topic of current political discussion.

"Given our footprint in the customer base we are largely agnostic to which of our customers wins business," commented Christopher Coldren, Lumentum SVP. "If Huawei is restricted to a more limited portion of the UK network, we don't believe this is a significant change for us. In terms of understanding what the US government is going to do, I don't think we have any more insight that what you can read in the general news."

The ongoing coronavirus outbreak across the Asia region will have a more immediate impact on the company, Lowe confirmed. The company currently employs around 1000 people in China, in addition to maintaining a manufacturing facility in Thailand.

"Our guidance for the coming Q3 incorporates a \$15 million to \$20 million reduction in revenue at the midpoint due to the anticipated impacts of the coronavirus outbreak," said CFO Wajid Ali. "The coronavirus situation is fluid and evolving."

Shares in Lumentum rose by 11 percent immediately after the earnings announcement.



Credit: Lumentum.

Lumentum's micro-machining platform is used in OLED display processing and 5G antenna manufacture.

<https://optics.org/news/11/1/51>

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# Mitsubishi Electric targets auto lidar with large MEMS mirror

Future development expected to result in a vertical scanning angle exceeding 25 degrees.

Japanese technology giant Mitsubishi Electric says it has developed a compact lidar system aimed at use in future autonomous vehicles.

The Tokyo firm claims that its selection of an optical MEMS-based approach achieves an extra-wide horizontal scanning angle that can detect the shapes and distances of objects ahead of a self-driving vehicle.

"The new lidar solution irradiates objects by laser and uses a dual-axis (horizontal and vertical) MEMS mirror to scan for the reflected light, generating three-dimensional images of vehicles and pedestrians," it announced. "Mitsubishi Electric expects this compact, low-cost solution to contribute to the realization of safe, secure autonomous driving."

Because it relies on collecting pulses of reflected laser light to map the surroundings of a moving vehicle, one of the requirements is to maximize light collection. The Mitsubishi team has chosen to do that by using a MEMS mirror with a large surface area.

On top of that, a wide scanning angle is needed for accurate monitoring of the vehicle's periphery. In response, Mitsubishi Electric says its approach incorporates what is claimed to be the industry's largest electromagnetic MEMS mirror, measuring 7 mm by 5 mm.

## Reduced system weight

Counter-intuitively, that relatively large MEMS component is said to be based on a unique structure that reduces the overall weight of the system, but without sacrificing rigidity.

"The lightweight design and high electromagnetically generated driving force allows the mirror to achieve large horizontal movement of  $\pm 15$  degrees," states the firm. "Vertical movement is currently  $\pm 3.4$  degrees, and Mitsubishi

Electric aims to increase this to  $\pm 6.0$  degrees or more by improving the beam structure of the MEMS."

Mitsubishi Electric adds that the key component can be manufactured in large quantities on a silicon substrate, using conventional semiconductor processing technology. Comprising fewer parts compared with lidar mirrors driven mechanically, it should also be more durable than older approaches to lidar.



Image: Mitsubishi Electric.

*Mitsubishi's MEMS lidar is based around a relatively large mirror, which the company says helps to reduce the overall size and weight of the full system. It is looking to shrink the size by another factor of three, as well as improve the vertical scanning capability.*

Among the optics-related technological features of the approach is the use of multiple laser light sources, photodetectors and lenses. This helps to suppress optical vignetting, and also means that the laser beam is not distorted by any of the system's internal components, explains Mitsubishi Electric.

While the current design's optical transmission and reception mechanism already yield a wide horizontal scanning angle, the company's development team is expecting to achieve a vertical scanning angle exceeding 25 degrees in the future. If this effort is successful, it would allow a single lidar to "see" vehicles and pedestrians in much

closer proximity than is possible with conventional approaches.

The team is also looking to shrink the size of the system. Currently occupying a volume of just under a liter, which the company attributes to "optimal arrangement" of its signal processing circuitry, power supply circuit, and optical transmission/reception mechanism, the aim is to reduce that size to just 350 cm<sup>3</sup>, or less.

## Race for the prize

Along with scores of other companies, Mitsubishi Electric is looking to establish itself in a market that analyst IDTechX reckons will be worth \$5.4 billion by 2030.

In its October 2019 report IDTechX identified 34 automotive lidar companies in Asia (including no fewer than 20 startups in China alone), alongside 19 in Europe, and 48 in North America. As yet, there has been little to no shake-out of those competitors, but by 2030 it is inevitable that only a few will remain as the market matures and consolidates.

That consolidation will revolve around which of the lidar technology options wins out in the end. In recent months developers of coherent lidar systems, which rely on a frequency-modulated continuous-wave (FMCW) regime rather than the more conventional pulsed approach, have attracted more attention and funding.

Though much more technologically demanding than pulsed time-of-flight systems, coherent lidar would be analogous to the way that existing radar systems work. It also offers the potential for chip-sized systems capable of long-range operation and the ability to use Doppler effects for directional sensing, and Intel is known to be working on this approach.

In its report, IDTechEx identified four important technology choices that every lidar player and lidar user must make, namely the measurement process (i.e. time-of-flight or continuous-wave), as well as the specific laser, beam steering mechanism, and photodetector deployed.

"The beam steering mechanism is the most complicated and critical choice," it concluded.

<https://optics.org/news/11/1/114>



# Lumibird postpones growth target on lidar delays

€150M annual turnover now expected by French photonics firm to be achieved in 2022, a year later than planned.

Lumibird, the Paris-listed developer of lasers and other photonics products, says its sales rose by just over 9 per cent from 2018 to 2019 - with revenues from lidar showing the fastest rate of growth.

But the company is now warning that delays to orders from some of its larger lidar customers will put the brakes on prior expectations of organic sales growth.

## Innovation strategy

Thanks to a strong closing quarter to last year, bolstered by defense-related sales, the company was able to post annual revenues of €110 million - up from €100.9 million last year.

Lumibird's laser division accounted for €70.8 million of the 2019 total, a 5.5 per cent rise on the prior year. Sales of lidar sensors fueled that uptick, jumping 33 per cent year-on-year to €20.5 million thanks to rising demand from customers in the automotive and wind power sectors.

The remainder of Lumibird's revenues are generated by its medical division, which reported a 17 per cent jump in annual sales, to €39.3 million.

"These figures confirm the success of the innovation strategy, with its new products receiving a very positive response, on both established and new markets, such as dry eyes," announced Lumibird. "In addition, the medical division is extending its geographical footprint, notably through the opening of a subsidiary in Poland."

The upward trajectory should continue this year, thanks in part to Lumibird's planned acquisition of Australia's Ellex Medical Lasers, and the addition of Slovenian firm Oportek last August.

"Ellex's laser and ultrasound business represented around €40 million in revenues last year, and if its acquisition is completed as planned during the first half of this year, the medical division is expected to more than double its level of business in 2020," stated the firm.

## Lidar delays

However, Lumibird now says it is unlikely to meet its existing target to grow organic sales - not including recent acquisitions - to €150 million in 2021. "The objective...could be postponed by a year given the order plan delays among large lidar customers," warned the Lannion-headquartered firm.

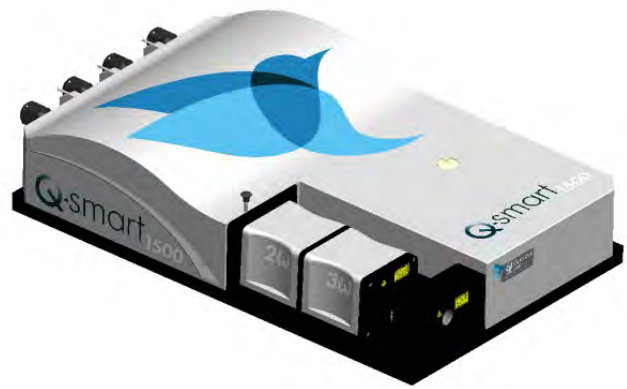


Image: Lumibird

In January, Lumibird released two new high-energy flashlamp-pumped Nd:YAG lasers. The "Q-smart" 1200 and 1500 models deliver up to 1.5J at 1064nm.

While Lumibird does not now expect to hit the €150 million target until 2022, it should still achieve planned profitability targets of 20 per cent earnings before interest, depreciation and amortization (EBITDA) in 2021. For comparison, EBITDA in 2018 was just over 16 per cent.

- Lumibird's stock price slipped in value slightly on news of the delayed growth target. Currently trading at around €12.40 on the Paris exchange, the company commands a market capitalization of just under €230 million. The firm will announce its full financial results for 2019, including profitability figures, after the close of trading on March 31.

<https://optics.org/news/11/1/38>

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# OmniVision and Artilux collaborate on 3D infrared sensors

Adoption of germanium-on-silicon light absorption layer extends sensing range to 1550 nm for higher performance.

The giant image sensor vendor OmniVision is collaborating with the Taiwan-based 3D imaging specialist Artilux on new devices that promise improved performance in the near-infrared spectrum.

Fabricated with a germanium-on-silicon (GeSi) light absorption layer, the Artilux sensors are able to detect out to 1550 nm in the near-infrared spectrum - meaning that 3D sensing solutions can take advantage of eye safety regulations that permit the use of more powerful light sources than at shorter wavelengths.

The two companies say that the main objective of the new collaboration is to combine that GeSi technology with OmniVision's more conventional CMOS approach for applications in mobile phones and beyond.

"The new product offerings will not only cover the mainstream light sensing spectrum from visible light to 850nm/940nm, but will further extend to 1350nm/1550nm, which can provide a superior outdoor experience and improved eye safety for multiple growing digital imaging market segments," announced the pair.

## ToF depth sensing

Zhubei City-headquartered Artilux unveiled the technology in the form of its Explore Series product at the Consumer Electronics Show (CES) in Las Vegas earlier this month, describing it as "the world's first wide-spectrum 3D time-of-flight (ToF) sensor based on GeSi photonic innovation".

Operating at the longer near-infrared wavelengths is regarded as being ten times safer than at the conventional 940 nm, while also offering better sensing accuracy and performance under sunlight.

However, the usual trade-off is that laser emitters at these longer wavelengths are much more difficult to produce. They must be fabricated using indium phosphide (InP) semiconductor material, rather than the more developed gallium arsenide (GaAs) - and are therefore significantly more expensive to make.

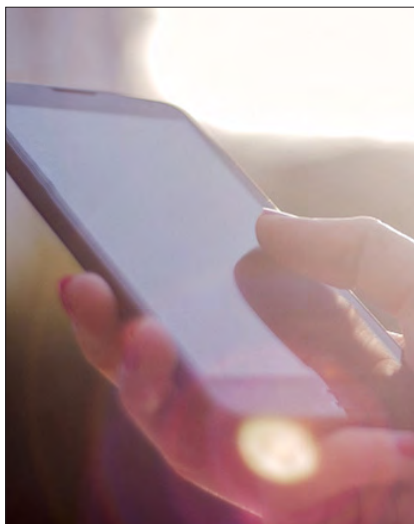


Photo: Artilux.

*The combination of Artilux's GeSi-on-CMOS approach to imaging and depth sensing with OmniVision's global scale promises to bring the novel technology into smart phones and other devices.*

At CES, Artilux demonstrated a color depth-sensing camera for logistics applications and robot vision, as well as a 3D camera able to operate at the longer wavelength.

"The sensor is projected to enter mass production in Q1 2020 and targets applications that will benefit from the improved 3D sensing performance such as mobile devices, automotive lidar, and machine vision," announced the company.

## Eye safety

Artilux also referenced recent work by its internal research team concluding that when the GeSi pixel is operated at the longer near-IR wavelength, it is "substantially safer" than at 940 nm, thus allowing the use of a much higher laser power but still in compliance with laser safety regulations.

The company claims that means ten times more laser power can be deployed safely at 1200-1400 nm than at 940 nm.

Its research team, whose devices were produced by foundry partner Taiwan Semiconductor Manufacturing Company (TSMC), added: "The system performance comparison between a silicon pixel and a GeSi pixel at 940 nm indicates that the

GeSi features lower depth errors compared to the silicon pixel in both indoor and outdoor scenarios."

By adopting both the longer wavelength and new algorithms, Artilux claims to have "redefined" the performance of 3D sensing, and overcome an industry bottleneck with an approach it believes will fundamentally transform 3D sensing technology and applications.

Coupling the GeSi layer with a CMOS process, the company said last summer that the technology delivered a quantum efficiency of 70 per cent at 940 nm, and of 50 per cent at 1550 nm.

That is combined with a modulation frequency of 300 MHz or more, with Artilux insisting that the approach is ready for mass production at an affordable price.



Photo: Artilux.

*Captured in the 1200-1400 nm wavelength range with Artilux's technology, this point-cloud shows the potential for better depth sensing and facial recognition, compared with the more conventional 940 nm operation.*

According to a LinkedIn profile, Artilux co-founder and CEO Erik Chen previously worked at both TSMC and Intel, and completed a PhD at Stanford University before setting up Artilux in 2014.

California-headquartered OmniVision is one of the world's largest providers of cameras and sensor devices used in consumer electronics, automotive, medical, and various other applications. In early 2016, the company was acquired by a consortium of Chinese investors led by Hua Capital Management.

<https://optics.org/news/11/1/33>

# Hyperspectral satellite data to get wireless optical links

BridgeComm says its global network of optical ground stations will be used to transmit imagery from HySpecIQ low-Earth orbit constellation.

From 2022, a pair of satellites with hyperspectral imaging capability should be transmitting data back to ground stations on Earth via a wireless optical network.

The ambitious partnership between the US firms BridgeComm and HySpecIQ, announced March 10, is expected to see the combination of two optics and photonics technologies bring a new level of data provision to applications in environmental intelligence, national security, natural resources, agriculture, insurance, and risk management.

Founded in 2015, HySpecIQ has so far used airborne platforms, but in 2022 is due to launch two hyperspectral satellites that will be capable of collecting data across 105 wavelength bands. Ordered from Boeing, the two 502 Phoenix satellites will make it the first commercial provider of high-resolution hyperspectral information from space.

## Terahertz technology

Meanwhile, BridgeComm is building a global network of optical ground stations designed to support complementary fixed and mobile terminals to provide high-bandwidth, high-security communications links.

Its technology is based on point-to-point data transmission using infrared lasers that connect between telescopes, with the company saying that the links operate in the terahertz spectrum.

BridgeComm recently agreed a deal with the French light-beam shaping specialist Cailabs to improve the reliability of the optical links in atmospheric turbulence - traditionally the weakness of this approach.

It has also been working with Boeing's "HorizonX" team to develop optical wireless systems with bi-directional mesh connectivity similar to that found in RF links.

"[The technology] is capable of supporting terrestrial, airborne and space systems that require 10-100+ Gbps throughput, as well as the high reliability and redundancy



Image: LeoSat Enterprises.

inherent in mesh architecture," claimed BridgeComm in January.

**Reconnaissance contract**

Last September, HySpecIQ was awarded an imagery contract by the US National Reconnaissance Office (NRO) - the first of its kind to a commercial entity in the hyperspectral field.

"HySpecIQ is developing interesting new hyperspectral imaging capabilities that have the potential to contribute to our current and future overhead architecture," said Pete Muend, director of the NRO's Commercial Systems Program Office, at the time.

According to a paper presented during SPIE's Defense, Security, and Sensing event

in 2015, the HySpecIQ system has two key elements, and combines satellite sensors with "multimodal interpretation" (MMI) processing capabilities that can generate highly specific sets of information that can be sold as products.

In order to overcome some of the historical limitations of hyperspectral imaging, and to fully realize the market potential of the data that will be collected, the approach will look to the use of upstream data fusion for contextual accumulation of data for specific needs.

The company had originally envisaged launching the hyperspectral constellation in 2018.

<https://optics.org/news/11/1/115>

# PW2020: DARPA seeking close cooperation with photonics sector

Proposed military-grade quantum sensors will require at least four lasers to address various quantum states.

By Ford Burkhart in San Francisco

Integrating quantum sensors will require plenty of help from the photonics community, a top DARPA researcher said in a presentation at Photonics West in San Francisco, In February. The US Defense Advanced Research Projects Agency (DARPA) is an agency of the US Department of Defense responsible for the development of technologies for military use.

Some devices cited by John Burke, of DARPA's Microsystems Technology Office, would help PC-toting warfighters of the future, like technology from AMBIENT (Atomic Magnetometer for Biological Imaging in Earth's Native Terrain). As an example, Burke cited the intrinsic magnetic gradiometer.

He was a keynote speaker at Photonics West's Quantum Sensors and Photonic



Image: DARPA.

DARPA's Dr. John Burke, Microsystems Technology Office (MTO) Program Manager. Dr. John Burke joined DARPA as a Program Manager in the Microsystems Technology Office (MTO) in August 2017. His research interests include the development of high-stability, low-noise sensors and frequency synthesis to enable new positioning, navigation, and timing (PNT) and remote detection capabilities. He is particularly interested in the integration of modern atomic physics techniques (e.g. laser cooling and trapping) with photonic circuits and atom chips to reduce the complexity, cost, and size of these techniques while increasing their robustness and reliability for use outside of a laboratory environment. Dr. Burke is currently on detail from the Air Force Research Laboratory (AFRL) Space Vehicles Directorate at Kirtland Air Force Base, New Mexico where he was a Senior Research Physicist. Dr. Burke led a research team developing atomic clocks, optical time transfer, and cold atom measurement techniques for use in space applications such as the Global Positioning System (GPS). The AFRL optical atomic clock uses a frequency comb, stable laser, and atomic vapor cell to generate a frequency tone that enables GPS satellite clocks to be accurate to nanosecond levels for long periods of time. Dr. Burke also led the Air Force's contribution to the NASA Cold Atom Laboratory for the International Space Station (ISS), and optical time transfer development under two defense programs. Dr. Burke won the AFRL Early Career Award and Senior Leadership Award.

Systems conference, held in February at the Moscone Center.

Field sensors of tomorrow will be able to use geodesy and quantum information to calculate, for example, how much water California is using at any given time. "The hardest part involves the lasers



Image: DARPA.

Field sensors of tomorrow will be able to use geodesy and quantum information.

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## PW2020: DARPA seeking close cooperation with photonics sector

and detection techniques, and those are photonics systems basically," Burke said.

"Quantum information is the most exciting part," he added.

### Quantum sensing

A quantum sensor, he explained, is basically a box receiving excitation energy from an external field, with qubit controls to provide output.

"How to achieve that is the question," he said.

New quantum sensors will make use of four-plus lasers to address various quantum states to a high degree of accuracy. The challenge for DARPA, Burke said, is "how to make things smaller. So far, we have been successful in doing so."

"We've got the device size down to a fraction of a liter, and that will be useful in the real world." The breakthroughs, he said, have enabled creation of an integrated photonic chip that works.

"You can't buy this yet," he said, "but we are approaching criticality. We are getting close. And that is mostly due to integrated photonics really."

The DARPA program called A-Phi provides "the vision for how to shrink it down," Burke said. "It is still nascent right now, but we are improving all the time."

The components, including trapped ion qubits, "are very fragile, and hard to work with," he said. And DARPA has "a stack of things to get right – the physics, the photonic interface, sources, systems, electronics".

Some solutions are "years away," Burke said, "but it's all doable."

The goal of the program called ACES is all about miniaturizing more mature atomic clocks.

Burke cited work on atomic photonic integration at several sites, including

the University of Arizona, which is working with Honeywell and U.C. Santa Barbara on components to trap and cool strontium atoms. Other work is unfolding at the University of Colorado – Boulder, at NIST, Caltech and Yale. "There are a lot of people working in this group," Burke said.

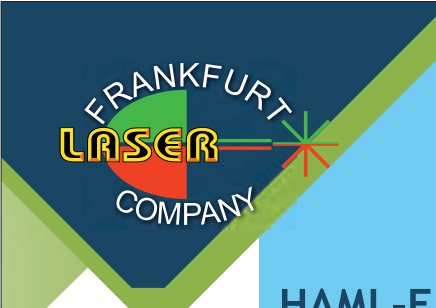
Sandia in New Mexico and the Lincoln Lab at M.I.T. are working on relating issues with ions.

The future integrated photonics chip, he said, is now "pretty large," roughly more than a few centimeters square, looking a bit like a small mousetrap, with a metamaterial chip on top.

"There's a lot going on here," Burke said.

"We need help with lots of issues, with frequency sources, frequency control elements. Everything has to be exact to many digits. We need agility, and amplitude control. This gives you a sense of the photonics we need to make this go."

<https://optics.org/news/11/1/63>



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# WFIRST space telescope ready for construction phase

**\$3.2BN follow-up to James Webb Space Telescope still faces funding hurdle, with Trump administration again requesting termination.**

NASA has announced that the next major space telescope project it wants to launch after the much-delayed James Webb Space Telescope (JWST) is ready to move into the construction phase.

The Wide-Field Infrared Space Telescope (WFIRST), currently slated for launch in the mid-2020s, is said by the agency to have passed a "critical programmatic and technical milestone", meaning that hardware development and testing can now begin.

Although the diameter of its primary mirror will only be the same size as that of Hubble Space Telescope, WFIRST's optical system will boast a field of view 100 times that of its predecessor.

As a result, NASA says WFIRST would be able to observe the entire Andromeda galaxy in just three hours. For comparison, Hubble took around 650 hours to image about half of the same galaxy.

## Future funding

During a five-year mission with a possible five-year extension, WFIRST is expected to investigate light from more than a billion galaxies, as well as perform a microlensing survey of the inner Milky Way to locate thousands of exoplanets.

"With the passage of this latest key milestone, the team will begin finalizing the WFIRST mission design by building engineering test units and models to ensure the design will hold up under the extreme conditions during launch and while in space," said the space agency.

However, the project's future remains

in the balance. WFIRST has funding committed through September 2020, but last month the Trump administration's budget request for fiscal year 2021 called for WFIRST support to be terminated.

In fact for the current fiscal year, the presidential request for WFIRST had also been zero - but Congress subsequently

stepped in with more than \$500 million to keep the project on track for a 2025 launch date.

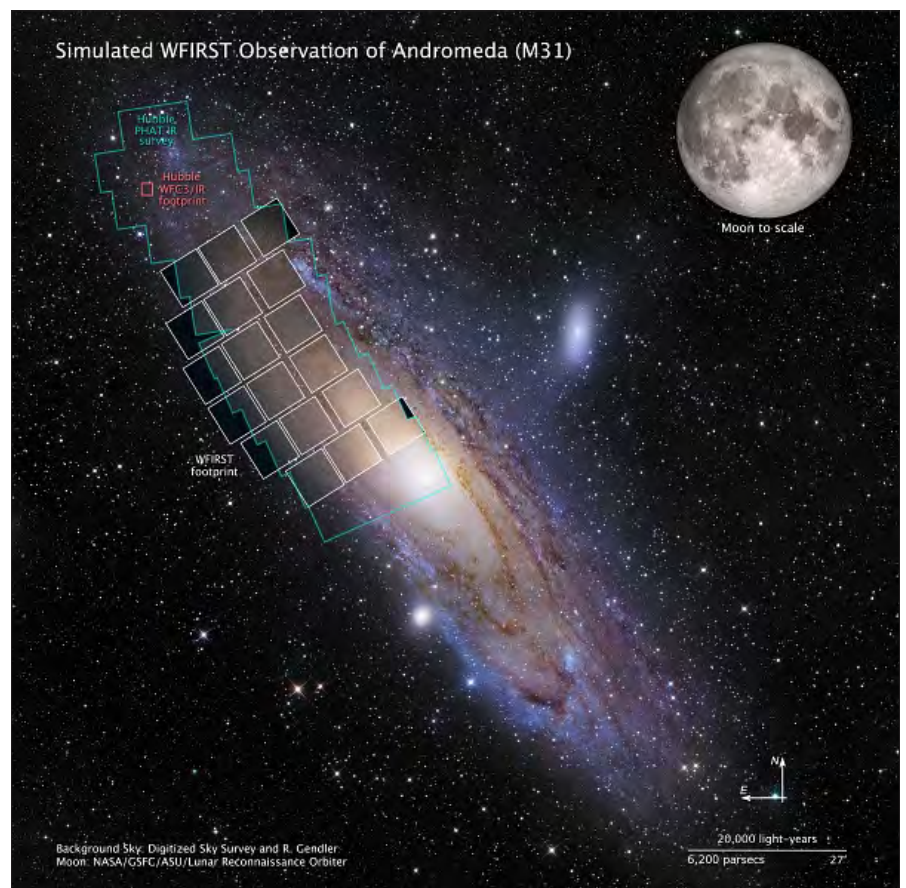
"The FY2021 budget request proposes to terminate funding for the WFIRST mission and focus on the completion of [JWST], now planned for launch in March 2021," NASA stated. "The Administration is not ready to proceed with another multi-billion-dollar telescope until [JWST] has been successfully launched and deployed."

According to SpacePolicyOnline.com, the development of WFIRST has already been delayed several years because money earmarked for it was instead spent on the huge JWST overruns.

## Higher priorities

WFIRST had in fact been pencilled in for launch in 2020 originally, and in 2010 was listed by the US National Academies

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Although the diameter of WFIRST's primary mirror will be less than half that of the James Webb Space Telescope (JWST), its optics will yield a far wider field of view, meaning that entire galaxies can be mapped in detail far more quickly than with either JWST or Hubble. This image shows the Andromeda galaxy with the Moon for a size reference.

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## WFIRST space telescope ready for construction phase

decadal study as the top priority for launch.

But in the latest NASA summary of the presidential budget request, the administration's priorities diverge with that view. "The [FY2021] budget proposes termination of the WFIRST mission due to its significant cost and higher priorities within NASA, including successfully launching and deploying JWST," it states, adding:

"WFIRST was originally proposed as a less-than-\$2 billion space telescope in the Decadal Survey. The current WFIRST architecture, which was supported by two National Academy studies, differs from that discussed in the 2010 Decadal Survey and exceeds \$3 billion."

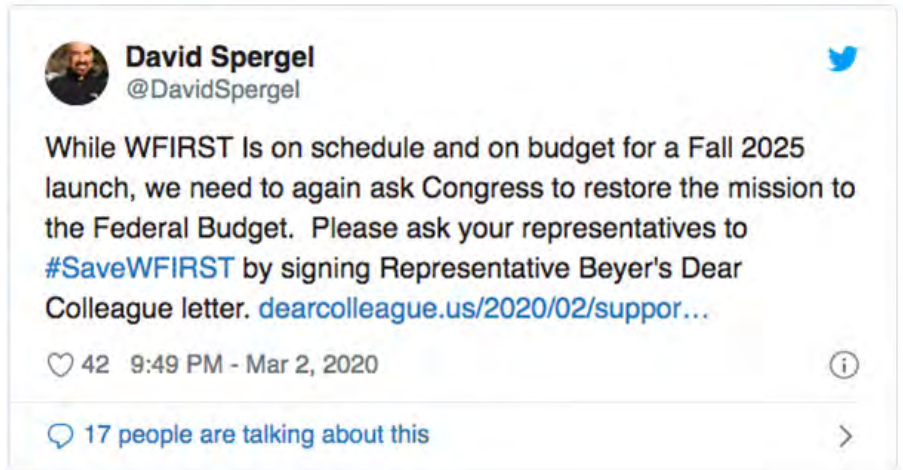
One of the casualties of the budget negotiations could be the coronagraph technology demonstration, which WFIRST proponents want to accompany the telescope to help provide direct imaging of exoplanets.

Essentially a mask to block out bright starlight from a target stellar-planetary system, the coronagraph designed for the WFIRST mission would enable scientists to view exoplanets directly, and in their true colors for the first time.

While the cost of the main WFIRST architecture is now set at \$3.2 billion, in its latest announcement NASA separated out for the first time the likely additional cost of the coronagraph element.

It said that the additional budget needed for both the coronagraph and the five years of WFIRST-related operations and science would be in the region of \$700 million.

In stark contrast, the presidential request for FY2021 earmarks more than \$12 billion in support of the "Moon to Mars" campaign (and more again in each of the next four years). It is aiming to land the next man and the first woman on the lunar surface by 2024 - in other words, before the end of the next US presidential term.



### Call for Congressional support

SpacePolicyOnline.com reported that, while Congress might be expected to repeat its previous efforts to restore funding for WFIRST, whether or not that support would extend to the coronagraph element remains to be seen.

In response to the presidential request for termination Don Beyer, a Democrat member of the US House of Representatives for northern Virginia, is calling for the House Appropriations Subcommittee on Commerce, Justice, and Science to include \$505.2 million in funding for WFIRST.

Beyer's "Dear Colleague" letter states that

the mission will allow astronomers to answer some of the most high-priority scientific questions facing humanity, related to the origin and evolution of the universe, and the potential for life on planets around other stars.

• Meanwhile, JWST is now said to be a "fully assembled observatory". NASA tweeted a time-lapse video of the instrument being built (below), ahead of scheduled environmental tests. If all goes according to plan, the telescope will be launched in March 2021.

<https://optics.org/news/11/1/90>






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