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Image: SPIE.

SPIE summit scheduled for September in Washington D.C.

SPIE summit will bring together policymakers and industry leaders

Event in Washington D.C. to highlight U.S. efforts in key sectors enabled by photonics.

SPIE, the international society for optics and photonics, will host its first-ever Photonics Industry Summit on 21 September in the heart of Washington, DC. The one-day event is aimed toward companies manufacturing optics and photonics products as well as executives within related industries.

Attendees will hear from multiple high-level US government agency and Congressional speakers who will discuss their latest plans for optics and photonics-related programs in key technology areas — including AI, quantum, hypersonics, energy, and semiconductors — as well as ways in which the industry can align to support and benefit from these efforts.

Featured speakers include the Office of Science and Technology Policy's Principal Deputy Director for Policy Kei Koizumi; Advanced Research Projects Agency-Energy's Acting Director for Technology Jennifer Gerbi; Maynard Holliday, the US Department of Defense's Deputy Chief Technology Officer for Critical Technologies in the Office of the Under-Secretary of Defense for Research and Engineering; and Laurie Locascio, Under Secretary of Commerce for Standards and Technology and Director of the National Institute of Standards and Technology.

Panel discussion

The event will also include a panel discussion with industry leaders considering the current challenges faced within the optics and photonics field, and ways the US government can assist in mitigating these issues. More speaker announcements will be made between now and September.

"This broad-ranging discussion on the current direction of US government policies and funding has something for everyone working within the optics and photonics industry," commented SPIE Director of Government Affairs Jennifer O'Bryan.

"If you're looking for information and networking opportunities that will contribute to the strategic growth of your business, this is the room you will want to be in."

The event is sponsored by Google, AmeriCOM, Edmund Optics, Excelitas Technologies, Hamamatsu, Jenoptik, Leonardo Electronics, Optimax, Thorlabs, and Toptica Photonics.

For more information on the SPIE Photonics Industry Summit and to register for the event, visit **this website**.

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https://optics.org/news/13/6/41

SPIE predicts rapid growth of 'core' photonics market

Society's latest industry report finds that revenues from production of optics and photonics components topped $300BN in 2020.

The global market for "core" optics and photonics components now exceeds $300 billion, and looks on course to surpass $400 billion before long.

That is one of the headline findings from the latest "state of the union" industry report from SPIE, the international optics and photonics society, and publisher of optics.org.

Photo: Messe München/Holger Rauner.

SPIE's latest industry report finds that the global market for "core" optics and photonics components - including lasers, LEDs, photodetectors, optical glass, lenses, prisms, gratings, and optical fibers, exceeded $300 billion for the first time in 2020, and is rapidly approaching $400 billion.

Essential selection

First produced in 2012, SPIE's latest biennial analysis of the optics and photonics industry again attempts to quantify the complex market by identifying sales of "core" optics and photonics components - defined as "the building blocks of photonics systems".

"These core components represent the lowest-value, yet essential, photonics parts in the value chain and include LED and laser chips, optical glass, detectors and image sensors, lenses, prisms, optical filters, gratings, and optical fibers," explains SPIE.

In 2020, revenues from sales of those components reached $302 billion, finds the report, up from $280 billion in 2018.

It means that the market for core components has increased in value by nearly 70 per cent between 2012 and 2020, equivalent to a compound annual growth rate of 6.5 per cent.

"The industry has grown to the point that combined demand for lasers and all other photonics components in 2020 underwrote more than 1.2 million jobs worldwide, with 4842 companies creating a market exceeding $300 billion in revenue," summed up SPIE in its report.

"As employment has grown, so too has the number of countries hosting components manufacturers, making it a truly global industry.

"The robust nature of the photonics industry was put to test during the global pandemic, but our data shows that the industry weathered the perturbations associated with lockdowns, supply chain, and shipping issues well - it experienced continued growth in 2020, albeit at a reduced level from prior periods."

Photo: Messe München/Markus Brönner.

"Photon is our business": Hamamatsu's tag line could be applied to the wider industry, where companies headquartered in Japan account for more than one-third of global "core" optics and photonics component revenues.

Japan still on top

Although the annual rate of growth appears to have slowed to 4 per cent between 2018 and 2020, SPIE's figures suggest that a much more rapid expansion has taken place over the past couple of years.

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SPIE predicts rapid growth of 'core' photonics market

"Looking ahead, SPIE currently forecasts global photonics component revenues for 2022 will end up reaching $378 billion," predicts the organization - equivalent to compound annual growth of 12 per cent as the industry recovered from the initial impact of the Covid-19 pandemic and benefited from investment in optical communications networks to support trends such as remote working.

Geographically speaking, the growth in revenues seen between 2018 and 2020 can be attributed almost entirely to companies headquartered in China and Korea.

Over the same time period, sales attributed to US and German firms were flat, while those based in Japan - who still account for the largest share of the market - declined slightly.

"Japan is still on top, but photonics revenue growth year-over-year has flattened," SPIE found. "China has seen significant growth over the last decade, with a compound annual growth rate of almost 23 per cent for the 2012-2020 period."

Despite the recent decline, Japan's 2020 total of $106 billion is equivalent to 35 per cent of the global market for core optics and photonics components, and reflects contributions from more than 800 companies - including major conglomerates like Hitachi, Fujitsu, Panasonic, and NEC alongside more obviously photonics-focused firms such as Hamamatsu and Nichia.

Enabled markets top $2 trillion

If SPIE's 2022 forecast proves accurate, it would mean that the market for core optics and photonics components is likely to exceed $400 billion in either 2023 or 2024.

However that total is eclipsed by the economic impact of what SPIE terms "enabled markets" - that is, the various vertical markets for systems and products that rely on optics and photonics components in some way.

For 2019 - the latest year to be reviewed - that is estimated at just over $2 trillion, with the consumer goods and defense sectors together accounting for more than half of that total.

Other key areas include medicine, displays, photovoltaics, lighting, sensing, communications, and semiconductor production - together estimated to employ more than 4 million people worldwide.

In comparison core photonics production now provides 1.2 million jobs - with China now employing the largest number of people in the industry, having overtaken Japan.

- For more details of SPIE's Optics & Photonics Industry Report, visit the society's dedicated web page **here**.

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Shaping laser beams boosts OCT depth of focus

Stanford University employs needle-shaped beams to improve resolution and image quality.

Needle-shaped laser beams (NBs) featuring a long and narrow localization of photons can potentially allow non-diffracting pulses with undistorted temporal profiles.

Using this kind of pulse in microscopy has been recognized as a route to enhancing the depth of focus, but to date there as been no convenient technique to generate a range of such pulses, limiting their applicability in real-world microscopy applications.

A project at Stanford University has now developed a new method for creating a variety of needle-shaped laser beams of different lengths and diameters. The work, published in Optica, investigated the particular advantages for OCT imaging that the shaped pulses could bring.

Although the axial resolution of OCT is constant along the imaging depth, it usually features a small depth of focus. OCT instruments are often made so that the focus can be moved along the depth to capture clear images of an entire region of interest, commented the Stanford team, but this dynamic focusing can make imaging slower and difficult when the sample is not static.

"Needle-shaped laser beams can effectively extend the depth of focus of an OCT system, improving the lateral resolution, signal-to-noise ratio, contrast and image quality over a long depth range," said Adam de la Zerda from Stanford University School of Medicine. "However, before now, implementing a specific needle-shaped beam has been difficult due to the lack of a common, flexible generation method."

The Stanford approach employed a micro-structured phase mask fabricated on a fused silica wafer to create various light patterns and numerous focal points. Groups of pixels in the phase mask were patterned so as to create many distinct densely spaced foci in the axial direction, effectively forming a needle-shaped beam with a long depth of focus.

Improved resolution for all microscopy systems

In trials, the needle-shaped beams were used first to image 0.8-micron polystyrene beads, and then for imaging of human skin epidermis. Both resolution and contrast were found to be better, and "NB allows for cellular-level resolution through a deep DOF," according to the team's paper.

The technique was also used to image the heartbeat, digestive system and muscle motion in Drosophila larva using a beam that was 700 microns long and 8 microns in diameter. This captured movement of the heart valve within the heart tube that was invisible with a conventional Gaussian beam.

A future improvement to the platform could see the diffractive optical element replaced with a single flat metalens, exploiting the ability of such metastructures to influence beam profiles in ways that conventional optics cannot. Such a metalens could be placed on the skull of a mouse to observe the neuron dynamics inside the mouse brain in real time, noted the project. Other microscopy modalities could also benefit.

"Needle-shaped beams can be used to improve the resolution of all microscopy systems, including particle manipulation with optical tweezers, materials processing, confocal microscopy, multiphoton microscopy, photolithography and photoacoustic tomography," said Stanford's Jingjing Zhao. "Our model can also be applied to electromagnetic waves for terahertz imaging and even the mechanical waves used in ultrasound imaging."

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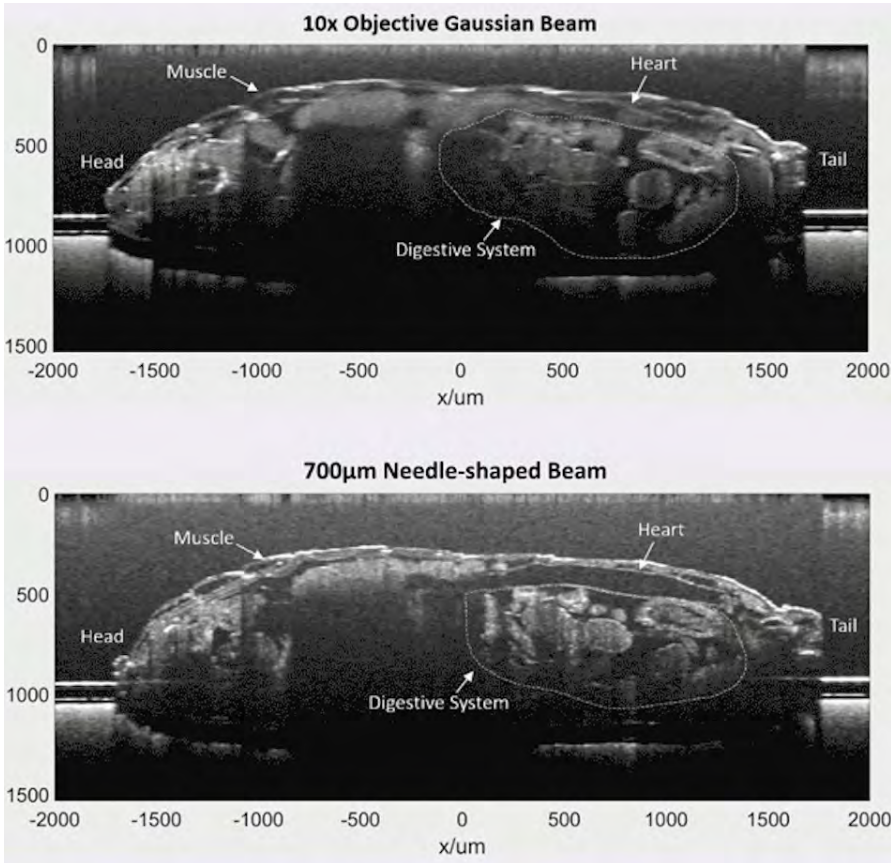


Credit: Jingjing Zhao, Stanford University School of Medicine.

High-resolution dynamic images of a beating heart in a living drosophila larva, using a laser beam 700 microns long and 8 microns in diameter to visualize organ structure over a long depth range.

Metalenz meta-optics arrive in time-of-flight sensor

Market debut of commercialized technology comes through partnership with STMicroelectronics.

A time-of-flight sensor from STMicroelectronics marks the commercial introduction of Metalenz metasurface technology.

The metasurface component within the VL53L8 direct time-of-flight (dToF) sensor is the product of a partnership between STMicroelectronics and Metalenz that was disclosed in June 2021.

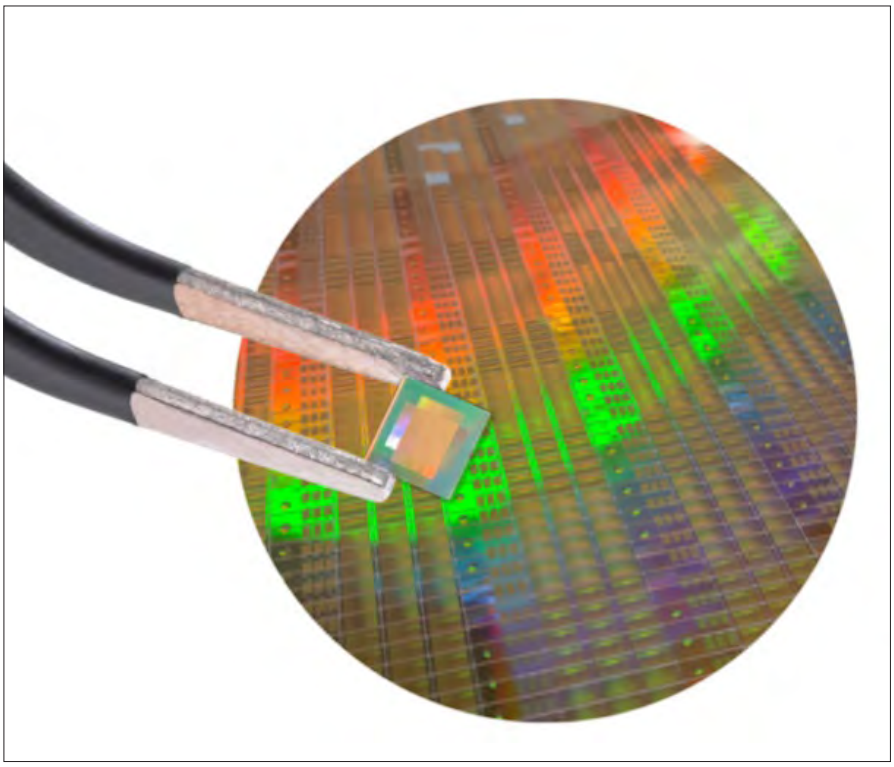
This marks the first time metasurface technology is commercially available and being used in consumer devices, according to the companies, and is intended to point towards improvements in performance, power, size, and cost that meta-optics could bring to several applications.

"More than a decade of foundational research has brought us to this point," commented Rob Devlin, co-founder and CEO of Metalenz.

"We have multiple wins that mark the first application of our platform technology and we are now designing entire systems around its unique functionality. Our meta-optics enable exciting new markets and new sensing capabilities in mobile form factors and at a competitive price."

Metalenz was founded in February 2021 as a spin-out from Harvard SEAS, with an exclusive worldwide license to a portfolio of innovations in flat optics developed in the Harvard lab of Federico Capasso. It launched with $10 million in investment from Intel Capital, 3M Ventures and others.

Speaking at the time, Capasso commented that the metalens platform "has the potential to drive a revolution in imaging and sensing, from the ubiquitous cameras in cell phones, cars, and self-driving vehicles to AR/VR, and in the future to widespread use in drones and CubeSats. I am grateful to Harvard OTD for encouraging and supporting, all along, the creation of Metalenz."



Credit: Metalenz.

Technology developed at the Harvard SEAS lab of Federico Capasso is licensed to Metalenz.

Planar optics on a chip

In June 2021, market analysis by Lux Research into the commercial prospects for optical metamaterials concluded that their commercial deployment was imminent, and that a market worth several billion dollars would develop by 2030. Metalenz was specifically identified as one of the companies driving that prospect, along with Canadian firm Meta and gradient index (GRIN) lens developer Vadient Optics.

In January 2022 Metalenz unveiled PolarEyes, a prototype platform employing the company's metasurface technology to reduce the size and complexity of polarized light cameras through "shrinking a polarization sensor by over 5000x." Such polarization cameras could be valuable in several consumer-facing sectors such as facial recognition and autonomous vehicle sensors.

Meanwhile the new dToF sensor is a first step towards broad industrial applications for similar metaoptics breakthroughs, according to vendor STMicroelectronics. Metalenz technology allows the device to incorporate planar optics on a chip, fabricated using standard semiconductor processes in the same foundries that produce microelectronics and CMOS image sensors.

"The introduction of products embedding Metalenz metasurface optics enables significant power efficiency, optical performance, and module-size optimization that all bring benefit across consumer, industrial, and automotive markets," said Eric Aussedat of ST's Imaging Sub-Group.

"Initially targeting applications using near-infrared wavelengths, especially for 3D sensing, the products we're introducing with Metalenz are perfectly suited for applications like face authentication, camera assist, consumer LIDAR, and AR/VR, where depth mapping is needed."

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NASA backs diffractive solar sails

$2M funding for 'Phase III' study to develop more efficient space propulsion using solar pressure.

NASA has funded further development of a new type of solar sail relying on diffractive optics, with the ultimate aim of a demonstration mission in space.

The "Diffractive Solar Sailing" project has been selected for "Phase III" study under the agency's Innovative Advanced Concepts (NIAC) program, with $2 million of support.

The Phase III projects aim to transition concepts with the highest potential impact for NASA and its partners, with NASA Administrator Bill Nelson saying:

"As we venture farther out into the cosmos than ever before, we'll need innovative, cutting-edge technologies to drive our missions. The NASA Innovative Advanced Concepts program helps to unlock visionary ideas - like novel solar sails - and bring them closer to reality."

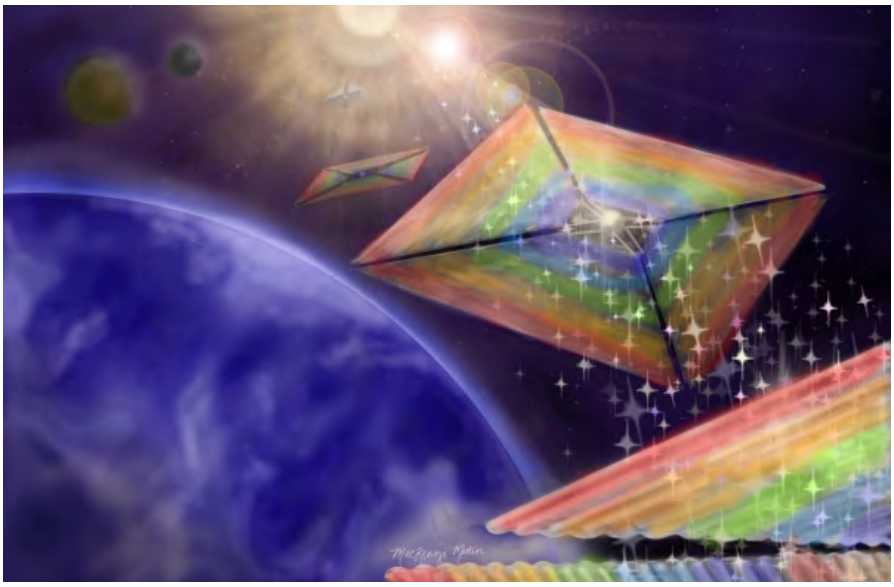

Image: NASA.

NASA's concept for a diffractive solar sail, potentially fabricated using thin films of metamaterial gratings. The approach could enable navigation by redirecting solar pressure, and the agency sees potential applications accessing orbits around the poles of the sun that are difficult to navigate into with conventional propulsion methods.

Diffractive design

While the concept of a solar sail is nothing new, existing designs are based on reflective materials that are able to harness the tiny amount of propulsive pressure exerted by sunlight.

Those sails are typically very large and very thin, so that they can convert as much solar pressure as possible into propulsive momentum. However, they are also limited by the direction of sunlight, resulting in trade-offs between power and navigation.

In contrast, diffractive lightsails would feature tiny gratings - possibly based on metamaterials - embedded into thin optical films. NASA says that this would allow the spacecraft to make more efficient use of sunlight without sacrificing maneuverability.

The Phase III award gives the research team $2 million over two years to continue technology development in preparation for a potential future demonstration mission, and is being led by Amber Dubill from the Johns Hopkins University Applied Physics Laboratory in Laurel, Maryland.

Earlier development under Phase I and Phase II awards had been led by co-investigator Grover Swartzlander from the Rochester Institute of Technology, with Dubill and Swartzlander co-authoring a recent journal publication entitled "Circumnavigating the sun with diffractive solar sails".

In the abstract for that paper, the pair wrote that they "envision placing a constellation of diffractive solar sails around the sun to collect images and other data for space weather monitoring and heliophysics science".

They added that the approach could inspire materials scientists to design and fabricate thin optical metamaterial films that efficiently diffract light at large angles across the solar spectrum for future solar sails. "Mission designers may also be prompted to imagine alternatives beyond reflective sails," they wrote.

Heliophysics potential

In a NASA release, Mike LaPointe, acting program executive for the NIAC program, said: "Our goal is to change the possible, and diffractive solar sailing promises to do just that for a number of exciting new mission applications."

Under the previous awards, the development team designed, created, and tested different types of diffractive sail materials, and designed new navigation and control schemes for a potential diffractive lightsail mission orbiting the poles of the sun.

Work under Phase III will seek to optimize the sail material and perform ground tests in support of a conceptual solar mission.

NASA explains that orbits passing over the solar poles are difficult to achieve using conventional spacecraft propulsion, whereas lightweight diffractive lightsails could place a constellation of science spacecraft in orbit.

"Diffractive solar sailing is a modern take on the decades old vision of lightsails," commented Dubill. "While this technology can improve a multitude of mission architectures, it is poised to highly impact the heliophysics community's need for unique solar observation capabilities.

"With our team's combined expertise in optics, aerospace, traditional solar sailing, and metamaterials, we hope to allow scientists to see the sun as never before."

Unlike a conventional reflective sail, a diffractive sail would experience a certain amount of force perpendicular to the direction of sunlight, meaning that a spacecraft could navigate without sacrificing the amount of solar power on the sail.

It is also thought that the angular deviation of light from a diffractive film could be engineered to provide electronic, rather than mechanical, navigation protocols, for example with electro-optic beam steering.

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Nanofluidic scattering microscopy offers new view of molecular behavior

Chalmers University label-free technique uses diffusion within nanofluidic channel.

Label-free microscopy of single biomolecules is inherently attractive as a complement to established fluorescence methods, where a marker label is attached to the molecules of interest.

At present several label-free modalities are available, but often require a surface-enhanced operation, with the target molecule binding to a surface or substrate in order to become visible. A technique able to image them directly in solution instead would be preferable.

A project at Chalmers University of Technology has now developed an alternative approach, potentially able to monitor conformational changes and interactions of single biomolecules inside a nanofluidic channel.

As described in Nature Methods, nanofluidic scattering microscopy (NSM) works by imaging the nanofluidic channels nanofabricated into an optically transparent matrix such as silicon dioxide, using dark-field light-scattering microscopy.

"With current methods you can never quite be sure that the labeling or the surface to which the molecule is attached does not affect the molecule's properties," commented Christoph Langhammer of Chalmers University. "With the aid of our technology, which does not require anything like that, it shows its completely natural silhouette or optical signature, which means that we can analyse the molecule just as it is."

The technique, developed at Chalmers and the University of Gothenburg, is being commercialized by Langhammer and colleagues via the spin-out company Envue Technologies.

In NSM the molecules or particles of interest are flushed through the channels of a nanofluidic chip, channels tens to hundreds of nanometers in diameter. A test fluid is added and the chip illuminated with visible light.

The light scattered from the chip is collected in dark-field configuration, with the nanochannels ensuring that the molecules are localized within the microscope focal plane. The NSM principle involves subtracting the scattering pattern of the empty nanochannel from that of the channel containing a biomolecule, to give a differential dark-field image of just the molecule.

Development of medicines and vaccines

The smaller the nanochannel, the greater the amplification effect and the smaller the molecules that can be seen, with the nanochannels improving the optical contrast of the imaged nano-object by several orders of magnitude according to the project.

"The interaction that occurs between the light, the molecule and the small fluid-filled channels makes the molecule inside show up as a dark shadow, and it can be seen on the screen connected to the microscope," commented the Chalmers project. "By studying it, researchers can not only see but also determine the mass and size of the biomolecule, and obtain indirect information about its shape, something that was not previously possible with a single technique."

Envue Technologies expects to address markets in industrial quality control as well as research and development, saving time and money in development of medicines and vaccines.

"The aim is to further hone our technique so that it can help to increase our basic understanding of how life works, and contribute to making the development of the next generation medicines more efficient," said Langhammer.

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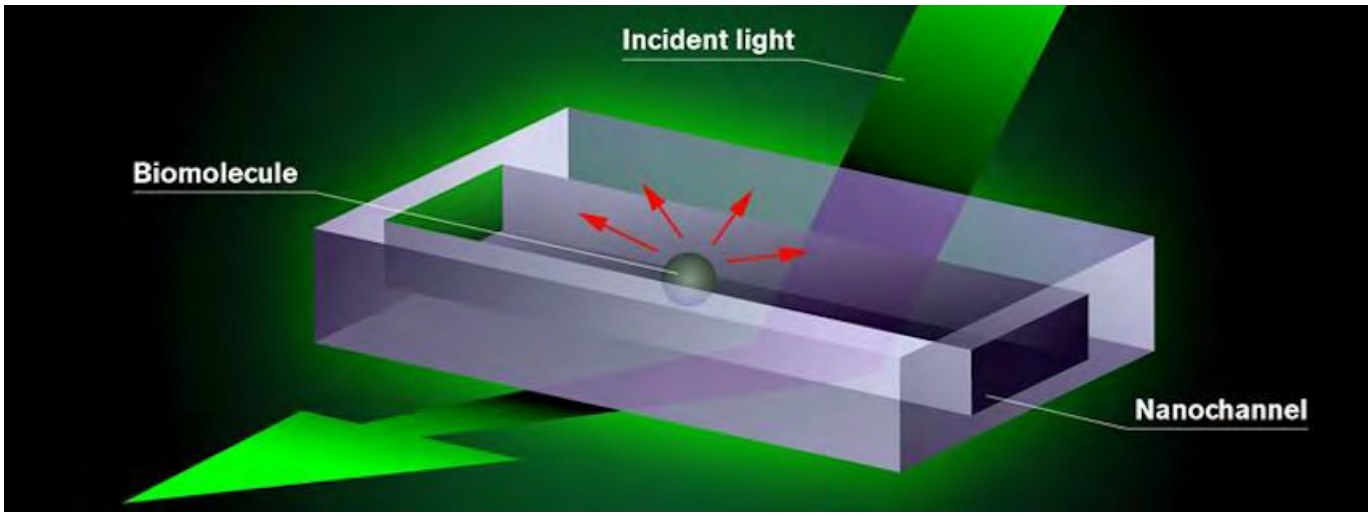


Credit: Chalmers University of Technology/Yen Strandqvist/ Daniel Sparek/Neuron Collective.

Biomolecules and test fluid are added to the nanochannels, mounted in an optical dark-field microscope. The molecule appears as a dark shadow moving freely inside the channel. The darkness of the shadow is proportional to the mass of the molecule, due to an interference effect from the interaction of the light with the nanochannel and the molecule.

Columbia's Covid-19 photonic test performs PCR faster than conventional systems

Photothermal process-based system co-developed with Rover Diagnostics, biotech start-up spun out of Columbia.

Researchers at Columbia Engineering and Rover Diagnostics, both at Columbia University, New York, NY, have teamed up to develop a low-cost, photonics-based portable platform that gives RT-PCR results in 23 minutes that match laboratory-based tests.

For more than 30 years, polymerase chain reaction (PCR) has been the gold standard in molecular diagnostic testing, detecting genetic material, such as those from a virus or from human DNA.

But PCR, including reverse transcription polymerase chain reaction (RT-PCR), is mostly done at large, centralized laboratories, not in point-of-care (POC) settings, because its instrumentation is bulky, expensive, takes a long time for results, and requires trained technicians to run it. These limitations have led to a shortage of accurate POC diagnostics as well as bottlenecks in test results, particularly during the Covid-19 pandemic.

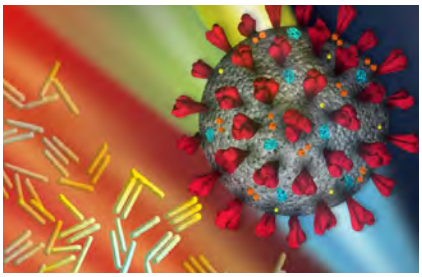
Now, researchers at Columbia Engineering and Rover Diagnostics have built an RT-PCR platform that gives results in 23 minutes that match the longer laboratory-based tests—faster than other PCR tests on the market.

It can be adapted to test for a broad range of infectious diseases including not just Covid-19 but also flu, strep, and other viruses that require fast diagnosis. Its targeted sensitivity is higher than other types of tests such as isothermal, antigen, and CRISPR. And, at just two pounds, the Rover PCR is easy to carry around and can be used by anyone.

"Our aim was to create a platform that can be used in locations where rapid turnaround results are critical, at pharmacies, transportation hubs, public events, and at companies screening employees coming back to work," said Sam Sia, professor of biomedical engineering and Vice Provost for the Fourth Purpose and Strategic Impact at Columbia.

Schematic of multiplexed real-time plasmonic RT-PCR, with heating driven by IR LEDs acting on AuNRs. Click for full captions.

Schematic of multiplexed real-time



Credit: Abigail Ayers/Columbia Engineering, Nicoletta Barolini.

Rapid testing for Covid-19 virus.

plasmonic RT-PCR, with heating driven by IR LEDs acting on AuNRs. Click for full captions.

Photothermal process

The system was co-developed with Rover Diagnostics, a biotech start-up co-founded in 2018 by Sia and serial tech entrepreneur Mark Fasciano, Rover's CEO. The platform uses sample preparation techniques developed at Sia's lab, combined with a new approach to thermal cycling, bypassing the standard approach of Peltier device—which heats the sample from outside the vial. Instead, Rover's system uses a photothermal process—plasmonic hermocycling—that relies on nanoparticles irradiated by light to rapidly generate heat from inside.

The team successfully performed reverse-transcriptase quantitative PCR (RT-qPCR) in a reaction vessel containing all the PCR reagents. qPCR is the current gold-standard laboratory technique for identifying COVID infection. The technique provides quantification of infectious units, but it also poses a number of hurdles for point-of-care (POC) miniaturization.

In the study published in Nature Nanotechnology, the researchers addressed these challenges by leveraging plasmonic nanoparticles—discrete metallic particles that respond to infrared light by releasing heat—to achieve real-time and multiplexed RT-qPCR on clinical specimens.

"This should really move the needle on delivering rapid and accurate molecular clinical diagnostics in decentralized settings," said Fasciano, a computer scientist turned software and biotech entrepreneur. "Thermal cycling, so critical to DNA and RNA testing, can now be sped up and clinicians and patients alike won't have to wait so long for results."

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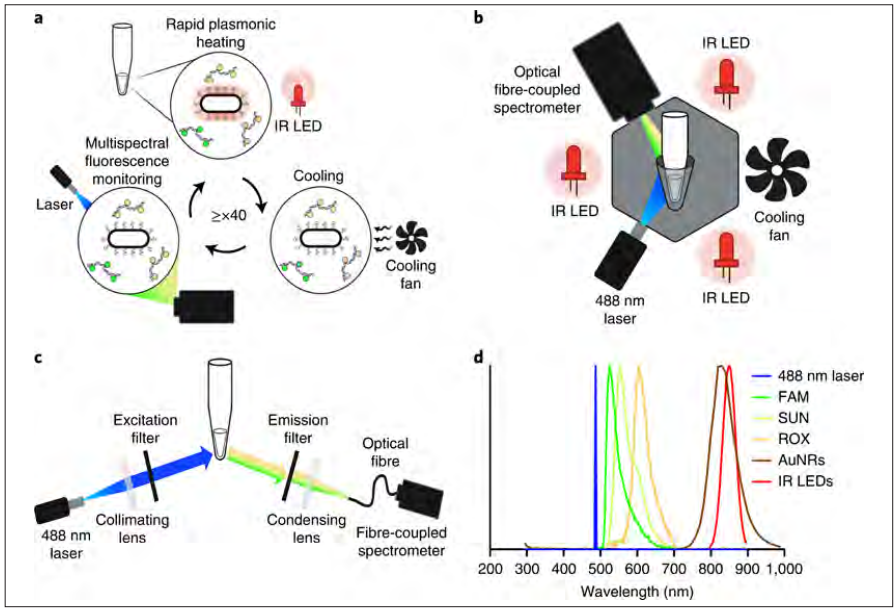


Credit: Columbia Engineering / Nature Nanotechnology.

a, Schematic of multiplexed real-time plasmonic RT-PCR, with heating driven by IR LEDs acting on AuNRs and cooling aided by a 12 V fan. The AuNRs are suspended in solution in a 0.2 ml PCR tube, rapidly absorbing light from the LEDs and converting it to heat, allowing for fast PCR thermal cycling. A 488 nm laser and spectrometer setup provides real-time fluorescence detection and takes a measurement at the end of each annealing/extension hold. b, Schematic of the instrument. A PCR tube is surrounded by low-cost optical components, without Peltier heating elements. The main components of the instrument include a thin-walled PCR tube surrounded by three IR LED modules, a cooling fan, and a 488 nm laser and spectrophotometer setup for fluorescence detection. The three IR LED modules consist of 850 nm IR LEDs attached to heat sinks as well as heat-sink fans and placed concentrically surrounding the PCR tube. Temperature control can be achieved through closed-loop sensing with a wire thermocouple or through contactless open-loop control. c, Schematic of the fluorometer system. Light coming from a 488 nm laser passes through a collimating lens and filter before reaching the PCR tube. Light emitted from the tube passes through a condensing lens and a 500 nm edge emission filter (Semrock) before travelling through an optical fibre to reach the spectrometer. d, Graph depicting non-overlapping optical spectra of various components within the system, namely, 488 nm excitation peak, three emissions (520, 555 and 610 nm), IR LED excitation and AuNR absorbance.

SPIE Astro: NSF's Gemini South telescope upgraded with 'GHOST' spectrograph

GHOST captures first light observations of a "bright, chemically-rich star".

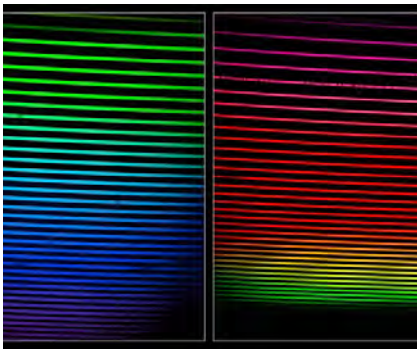
Gemini South, a powerful optical-infrared telescopes, has received a significant performance boost with the successful installation of a new high-resolution spectrograph called GHOST constructed by an international consortium.

The addition of the scientific instrument is intended to expand our understanding of the earliest stars, the chemical fingerprints of distant planetary systems, and the formation and evolution of galaxies. Gemini South in Chile is one half of the International Gemini Observatory, operated by the U.S. NSF's NOIRLab.

The Gemini South telescope's newest science instrument — GHOST, the Gemini High-resolution Optical SpecTrograph — achieved first light by making exquisite observations of HD 222925, a remarkably bright, chemically complex star located more than 1400 light-years away in the direction of the southern hemisphere constellation Tucana.

This star is a prime example of the type of object that GHOST will investigate. Gemini South is one half of the International Gemini Observatory.

Jennifer Lotz, Director of Gemini Observatory, commented, "This is an exciting milestone for astronomers around the globe who rely on Gemini South to study the Universe from this exceptional vantage point in Chile. Once this next-generation instrument is commissioned, GHOST will be an essential component of the astronomers toolbox."



Credit: International Gemini Observatory/NOIRLab/ NSF/AURA/GHOST Consortium

This mosaic shows the two GHOST spectra of HD 222925, a remarkably bright, chemically complex star. This star is a prime example of the type of object that GHOST will investigate. The two GHOST spectra shown here, which were produced in the same single observation, measure light from around 350 nm to around 1015 nm. Light that is 'bluer' than 380 nm is ultraviolet and is invisible to our eyes. Light that is 'redder' than around 750 nm is infrared and is also invisible to our eyes. The dark lines in the rainbow are like the fingerprints of the gasses present in the star, including hydrogen, calcium, iron and gold. See this image comparison to see the most prominent features labeled.

Credit: International Gemini Observatory/NOIRLab/NSF/AURA/Kwon O Chul.

Gemini South in Chile is one half of the International Gemini Observatory.

Spectrograph's 'amazing details'

Spectrographs are among the most important science instruments in all of astronomy. Unlike high-resolution cameras that capture amazing details of distant stars and galaxies, spectrographs precisely analyze the spectrum of light emitted by these objects, revealing detailed information about their chemical composition, motion and rotation, and ancient counterparts at the edge of the observable Universe.

GHOST, which has ten times the spectral resolution of GMOS, Gemini's other major optical spectrograph, is the most sensitive high-resolution spectrograph across the full optical wavelength range of any of the spectrographs currently in operation on comparably-sized telescopes.

The spectrograph will also provide crucial follow-up observations of key targets emerging from many ongoing and future surveys, such as Vera C. Rubin Observatory's Legacy Survey of Space and Time, SkyMapper, and GAIA.

The instrument is open-access, meaning any researcher with a compelling science case will be able to submit proposals to use it for their research. NOIRLab will provide a data reduction pipeline for astronomers using the instrument.

Australian Astronomical Optics (AAO) at Macquarie University leads the GHOST team, which includes the National Research Council of Canada (NRC) Herzberg Astronomy & Astrophysics Research Center which was responsible for the construction of the spectrograph, and the Australian National University (ANU), leading on the instrument control system and data reduction software.

The design and construction of GHOST began in 2010 and took ten years to complete. The instrument was delivered to Gemini South in early 2020, although COVID-19 restrictions meant that installation by the teams from Canada and Australia had to wait until early 2022.

With its successful installation and first-light observations, the commissioning team put GHOST through its paces to verify its systems are performing as designed. Once the commissioning process is complete, it will join Gemini South's diverse suite of advanced optical and infrared instruments and be offered to astronomers to use.

"The installation and commissioning have been a long time coming, but the team has been working efficiently and quickly", said Steve Margheim, GHOST Project Scientist at NSF's NOIRLab. "It was a really special day when we saw our first rainbow from the instrument".

It is expected that GHOST will be made available to the astronomical community during the first half of 2023.

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https://optics.org/news/13/7/30

QuiX creates 'largest' quantum photonic processor to work with quantum dots…

…as Quantinuum upgrades its Model H1 quantum-computer – expanding to 20 connected qubits.

Quantum computers promise to propel computing far beyond what today's computers are capable of, but this potential has yet to be realized. In their search for a way to demonstrate quantum supremacy, researchers working in the EU-funded PHOQUSING project are developing a hybrid computational system based on cutting-edge integrated photonics that combines classical and quantum processes.

The project's goal is to develop a quantum-sampling machine that will put Europe at the forefront of photonic quantum computing. With this goal in mind, PHOQUSING project partner QuiX Quantum in the Netherlands (a spin-out of the University of Twente) has created the largest quantum photonic processor compatible with quantum dots. The processor is the central component of the quantum sampling machine, described by Quix as, "a near-term quantum computing device able to show a quantum advantage."

'Quantum advantage'

"Quantum sampling machines based on light are believed to be very promising for showing a quantum advantage," states the QuiX Quantum website. "The problem of drawing samples from a probability distribution, mathematically too complex for a classical computer, can be solved easily by letting light propagate through such quantum sampling machines. At the very core of quantum sampling machines there are large-scale linear optical interferometers, i.e. photonic processors."

The processor the research team developed is a "record-sized" 20-mode silicon nitride photonic chip that is optimized for use at the near-infrared wavelength range, operating at a wavelength of 925nm. According to a webinar video presenting the processor, the 20 input modes with 190 unit cells and 380 tunable elements likely make this processor the most complex photonic chip available today.

Besides the large number of modes, key features of the quantum photonic processor include low optical losses (of 2.9 decibels per mode) and high fidelity (99.5% for permutation matrices and 97.4% for Haar-random matrices). The turnkey processor also enables high-visibility quantum interference (98 %).

Prof. Fabio Sciarrino commented, "The established high-performance photonic technology provided by QuiX Quantum is crucial for the success of the project as it addresses the need of science-to-technology transition needed for developing useful quantum computation."

The project brings together seven partners from France, Italy, the Netherlands and Portugal: five academic and research organizations and two industrial players, all European leaders in the field of quantum information processing and integrated photonics.

Quantinuum upgrades Model H1 with 20 connected Qubits

Quantum computing systems developer Quantinuum, based in Charlotte, NC, US, with locations worldwide, has announced a major upgrade to its System Model H1 technology that includes expanding to 20 fully connected qubits and increasing the number of quantum operations that can be completed in parallel.

Quantinuum claims to be the world's largest integrated quantum computing company, formed by the combination of Honeywell Quantum Solutions' hardware and Cambridge Quantum's middleware and applications. The newly upgraded H1-1 quantum computer has undergone extensive testing to verify performance and functionality, including by banking customer JPMorgan Chase, which has published its results.

"With these upgrades, developers can run more complex calculations than they could before, without sacrificing

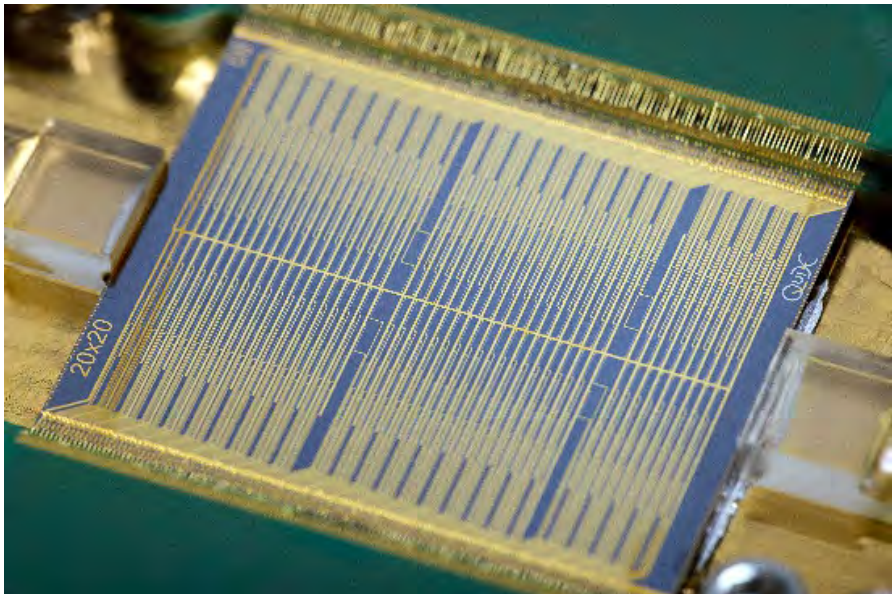

Photo: QuiX Quantum.

QuiX Quantum has created the largest quantum photonic processor compatible with quantum dots.

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QuiX creates 'largest' quantum photonic processor to work with quantum dots

performance," said Tony Uttley, Quantinuum's president and COO. "This upgrade is another example of our business model of continuously upgrading systems, even after they are in commercial use."

"The quantum computing team at JPMorgan Chase has been using Quantinuum's quantum computer to run experiments that use mid-circuit measurement and reuse and quantum conditional logic, taking advantage of the computer's high quantum volume," said Marco Pistoia, Ph.D., Distinguished Engineer and Head of Quantum Computing and Communication Research in the bank.

Pistoia added, "In our experiments, we used the 20 qubits of the H1-1 computer on a quantum Natural Language Processing algorithm for extractive text summarization. The results were almost identical to the reference values computed with a noiseless simulator, validating the computer's high fidelity, as shown in our recent arXiv preprint."

Several upgrades were made by the Quantinuum team to the H1-1 machine, including:

- Increasing the number of fully connected qubits from 12 to 20 while simultaneously preserving its low two-qubit gate errors (typical performance fidelities of 99.7 percent with fidelities as high as 99.8 percent) and critical features such as mid-circuit measurement, qubit reuse, quantum conditional logic and all-to-all connectivity; and
- Increasing the number of gate zones from three to five, enabling the H1-1 to complete more quantum operations simultaneously and allowing increased parallelization in circuit execution.

Uttley said such upgrades prove an important next step in the H-Series roadmap - the ability to increase the qubit count and number of gate zones without compromising gate fidelity. The second version of the System Model H1, the H1-2, is scheduled to undergo similar upgrades later in 2022.

Quantinuum also provides commercial access to its trapped ion quantum computers H1-1 and H1-2, as well as the H1 Emulators through Microsoft's Azure Quantum. "The continuous upgrading of Quantinuum's systems has been a great benefit to Microsoft customers," said Fabrice Frachon Azure Quantum Principal Program Manager.

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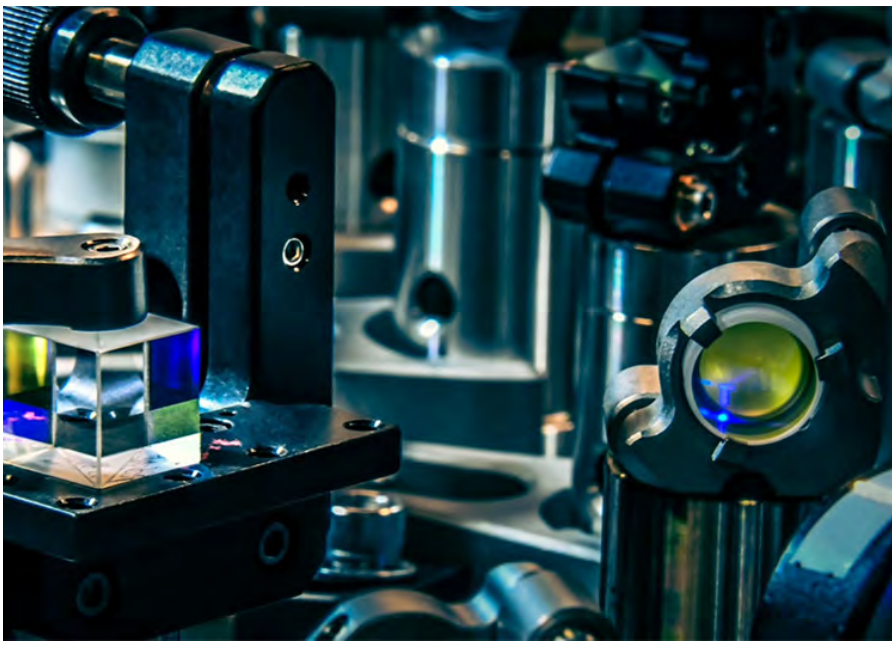

Photo: Quantinuum.

A major upgrade to Quantinuum's System Model H1 technology that includes expanding to 20 fully connected qubits.

Headwall expands with twin acquisitions

Hyperspectral imaging technology firm adds software with perClass and photonics manufacturing expertise with Holographix.

Headwall Photonics, the Massachusetts-based company that specializes in hyperspectral imaging technologies, has expanded its offering with two acquisitions.

Last week, Headwall said that it had acquired spectral analysis software company perClass. Based in The Netherlands, perClass has developed the "Mira" software package - described as "the easiest interface for spectral imaging with real-time deployment".

In fact Headwall already uses Mira in its own "Hyperspec MV.X" product, creating spectral classification models that are deployed in applications such as the detection of food contamination, material sorting in recycling, and grading of fruit and nuts.

And just a few days later the company revealed that it had also acquired precision optics manufacturing expertise, with a deal to buy its Massachusetts neighbor Holographix.

Together, the two acquisitions bring the total company headcount to 100, with Headwall saying that it continues to recruit for open job listings at each of its locations.

Intuitive interface

Commenting on the perClass deal, Headwall president Don Battistoni said: "Spectral imaging has been used in research for decades to help answer a variety of complex questions.

"Until recently, this involved a time-consuming process of data acquisition, model development, and lengthy data analysis typically performed by a senior level scientist.

"perClass Mira eliminates those complexities through an intuitive interface backed up by advanced machine learning algorithms, in the process dramatically expanding the addressable use cases for spectral imaging across numerous industrial markets."

perClass founder and general manager Pavel Paclik added: "The perClass mission remains to simplify interpretation of spectral imaging data to expand deployment for industrial applications.

"We remain dedicated to and will continue to support and work with our many loyal and new spectral sensor manufacturer partners.

"This growth investment and our extended partnership with Headwall will facilitate our ability to provide best-in-class solutions to the market for any sensor, and our deeper integration with a leading sensor provider accelerates our goal of advancing widespread adoption of spectral imaging in real-world applications."

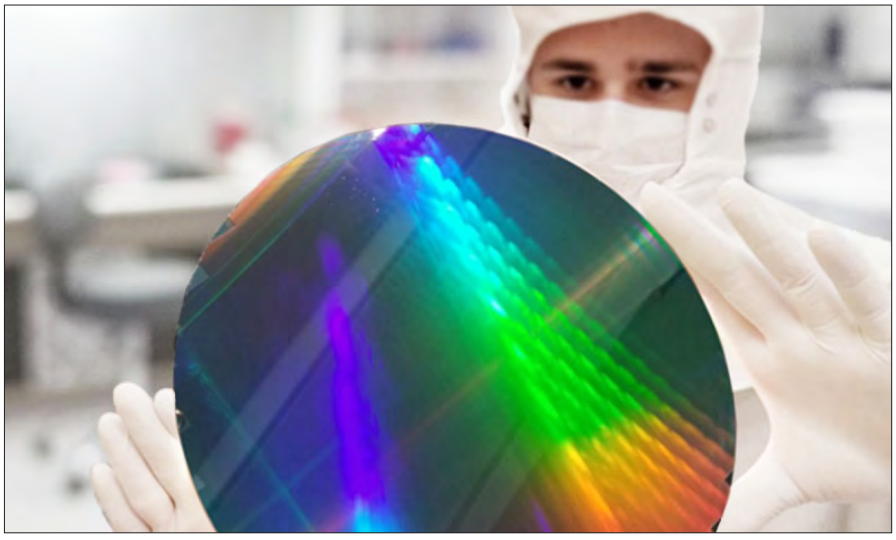

Photo: Headwall Photonics.

Headwall says that its acquisition of Holographix adds proprietary nano-replication capabilities to its repertoire of technologies aimed at hyperspectral imaging.

Headwall says that the perClass deal will help to bring hyperspectral imaging to more industries and researchers globally - thanks to the combination of intuitive, powerful spectral analysis and the elimination of data interpretation complexities that have historically limited broader adoption of the technology.

Gratings and microlens arrays

Headwall's second acquisition sees it gain a proprietary technology for reproducing structured surfaces for optical devices used across a wide range of industrial applications.

Located close to Headwall and with a manufacturing facility in Marlborough, Holographix has over 25 years' experience in micro- and nano-structure replication of high-performance optics for applications in life sciences, semiconductor, aerospace, defense, and metrology markets.

"Headwall's holographic master gratings are core to both our OEM and hyperspectral imaging businesses," pointed out Battistoni.

"Adding Holographix's replication technology immediately opens channels to new customers and markets as well as new products and capabilities for existing customers of both companies, while expanding our manufacturing capabilities to address future growth."

The deal also gives Headwall the ability to make high-precision microlens arrays, structured diffusers, waveguides, and replicated mirrors, which Battistoni says will open up further high-volume applications.

Holographix president David Rowe observed: "Headwall's mastering expertise and Holographix's replication capabilities go hand-in-hand. Therefore, it is clear to us that Headwall is the perfect complementary partner for Holographix."

Rowe said that as well as a close geographic proximity, the two firms' shared a common company culture and commitment to excellence.

"Access to Headwall's master holographic gratings and OEM assembly capabilities, as well as their commercial infrastructure, will help Holographix realize the inherent scalability of our replication technology," he added.

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https://optics.org/news/13/7/14

Image: Honor.

Built with high-spec photography as a key feature, Honor's flagship Magic4 Pro phone is a rare example of an Android device featuring 3D sensing for facial security applications.

Yole sees 3D sensing market topping $16BN by 2027

Market analyst sees applications starting to blossom outside of smart phones.

An updated report from France-headquartered market analyst firm Yole Développement suggests that the market for 3D sensing technologies - based around photonic components including VCSELs, optics, and photodetectors - will rise to $16.7 billion by 2027.

The current market remains closely allied to the popularity of iPhones - sales of which soared in 2021 - with Yole's Richard Liu pointing out that Apple continues to drive the market upwards as it pushes for more 3D sensing in its products.

"As expected, in 2021, the Android smartphone camp saw no progress in mobile 3D sensing," said Liu, an analyst covering imaging and display technologies at Yole.

"However, the leading smart phone manufacturer, Apple, continues to adopt 3D camera solutions in both front and rear applications, even updating face ID, by simplifying and shrinking its optical structure. That's Apple's strategy to push 3D sensing on its phones, further appealing to consumers."

Largely as a result of that push, the market for 3D sensing technologies in mobile and consumer applications rose to $3.6 billion - or 326 million units - last year, slightly higher than Yole had predicted earlier.

Android challenge

Liu indicates that there are two main challenges to the adoption of 3D cameras in Android phones: firstly the competition from alternative sensing and security features, for example under-display fingerprint sensing, which are cost-effective and work well.

But the second reason, which Yole sees as more significant, is simply a shortage of applications.

"If a 3D camera is placed on the rear of the phone, there should be at least one killer application for daily use," said the firm. "But there are only a few AR [augmented reality] games or other infrequently used applications."

But despite that lack of progress, the rate of penetration of 3D sensing in mobile phones is still increasing, because Apple has gained market share against its Android rivals.

Yole suggests that the Android ecosystem will need to deliver the same functionality as Apple, and perhaps even surpass it, to register significant impact.

"Once Android phones adopt this strategy, 3D sensing will return to Android phones," says Yole, noting that China's Honor - the consumer electronics brand spun off by Huawei in late 2020 - has adopted 3D sensing in the front-facing camera of its flagship phone, the Magic 4 Pro, for facial security.

"We assume it is just using it on its flagship models, similar to Apple," said Yole, adding that it expects the market for 3D sensing in mobile phone applications alone to rise to $6.6 billion in 2027, at a compound annual growth rate of nearly 12 per cent.

Metaverse 'needs' 3D sensing

"In addition to mobile phones, 3D sensing is blossoming in other industries," adds the analyst firm. "As 3D sensing has temporarily come to a standstill in Android phones, upstream device suppliers or integrators have to work hard to open up other consumer markets."

Examples include smart door locks, robot cleaners, and smart fitness devices, while Yole believes that in recent months the concept of the "metaverse" has stimulated a new understanding of 3D sensing for the emerging market.

"The metaverse desperately needs 3D sensing technologies, such as virtualized worlds and digitization, and ways of interacting in virtual worlds, such as eye and lip tracking," said the company.

"This will greatly incentivize more players to participate in developing 3D sensing technology."

Outside of the consumer space, traditional lidar techniques are seen as suitable for many topographic and industrial applications. But with the rise of machine vision, Yole expects to see 3D cameras performing more delicate and complex work in manufacturing, logistics, and public security settings.

Another area with massive potential is the automotive sector, where 3D sensing for advanced driver assistance is just starting to emerge.

According to Yole's figures, 3D sensing in automotive applications will rise from just $530 million in 2021 to exceed $3 billion in 2027.

- For more information on Yole's latest 3D Imaging and Sensing report, visit **yole.fr.**

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https://optics.org/news/13/7/13

NASA announces launch delay for Psyche asteroid mission

$1 billion mission is planned to feature deep space optical communications demo; NASA now "assessing options".

NASA announced on June 24 that its planned Psyche asteroid mission – the agency's first mission designed to study a metal-rich asteroid a – will not make its planned 2022 launch attempt.

Due to the late delivery of the spacecraft's flight software and testing equipment, NASA does not have sufficient time to complete the testing needed ahead of its remaining launch period this year, which ends on October 11. The mission team needs more time to ensure that the software will function properly in flight.

Credits: NASA/JPL-Caltech/Arizona State Univ./Space Systems Loral/Peter Rubin.

Not yet: illustration of Psyche spacecraft with five-Panel array.

NASA selected Psyche in 2017 as part of the agency's Discovery Program, a line of low-cost, competitive missions led by a single principal investigator. The agency is forming an independent assessment team to review the path forward for the project and for the Discovery Program.

NASA 'exploring options'

"NASA takes the cost and schedule commitments of its projects and programs very seriously," said Thomas Zurbuchen, associate administrator for NASA's Science Mission Directorate in Washington, DC. "We are exploring options for the mission in the context of the Discovery Program, and a decision on the path forward will be made in the coming months."

The independent assessment team, typically made up of experts from government, academia, and industry, will review possible options for next steps, including estimated costs. Implications for the agency's Discovery Program and planetary science portfolio also will be considered.

The spacecraft's guidance navigation and flight software will control the orientation of the spacecraft as it flies through space and is used to point the spacecraft's antenna toward Earth so that the spacecraft can send data and receive commands. It also provides trajectory information to the spacecraft's solar electric propulsion system, which begins operations 70 days after launch.

As the mission team at NASA's Jet Propulsion Laboratory in Southern California began testing the system, a compatibility issue was discovered with the software's testbed simulators. In May, NASA shifted the mission's targeted launch date from August 1st to no earlier than September 20th to accommodate the work needed.

Not enough time for 2022 launch

The issue with the testbeds has been identified and corrected; however, there is not enough time to complete a full checkout of the software for a launch this year.

"Flying to a distant metal-rich asteroid, using Mars for a gravity assist on the way there, takes incredible precision. We must get it right. Hundreds of people have put remarkable effort into Psyche during this pandemic, and the work will continue as the complex flight software is thoroughly tested and assessed," said JPL Director Laurie Leshin. "The decision to delay the launch wasn't easy, but it is the right one."

The mission's 2022 launch period, which ran from August 1st through October 11th, would have allowed the spacecraft to arrive at the asteroid Psyche in 2026. There are possible launch periods in both 2023 and 2024, but the relative orbital positions of Psyche and Earth mean the spacecraft would not arrive at the asteroid until 2029 and 2030, respectively. The exact dates of these potential launch periods are yet to be determined.

"Our amazing team has overcome almost all of the incredible challenges of building a spacecraft during the Covid pandemic," said Psyche Principal Investigator Lindy Elkins-Tanton of Arizona State University, who leads the mission. "We have conquered numerous hardware and software challenges, and we've been stopped in the end by this one last problem. We just need a little more time and will get this one licked too. The team is ready to move forward, and I'm so grateful for their excellence."

Total life-cycle mission costs for Psyche, including the rocket, are $985 million. Of that, $717 million has been spent to date. The estimated costs involved to support each of the full range of available mission options are currently being calculated.

Two ride-along projects were scheduled to launch on the same SpaceX Falcon Heavy rocket as Psyche, including NASA's Janus mission to study twin binary asteroid systems, and the Deep Space Optical Communications technology demonstration to test high-data-rate laser communications that is integrated with the Psyche spacecraft. NASA is assessing options for both projects.

ASU leads the Psyche mission. JPL, which is managed for NASA by Caltech in Pasadena, California, is responsible for the mission's overall management; system engineering; integration and test; and mission operations. Maxar is providing the high-power solar electric propulsion spacecraft chassis. NASA's Launch Services Program, based at the agency's Kennedy Space Center in Florida, is managing the launch.

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Biofinder device spots biological residues via fluorescence imaging

University of Hawaii platform could help NASA detect organics on planetary bodies.

A device developed by the University of Hawaii at Mānoa (UH Mānoa) could be valuable in NASA's future efforts to spot evidence for extraterrestrial life.

The Compact Color Biofinder (CoCoBi) has been designed to locate trace amounts of biological material in a large examined area at video speeds from a standoff distance, using biofluorescence imaging techniques.

Published in Nature Scientific Reports, the new UH Mānoa study built on research into the design of a "standoff biofinder" that has been underway at the university since 2012.

The project's long-term goal has been locating biological materials and biomarkers at distances ranging from 1 meter to 10 meters with scanning speeds below 1 second in an area of 500 square centimeters.

"The Biofinder is the first system of its kind," said Anupam Misra of UH Mānoa School of Ocean and Earth Science and Technology (SOEST). "At present, there is no other equipment that can detect minute amounts of bio-residue on a rock during the daytime. Additional strengths of the Biofinder are that it works from a distance of several meters, takes video and can quickly scan a large area."

The Biofinder exploits the way that most biological materials, including amino acids, fossils, clays and microbes, have strong fluorescence signals which have a very short lifetime of less than 20 nanoseconds. Distinguishing between this organic fluorescence and longer-lived mineral phosphorescence from standoff distances in daylight conditions has been the key to developing an instrument able to identify traces of life on mineral substrates.

Detecting the evidence of past life

Designed to be a portable instrument operated using a 24 volt battery and a laptop, the latest iteration of the Biofinder instrument uses a compact solid state, conductively cooled Nd:YAG nanosecond laser providing two simultaneous wavelengths, 355 and 532 nanometers, for fluorescence excitation. A gated color CMOS sensor detects the returned signals.

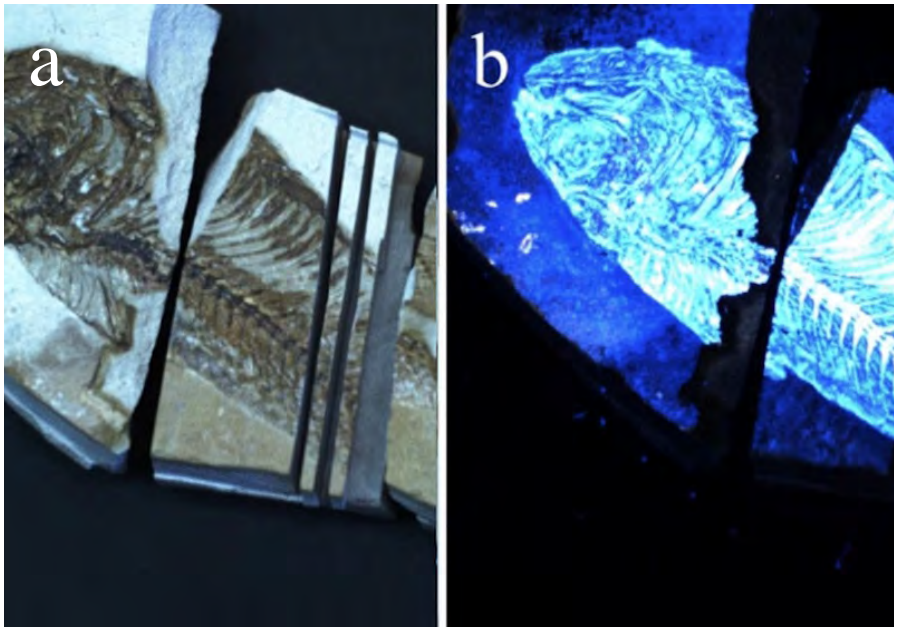
According to the project's paper, for organic and biological fluorescence imaging the detector is gated for its shortest exposure time of 1 microsecond and records the short-lived fluorescence signals from organics and biological materials. Short detection time is helpful in blocking off the unwanted mineral phosphorescence as well as background signal from ambient light.

In trials, the Biofinder was used to examine 35 examples of fossilized Knightia fish in the US geologic area called the Green River Formation. The Biofinder instrument imaged the fossils from 50 centimeters away, and showed that all of the fish fossils still contain a significant quantity of bio-fluorescence. The data was validated as accurate using gold-standard traditional techniques including Raman spectroscopy and fluorescence lifetime imaging microscopy.

Fossilized fish around the Colorado River are one thing; the Biofinder team envisages its instrument in use farther afield. If the Biofinder were mounted on a rover on Mars or another planet, it could rapidly scan large areas quickly to detect evidence of past life, even if the organism was small and dead for many millions of years, according to the project.

The device could also be suitable for NASA's Planetary Protection program, for the accurate and non-invasive detection of contaminants such as microbes or extraterrestrial biohazards to or from Earth.

"We anticipate that fluorescence imaging will be critical in future NASA missions to detect organics and the existence of life on other planetary bodies," said Anupam Misra. "The detection of such biomarkers would constitute groundbreaking evidence for life outside of planet Earth."



Credit: UH Mānoa/Scientific Reports

Biofinder detection of biological resides in fish fossil. (a) White light image of a Green River formation fish fossil (b) Fluorescence image of the fish fossil obtained by the Biofinder.

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https://optics.org/news/13/6/43

UK researchers using photonics to cut pesticide use for crop protection

Sensor being developed at Aston and Harper-Adams universities optically analyzes plant VOC emissions.

Each year, plant diseases cost the global economy over $220 billion. Scientists at two universities in the UK are starting a new project to develop a photonic "nose" to monitor crops for pest infestations and plant disease. Aston University is collaborating with Harper Adams University to research and develop technology using light to monitor crop health.

According to the Food and Agriculture Organization of the United Nations, annually up to 40 percent of global crop production is lost to pests. Each year, plant diseases cost the global economy over $220 billion, and invasive insects at least $70 billion.

The researchers, based in the UK Midlands, will be using strawberries to test the new technology. The fruit is worth £350 million ($430 million) to the UK economy but it is vulnerable to potato aphid which has the potential to wipe out an annual harvest. Currently crops are treated with pesticides, but there is increasing pressure to find alternatives due to their environmental impact.

Photonics analyzes levels of VOCs

One approach is to use integrated pest management to create an early warning system. It monitors plants for build-up of insects and diseases rather than spraying plants with chemicals, but so far it's proven unreliable and expensive.

The project uses recent developments in photonics technology that can analyse low levels of volatile organic compounds (VOCs) emitted by plants, which indicate their health. This is coupled with machine learning hardware which makes it practical to use artificial intelligence in commercial settings.

Professor David Webb of Aston Institute of Photonic Technologies (AIPT) commented, "Better invertebrate pest and plant disease monitoring technologies will significantly help cut crop losses. However most electronic noses use electrochemical sensors, which suffer from sensitivity issues, sensor drift/aging effects and lack specificity."

He added, "We intend to address this by building on the fast-moving technology of photonics - the science of light - whilst collaborating with scientists in other disciplines."

The 12-month project is to receive £200,000 from the UK's Biotechnology and Biological Sciences Research Council (BBSRC) and the Natural Environment Research Council. The grant is the maximum amount given from their molecules to landscapes project, which funds interdisciplinary solutions to real world challenges.

Dr Joe Roberts from Harper Adams University said, "With the projected increase in the global population there is increasing pressure on the agricultural sector to achieve higher crop yields. "Reducing crop losses within existing production systems will improve food security without increasing resource use.

"We intend to establish an interdisciplinary community of agricultural science, optical sensing and machine learning experts to develop novel plant health monitoring platforms that enhance agricultural production through localised pest and disease monitoring to detect hotspots."

Image courtesy of Aston / Harper-Adams universities.

Potato aphids, a threat to strawberries and other crops, can be detected optically.

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https://optics.org/news/13/8/1