2023
SPIE. | the business of photonics optics.org | 20 - 24 August 2023

OPTICS+ PHOTONICS PRODUCT FOCUS

In this Issue

ESO announces first light on HiRISE scope for studying exoplanets...

...and NASA's GEDI space laser solves longstanding rainforest canopy mystery.

The European Southern Observatory's Very Large Telescope (VLT) has been enhanced with a new instrument featuring an innovative concept that combines the capabilities of two flagship instruments already installed on the telescope.

The newcomer, dubbed HiRISE, will couple the SPHERE exoplanet imager and the CRIRES+ high-resolution spectrograph. While SPHERE has good resolution for direct imaging of exoplanets, CRIRES+ is 2,000 times more powerful when it comes to separating and analysing the light emitted by such planets – making it possible to determine the composition of their atmospheres.

By combining the two instruments via fiber optics, HiRISE will be able to carry out in-depth studies of known planets. It successfully captured its first light from the VLT in Chile's Atacama Desert on July 9, 2023.

HiRISE, which was developed at the Marseille Astrophysics Laboratory (France), benefited from the expertise of teams at the Grenoble Institute of Planetology and Astrophysics and at the JL Lagrange Laboratory.

NASA space laser solves rainforest canopy mystery

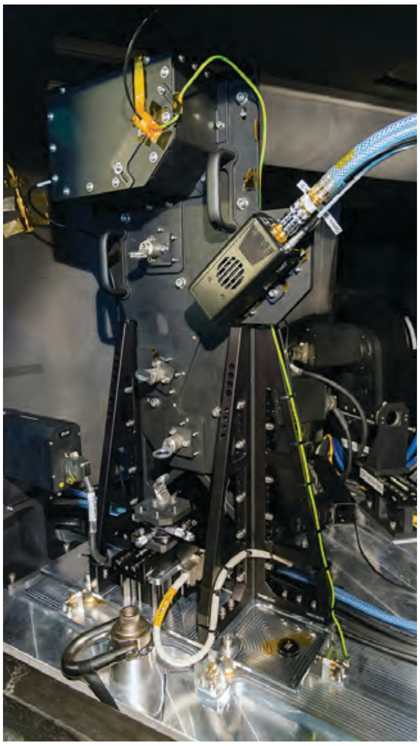
GEDI – a NASA-developed space laser – has provided a detailed structure of the world's rainforests for the first time ever, said its operational team, recently. The achievement is described in a paper in Environmental Research Ecology, entitled "Tropical forests are mainly unstratified especially in Amazonia and regions with lower fertility or higher temperatures".

Prof. Christopher Doughty, of Northern Arizona University's School of Informatics, Computing, and Cyber Systems, and first author on the study, commented, "Most of the world's species live in tropical forests and most of those make use of the canopy, and yet, we know so little. Rainforest structure matters because it controls how animals access resources and escape predators, and these findings will help us understand tropical forest animal's susceptibility to climate change."

'Three-dimensional canopy structure'

Hao Tang, professor in the Department of Geography at the National University of Singapore and co-author, added, "A key difference between GEDI and many other satellites is its measurement of three-dimensional canopy structure," said.

Tang, who is also a principal investigator at the NUS Center for Nature-based Climate Solutions, added, "Conventional satellites, while providing valuable data on land cover and canopy greenness, often lack the detailed vertical information offered by GEDI. This vertical information is crucial for understanding ecosystem dynamics, carbon storage and biodiversity that cannot be easily seen from typical satellite images."

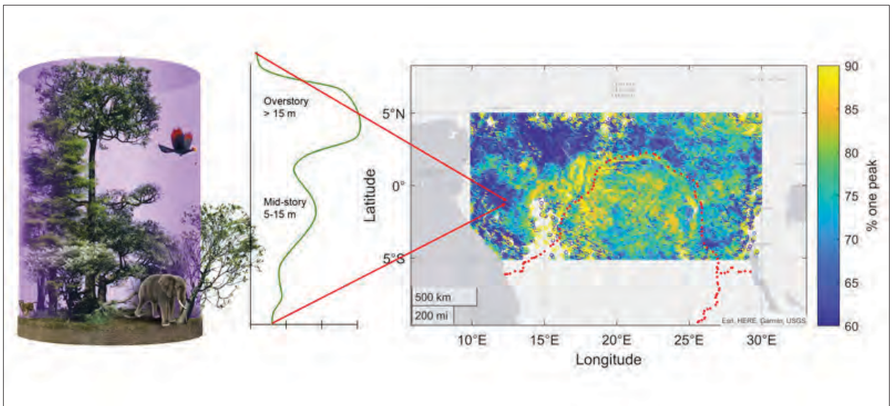


© Arthur VIGAN / LAM / CNRS Images.

HiRISE project fiber injection module in the SPHERE instrument on the VLT. It picks up the signal from a known exoplanet imaged by SPHERE, and this light is then carried by a fibre bundle to an extraction module that sends it to CRIRES+.

Launched in late 2018, NASA's GEDI transmits a laser beam from the International Space Station into Earth's forests thousands of times a day. Depending on the amount of energy returned to the satellite, it can provide a detailed 3D map that shows where the leaves and branches are in a forest and how they change over time.

Doughty, Tang and the other authors of the paper analyzed GEDI data across all tropical forests and found that the structure was simpler and more exposed to sunlight than previously thought. Data also revealed that most tropical forests (80% of the Amazon and 70% of Southeast Asia and the Congo Basin) have a peak in the number of leaves at 15 meters instead of at the canopy top, debunking the fullest-at-the-top theory of early researchers.



Credit: Nicolle Fuller and Chris Doughty.

Graph depicting canopy information obtained from GEDI.

https://optics.org/news/14/7/26

Blue Laser Fusion claims $25M seed round

Silicon Valley startup co-founded by Nobel laureate Shuji Nakamura aims to build a 'commercial-ready' fusion reactor by 2030.

Blue Laser Fusion (BLF), a startup firm in Palo Alto, California, says it has raised $25 million in an initial round of seed funding supporting its particular approach to laser-based fusion.

Co-founded by CEO Shuji Nakamura, who won a share of the 2014 Nobel Prize for Physics for the development of gallium nitride (GaN) blue LEDs, the company claims to have developed a novel approach capable of achieving laser fusion energy generation for power grids.

Investors include two top-tier venture capitalists in Japan, in the form of JAFCO Group Co., Ltd., and SPARX Group Co., Ltd (via the Toyota-backed Mirai Creation Fund III).

Nakamura, a professor at the University of California, Santa Barbara (UCSB), founded the company last year alongside Hiroaki Ohta from Waseda University Ventures (WUV), and Richard Ogawa, an attorney based in Silicon Valley.

The funding for BLF comes less than a month after EX-Fusion, another Japanese company targeting laser fusion for energy, raised $13 million, while other startups have gained US Department of Energy support for pilot schemes.

'HB11 fuel'

BLF has revealed little about its patent-pending technology, except that it utilizes megajoule-scale pulses with a fast repetition rate, but believes it will be able to build a viable reactor within seven years.

"BLF plans to complete its first prototype in 2025, and then demonstrate a commercial-ready fusion reactor by 2030," announced the company.

One thing that BLF has revealed is that it plans to use a hydrogen-boron fuel known as 'HB11' as a fusion target, not the deuterium-tritium material used in the landmark National Ignition Facility (NIF) experiment that confirmed the possibility of energy gain with laser inertial confinement fusion.

"The HB11 fuel is not radioactive, is free from harmful neutrons, yields safe helium elements, and is a naturally abundant mineral," stated Ohta, the firm's CTO. "HB11 is the perfect fuel for fusion and has no harmful neutron or tritium elements.

"We are pleased to be working with our group of world's top scientists and experts to not only ignite a fusion reaction with HB11 but maintain the reaction to create clean renewable energy.

Nakamura claimed: "Blue Laser Fusion has the best fusion technology in my view to achieve commercial fusion by 2030. I am so excited with our opportunity and the support. I have always looked for ways to help change the world and save our planet from carbon."

Toshiba involvement

The funding package will be used to expand the firm's research and development activity in the Santa Barbara area, and in Tokyo, where it plans to develop the prototype commercial reactor.

"Fusion is the ultimate energy source, and its successful commercialization will be a huge leap towards achieving clean and abundant energy for everyone," added Keisuke Miyoshi, the president and CEO of JAFCO.

"Advances in laser inertial technology, including Blue Laser Fusion's ability to execute the next generation of laser technology, provide the basis for a very exciting and promising path to the ultimate sustainable energy source."

Nakamura, who famously sued his former employer Nichia before co-founding the UCSB blue laser spin-out Soraa, reportedly told the Japanese business publication Nikkei that BLF would be working with Toshiba and YUKI Holdings on the reactor development.

Using HB11 fuel offers a key advantage for laser fusion in principle, since no neutrons are produced in the fusion reaction. Protecting optical components and other key parts of the system from high-energy neutron bombardment proved to be a major challenge during the NIF experiments, and would likely lead to high costs of protecting and replacing parts in a similar commercial system.

Nikkei says that around ten startup companies are currently working on laser fusion, with Australia's HB11 Energy also aiming to use the novel hydrogen-boron fuel.

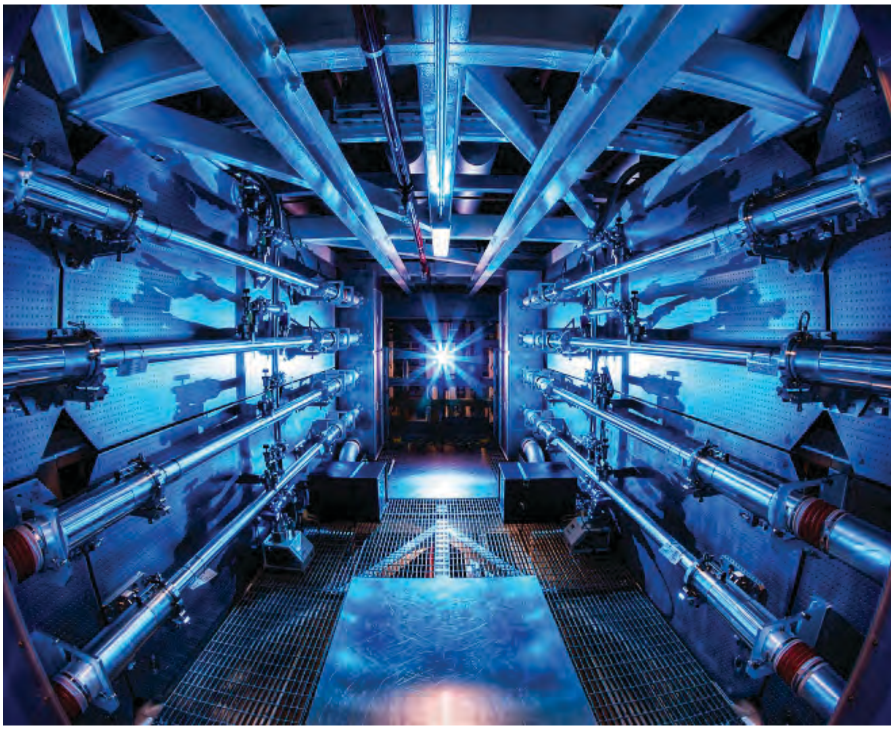


Photo: Damien Jemison/LLNL.

Although Blue Laser Fusion has revealed little about its specific approach to laser fusion for energy generation, it is known to be using hydrogen-boron fuel, instead of the deuterium-tritium target used in the critical NIF fusion experiments. This image shows the inside of pre-amplifier support structures in the giant NIF facility.

https://optics.org/news/14/7/44

Namuga selects Lumotive to manufacture 3D sensing solutions

Korea-based camera module maker Namuga is a supplier for Samsung's smart phones.

Optical semiconductor developer Lumotive has entered a commercial agreement with camera module specialist Namuga, which will use Lumotive's Light Control Metasurface (LCM) chipsets to develop solid-state lidar module solutions for a range of 3D sensing applications.

Publicly-traded in South Korea, Namuga makes cameras and 3D sensing modules. These components are integral to a variety of consumer electronics products such as notebooks, smartphones, and smart home automation. As a supplier for Samsung Electronics' flagship smart phones, including the Galaxy S23, Namuga also provides diverse capabilities for drones, head-mounted and head-up displays.

Using metamaterial-based technologies to steer laser beams without moving parts, Lumotive's LCM overcomes the size, scalability and reliability limitations of conventional mechanical beam steering systems.

Namuga says its expertise in the miniaturization of sensing modules, combined with the intrinsic advantages of LCM-based beam steering, "will enable lidar to expand into new domains of 3D sensing, particularly applications where compactness and weight are crucial."

Expanding the market

The partners aim to create a variety of solid state lidar modules that go beyond robotic automation solutions, extending into additional sectors such as services, homecare, and logistics. Lumotive's technology broadens Namuga's capabilities in perceiving surrounding information, enhancing performance and opening avenues into future ventures such as autonomous driving vehicles.

Dr. Sam Heidari, CEO of Lumotive, commented, "Our mission is to catalyze mass accessibility of solid-state lidar by partnering with innovative sensor makers like Namuga. We eagerly anticipate the application of our LCM digital beam steering chipsets in a broad spectrum of use-cases."

Tae Youn Won, CEO of Namuga, said, "Through this partnership we will accelerate the development of next-generation lidar technology and secure a technological and manufacturing competitive advantage in the global market. Based on Namuga's leading 3D sensing camera technology, we will take the lead in not only the autonomous driving car market, but also the next-generation device technology markets such as robotics, XR, and other innovative technologies."

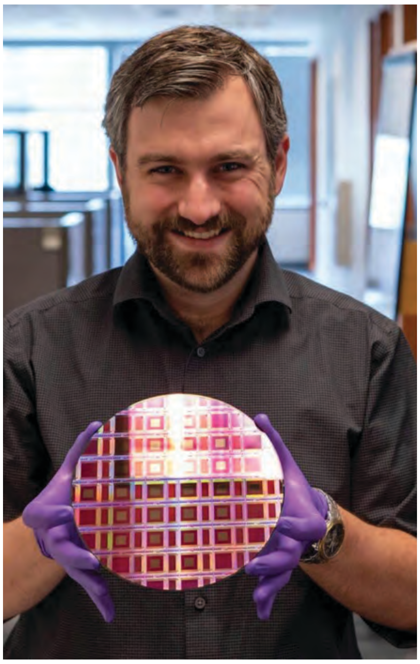


Image: Lumotive.

Light Control Metasurface™ (LCM) beam steering chips - now available as part of Lumotive's Technology Access Program.

https://optics.org/news/14/7/42

Novel 3D glass printing method works without sintering

Low-temperature process developed at KIT delivers a variety of high-resolution optics products.

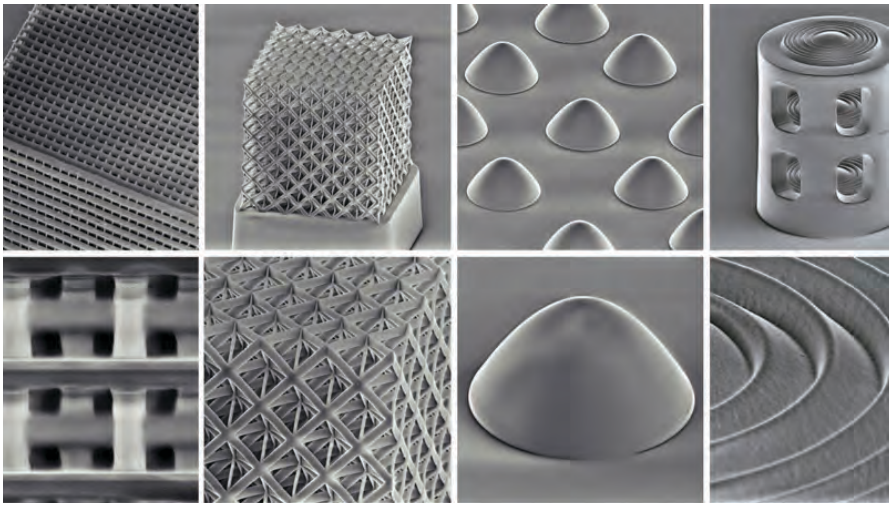
A new 3D glass printing process developed at Karlsruhe Institute of Technology (KIT), Germany, produces nanometer-fine quartz glass structures that can be printed directly onto semiconductor chips.

A hybrid organic-inorganic polymer resin serves as the starting material for the 3D printing of silicon dioxide. Since the process does not require sintering, the temperatures required are significantly lower. At the same time, higher resolution enables nanophotonics with visible light. The work is described in Science.

The printing of quartz glass made of pure silicon dioxide in micro- and nanometer-fine structures opens up new possibilities for many applications in optics, photonics and semiconductor technology. However, until now, techniques based on traditional sintering have dominated.

The temperatures required for the sintering of silicon dioxide nanoparticles are over 1,100 degrees Celsius – far too hot for direct deposition on semiconductor chips. A research team led by Dr. Jens Bauer from the KIT Institute of Nanotechnology (INT) has now developed a new process to produce transparent quartz glass with high resolution and excellent mechanical properties at significantly lower temperatures.

Bauer, who heads the Emmy Noether junior research group "Nanoarchitected Metamaterials" at KIT, and his colleagues from the University of California Irvine and the medical technology company Edwards Lifesciences in Irvine present the method in the journal Science.



(Image: Dr. Jens Bauer, KIT) Jens Bauer, KIT.

With the new process, a large variety of quartz glass structures can be produced on a nanometer scale.

Hybrid organic-inorganic polymer resin

A specially developed hybrid organic-inorganic polymer resin serves as the starting material. This liquid resin consists of so-called polyhedral oligomeric silsesquioxane molecules (POSS): tiny cage-like silicon dioxide molecules are equipped with organic functional groups.

Once formed, the fully 3D printed and networked nanostructure is heated in air to a temperature of 650 degC. In the process, the organic components are expelled and, at the same time, the inorganic POSS cages combine, resulting in a continuous fused silica micro- or nanostructure. The required temperature is only half that of processes based on the sintering of nanoparticles.

"The lower temperature makes it possible to print robust, transparent and free-form optical glass structures directly onto semiconductor chips with the resolution required for visible-light nanophotonics," explains Bauer. In addition to the excellent optical quality, the quartz glass produced in this way has excellent mechanical properties and is easy to process.

The team from Karlsruhe and Irvine printed many different nanoscale structures with the POSS resin, including photonic crystals of free-standing 97-nanometer beams, parabolic microlenses, and a multilens microlens with nanostructured elements. "Our process enables structures that also withstand difficult chemical or thermal conditions," said Bauer.

"The group at INT headed by Jens Bauer belongs to the Cluster of Excellence 3DMM2O," said Professor Oliver Kraft, VP Research at KIT. "The research results now published in Science are just one example of how well the consistent promotion of young talent within the cluster works."

The 3D Matter Made to Order cluster of excellence, a joint cluster of KIT and Heidelberg University, is combination of natural and engineering sciences a strongly interdisciplinary approach. His goal is to take 3D additive manufacturing processes to the next level – from the molecular level to macroscopic dimensions.

https://optics.org/news/14/6/13

Southampton develops 'time crystal' based on metamaterial

System developed by Prof. Nikolay Zheludev promises new optical and photonic devices.

A "time crystal", as originally proposed in 2012, is a new state of matter in which the particles are in continuous oscillatory motion. Time crystals break time-translation symmetry. Discrete time crystals do so by oscillating under the influence of a periodic external parametric force, and this type of time crystal has been demonstrated in trapped ions, atoms and spin systems.

Continuous time crystals are more interesting and arguably more important, as they exhibit continuous time-translation symmetry but can spontaneously enter a regime of periodic motion, induced by a vanishingly small perturbation. It is now understood that this state is only possible in an open system, and a continuous quantum-time-crystal state has recently been observed in a quantum system of ultracold atoms inside an optical cavity illuminated with light.

Related news: Aalto University creates photonic 'time crystals' that amplify light

Now researchers at University of Southampton, UK, say that a recent paper that they published in Nature Physics, "shows that a classical metamaterial nanostructure can be driven to a state that exhibits the same key characteristics of a continuous time crystal".

'New state of matter'

Prof. Nikolay Zheludev, one of the researchers who carried out the study, commented, "We have been studying light-matter interactions with nano-opto-mechanical metamaterials for several years.We recently realized that this was a perfect platform for demonstrating the time crystal state."

As part of their recent study, Prof. Zheludev and his colleagues set out to realize a continuous time crystal state using a photonic metamaterial. The system they used is a 2D array of plasmonic metamolecules – artificial structures that facilitate interaction with light at the nanoscale – supported by flexible nanowires.

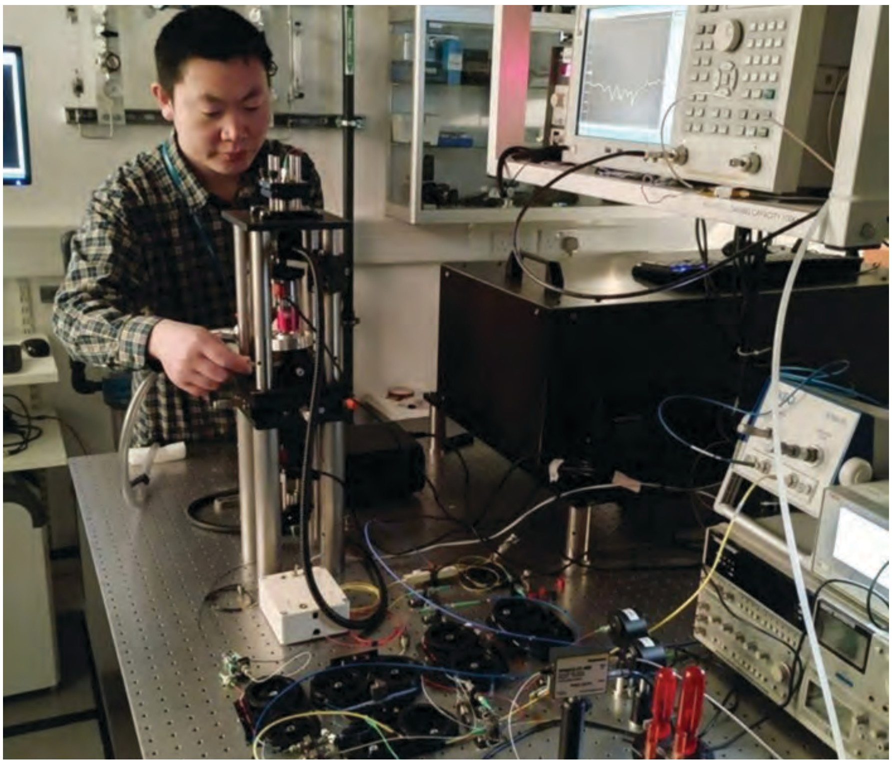
The researchers demonstrated that continuously and coherently illuminating this photonic metamaterial with a light that resonates with the plasmonic mode of the metamolecules contained within it caused a spontaneous phase transition to a state that possesses the key properties of a continuous time crystal. This state is characterized by continuous oscillations resulting from many-body interactions between the metamolecules.

"We found that a photonic metamaterial, an array of nanowires decorated with plasmonic nanoparticles, can be driven to the state of coherent oscillations of the nanowires by light-induced interaction between the particles," said Prof. Zheludev. "These oscillations emerge spontaneously upon reaching a threshold of light illumination. Such behavior constitutes a continuous time crystal, a new state of matter."

The recent study by this team of researchers could open new avenues for research into time crystals and dynamic classical many-body states in the strongly correlated regime. In the future, the unique system realized by Prof. Zheludev and his colleagues could also pave the way toward the development of new optical and photonic devices.

"We demonstrated a continuous time crystal, a new state of matter on a simple classical platform, which is a substantial step towards applications of the continuous time crustal state in photonics devices," Prof. Zheludev added. "The reported observation is only the beginning, and we will continue exploring fundamental properties of the nano-opto-mechanical metamaterial continuous time crystals and their applications."

https://optics.org/news/14/5/3



Credit: Liu et al.

Dr Tongun Liu, University of Southampton, UK performs experiments with the photonic time crystal on the nano-opto-mechanical platform.

Extremely Large Telescope now half completed, after nine years' work

ESO update says remaining half of Chile-based project expected to take just five more years.

The European Southern Observatory's Extremely Large Telescope (ELT) is a revolutionary, ground-based telescope that will have a 39-metre main mirror and in around five years will be the largest telescope in the world for collecting visible and infrared light. ESO this week reports that "construction of this technically complex project is advancing at a good pace, with the ELT now surpassing the 50% complete milestone."

The telescope is located atop Cerro Armazones in Chile's Atacama Desert, where engineers and construction workers are currently assembling the structure of the telescope dome at a staggering pace. Visibly changing each day, the steel structure will soon acquire the familiar round shape typical of telescope domes.

The telescope mirrors and other components are being built by companies in Europe, where work is also progressing well. ESO's ELT will have a pioneering five-mirror optical design, which includes a giant main mirror (M1) made up of 798 hexagonal segments. More than 70% of the blanks and supports for these segments have now been manufactured, whileM2 and M3 are cast and in the process of being polished.

Progress on M4, an adaptive, flexible mirror that will adjust its shape a thousand times a second to correct for distortions caused by air turbulence, is particularly impressive, notes the ESO statement: "All six of its thin petals are fully finalised and being integrated into their structural unit. Further, all six laser sources, another key component of the ELT's adaptive optics system, have been produced and delivered to ESO for testing."

All other systems needed to complete the ELT, including the control system and the equipment needed to assemble and commission the telescope, are also progressing well in their development or production. Moreover, all four of the first scientific instruments the ELT will be equipped with are in their final design phase with some about to start manufacturing. In addition, most of the support infrastructure for the ELT is now in place at or near Cerro Armazones.

Photo: ESO.

Night view of the ELT under construction atop Cerro Armazones.

For example, the technical building that, among other things, will be used for storage and coating of different ELT mirrors is fully erected and fitted out, while a photovoltaic plant that supplies renewable energy to the ELT site started operating last year. Construction of ESO's ELT commenced in 2014 with a groundbreaking ceremony. The top of Cerro Armazones was flattened in 2014 to make space for the giant telescope.

'Quicker completion'

Completing the remaining 50% of the project, however, is anticipated to be significantly quicker than building the first half of the ELT. The first half of the project included the lengthy and meticulous process of finalising the design of the vast majority of components to be manufactured for the ELT.

In addition, some of the elements, such as mirror segments and its supporting components and sensors, required detailed prototyping and significant testing before being produced en masse. Furthermore, construction was affected by the Covid-19 pandemic, with the site closing for several months and production of many of the telescope components suffering delays.

With production processes now fully resumed and streamlined, finalising the remaining half of the ELT is anticipated to take only five years. Nonetheless building such a large and complex telescope like the ELT is not free of risks until it's finished and working.

ESO Director General Xavier Barcons says: "The ELT is the largest of the next generation of ground-based optical and near-infrared telescopes and the one that is most advanced in its construction.

Barcons added, "Reaching 50% completion is no small feat, given the challenges inherent to large, complex projects, and it was only possible thanks to the commitment of everyone at ESO, the continued support of the ESO Member States and the engagement of our partners in industry and instrument consortia. I am extremely proud that the ELT has reached this milestone."

Scheduled to start scientific observations in 2028, ESO's ELT will tackle astronomical questions such as: Are we alone in the Universe? Are the laws of physics Universal? How did the first stars and galaxies form? It will dramatically change what we know about our Universe and will make us rethink our place in the cosmos.

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

Dual frequency illumination fights E. coli superbugs

New Zealand's AgResearch combines blue and UV light to counter antibiotic resistance.

The ability of bacteria and microbial pathogens to become resistant to the antimicrobial treatments intended to kill them is a global issue, identified by the World Health Organisation (WHO) as one of the top ten health concerns.

Optical techniques have been valuable tools in the fight against antimicrobial resistance (AMR), stemming principally from the ability of UV light and ultrashort-pulse illumination to disrupt the protein structures in a pathogen and alter its potency.

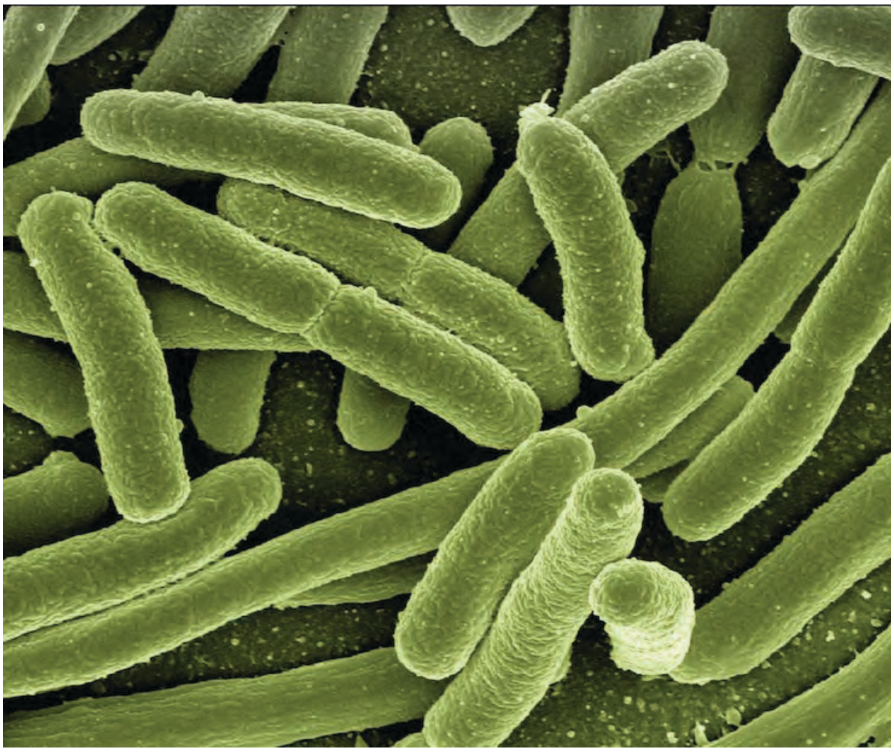
Use of basic UV irradiation is not a perfect solution, however. Beyond the potential for damage to healthy cells, there are many mechanisms through which bacteria can adapt to UV exposure and repair the protein damage caused by the light. Repetitive exposure can also breed tolerance and an increase in AMR.

A project at New Zealand research institute AgResearch has now studied a novel dual wavelength regime, whereby bacteria are illuminated with both blue and far-UVC light.

The group targeted extended spectrum β-lactamase producing E. coli (ESBL-Ec), a treatment-resistant bacteria listed as a Priority 1 pathogen by the WHO.

"Our previous work showed that dual blue LED and far-UVC wavelengths were virucidal against feline infectious peritonitis virus (FIPV) in solution and on different surfaces, indicating the potential of dual light wavelengths to be effective against bacteria," commented the project in its Journal of Applied Microbiology paper.

"In this study, we aimed to investigate the effect of dual blue LED (405 nanometer) and far-UVC (222 nanometer) light on the inactivation of clinically relevant ESBL-Ec, and determine whether repetitive exposure to long pulse doses of dual or individual light wavelengths results in changes to light tolerance and antibiotic susceptibility."



Credit: Pixabay/stock photo.

Dual wavelength illumination offered more effective antibiotic action than either wavelength individually.

Disinfection of public places in shorter times

In trials, the AgResearch group found that combining the two wavelengths inhibited the potency of the E. coli, by triggering different mechanisms that disrupt the activity of the microorganisms. The same method was also shown to deactivate another variant of E. coli that does respond to antibiotic treatment, suggesting that the dual-light technique could be used to combat a broad range of harmful microbes.

The overall effect achieved by a dual light treatment was always greater than that from exposure to the wavelengths individually, indicating a synergistic relationship between blue LED and far-UVC light when used together.

However, the researchers also found that ESBL-Ec can start to tolerate light after repeated irradiation at sublethal levels, an effect that was not observed for the variant that is sensitive to antibiotics. So further work is needed to understand whether the light tolerance exhibited by ESBL-Ec might be caused by a genetic change or whether some other mechanism is involved, according to the AgResearch team.

If dual light illumination can be optimized, it may allow whole-room disinfection in shorter timescales than those needed for current UV-only methods, as lower far-UVC doses would be expected to achieve the same outcome. But for that to happen, the safety of dual far-UVC and blue LED light applications in public places would need to be investigated, noted the project.

"There is great potential for these two light wavelengths to be used together in many applications where safety to the end user is of most importance," commented Amanda Gardner of AgResearch. "It will also be important to investigate the development of light tolerance in other antimicrobial-resistant bacteria, and to determine the minimum dose of far-UVC light that can create light tolerance."

https://optics.org/news/14/8/1

Berkeley Lab mixes different color fiber lasers to form ultrashort pulses

New technique set to boost the potential of laser-plasma accelerators.

A team of researchers from the Accelerator Technology & Applied Physics (ATAP) Division at Berkeley Lab, California, has developed a new technique for combining fiber lasers operating at different wavelengths to produce ultrashort laser pulses.

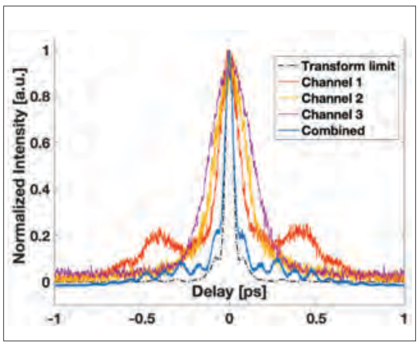
The team says the work could advance the development of laser-plasma accelerators (LPAs), which have the potential to push the frontiers of high-energy physics and enable discoveries in materials science, fusion research, and many other areas.

LPAs use intense, ultrafast laser pulses passing through a plasma to accelerate charged particles up to a thousand times faster than current technologies. They promise more compact and powerful machines that are less expensive to build and operate than conventional accelerators.

The research was published in Optics Express.

Currently, most LPAs use laser pulses with repetition rates of only a few Hertz; however, realizing the full potential of LPAs "will require high-power laser systems capable of generating ultrashort, high-energy laser pulses at repetition rates in the kHz range or higher," said Siyun Chen, a researcher at ATAP's BELLA Center, who led the experimental demonstration of the new technique.

These constraints, added Chen, place demanding requirements on the laser systems that generate such pulses. So, the researchers turned to fiber lasers, which she explained are the "most efficient high-power laser technology demonstrated to date and also have extensive industrial development that could be leveraged in our work."



Credit: Berkeley Lab.

Measured autocorrelation traces after compression (combined pulse and pulse from each channel) and calculated autocorrelation trace of the transform-limited pulse for the combined spectrum.

Although the energy and power of pulses produced by fiber lasers can be scaled up by combining multiple pulses in space and in time, these pulses, however, are currently limited to about 100 fs, which are not short enough to drive LPAs.

"While fiber laser systems offer the highest wall-plug efficiencies—the electrical-to-optical power efficiency—the spectrum of ultrashort laser pulses amplified in these systems narrows," explained Tong Zhou, a research scientist in ATAP's BELLA Center who led the development of the new technique.

Spectral combination

"This gain narrowing is a fundamental effect when laser pulses are amplified in this way; the narrower the pulse's spectrum is, the longer its duration. Consequently, it is very challenging for high-power fiber lasers to generate pulses shorter than about a hundred fs."

However, by spectrally combining multiple laser pulses operating at adjacent wavelength ranges, the team, which also included Qiang Du from the Engineering Division and Dan Wang and Russell Wilcox from ATAP, achieved an ultra-broad combined spectrum able to support very short pulses at tens of femtoseconds.

To increase the bandwidth and produce tens-of-fs-long pulses, the researchers first used a mode-locked oscillator and ytterbium-doped fiber amplifier to generate pulses of 120 fs at 100 MHz repetition rates. These were sent to a photonic-crystal fiber, where their spectrum was broadened from 27 nm to 90 nm.

Credit: Paul Mueller/Berkeley Lab.

Research Scientists Tong Zhou (left) and Siyun Chen work on the spectral combining of multiple fiber lasers in the Fiber Laser Lab at ATAP.

"This ultra-broadband spectral combining with synthesized pulse shaping produced pulses of only 42 fs in duration, which is significantly shorter than the pulses generated from each of the three fiber channels," said Chen. "We believe this is the shortest pulse duration ever achieved from a spectrally combined ytterbium fiber laser system."

Zhou said, "While the work has demonstrated ultrafast pulses that are so far at low energy, it demonstrates the key principles of ultra-broadband spectral combining and coherently spectrally synthesized pulse shaping and provides a path forward for using fiber lasers to drive LPAs."

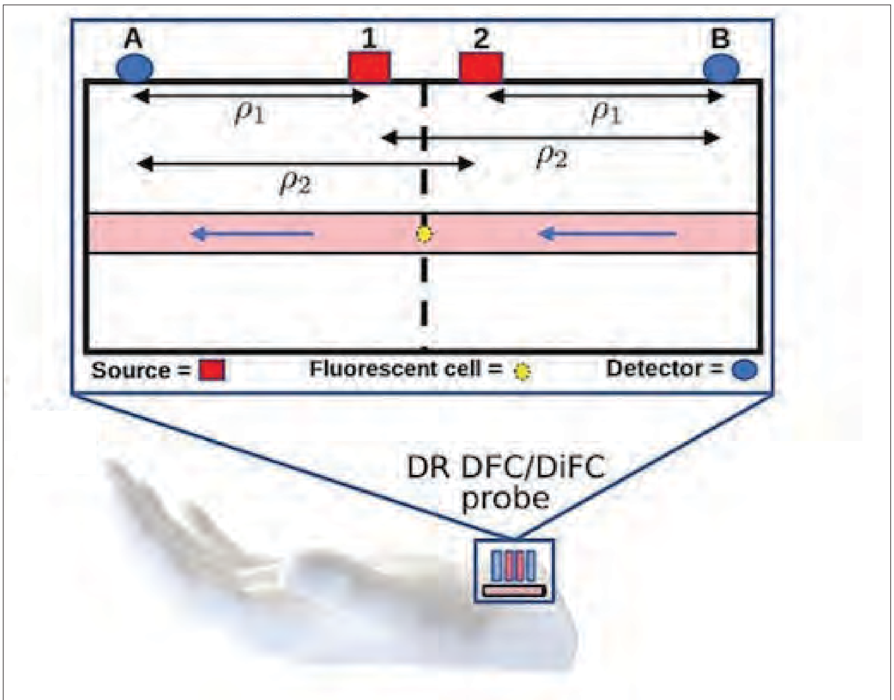
The team plans to add more amplification stages and implement multidimensional techniques capable of spatially, temporally, and spectrally combining fiber lasers to produce high-energy, tens-of-fs laser pulses.

https://optics.org/news/14/2/34

Tufts University detects circulating tumor cells in blood

Dual-ratio approach enhances fluorescence signal during sensing in biological systems.

Fluorescence techniques to observe numerically sparse circulating tumor cells (CTCs) in the bloodstream could offer a way to detect cancer as it undergoes metastasis and observe malignant cells and the measurement depths achieved can be severely affected by background noise, especially if it originates from the inherent autofluorescence of other cells and tissues in the examined area.



Credit: Tufts/Northeastern.

The dual-ratio (DR) diffuse in-vivo flow cytometry (DiFC) is a novel technique that uses two laser sources and two detectors to mitigate the effects of noise and autofluorescence, which may enable doctors to precisely detect fluorescent tags attached to circulating tumor cells in the bloodstream.

as they move around the body.

Flow cytometry, in which cells tagged with fluorescent markers are illuminated while passing along a narrow channel, is one promising technique, potentially revealing information about cell size and DNA content.

If CTCs are labeled with a fluorescent agent, then a flow cytometry approach with a laser directed directly onto an artery will induce fluorescent emission in any labelled cells present, and the emission can be related directly to the presence and number of those CTCs. This operation is termed diffuse in vivo flow cytometry (DiFC).

However, in practice DiFC performance

A project at Tufts University and Northeastern University has now developed a new optical measurement method intended to suppress this interference and enhance the signal to noise ratio in deep tissue regions. The study was published in Journal of Biomedical Optics.

The project applied a dual-ratio (DR) approach, originally developed for spectroscopy techniques and now adopted for DiFC, in which two laser sources and two detectors are utilized. This should allow interference from autofluorescence emitted by species in the artery and by the surface skin to be reduced, although how best to apply the principle to DiFC had not been studied until now.

Detection of cancer markers without taking blood samples

To optimize a DR approach, the project first ran Monte-Carlo analysis techniques to simulate various noise and autofluorescence parameters, along with different source/detector configurations. It also conducted DR DiFC experiments using an artificial tissue-mimicking flow phantom, with fluorescent microspheres taking the place of cells.

Lastly, the team used its optimized technique to measure the AF of the skin and the underlying muscle of mice, to assess the variation of noise with tissue type and depth in a real-world scenario. The distribution of autofluorescence sources and the proportion of noise not cancelled by the dual-ratio approach proved to be the key parameters.

"The experiments revealed that dual-ratio DiFC was superior to standard DiFC if the fraction of noise not canceled by DR was under 10 percent, and if the contributions to auto-fluorescence were surface-weighted, being near the surface rather than evenly distributed in the target volume," commented the research team.

"However, as the experiments in mice suggested, autofluorescence is typically much higher in skin than in the underlying muscle, implying that DR DiFC may offer an advantage over standard DiFC in most cases. If autofluorescence was near the surface rather than being homogeneous, the dual-ratio version had a significantly higher penetration range than standard DiFC."

The team anticipates that establishing these principles will now help position DR DiFC as an emerging technique to non-invasively detect fluorescent molecules in the bloodstream, potentially enabling doctors to quickly detect cancer cells in the blood of patients without having to draw samples. Other cell types and molecules of interest may also ultimately be identifiable in the same way.

https://optics.org/news/14/7/39

Iridian Spectral Technologies

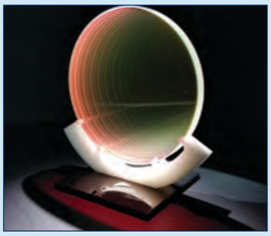
Visit us at Booth #510

"More signal, less background – custom wavelength selective optical filters"

Need a way to manage optical signal from background/noise in your optical systems?

Iridian designs and manufactures wavelength selective optical filters from 300nm-15um including narrow single or multi-band/edge/notch filters as single element filters or multi-zone/multispectral filter arrays customized to meet the needs of applications such as remote sensing and detection *(Earth observation, LiDAR, astronomy, NDIR gas detection)*, spectroscopy *(Raman, fluorescence)*, communications *(telecom/datacom/satcom)* and many more.

See us at SPIE Optics+Photonics Booth#510



Contact Details

Iridian Spectral Technologies
2700 Swansea Crescent, Ottawa, ON, Canada K1G6R8
www.iridian.ca
sales@iridian.ca
Tel: +1 (613) 741 4513
Twitter: @IridianSpectral

Omega Optical Holdings

Visit us at Booth #608

Optometrics Gratings in a week

Our ultrafast replication allows rapid delivery of any of our 400+ designs with performance and accuracy.

Move fast on project designs by replicating the critical surface finish and figure onto selected, less expensive, and pre-aligned integral system components.

Our gratings offer low RMS at a fraction of the original cost for diffractive, transmissive, and reflective components.

Visit the stand 608 to find out how we can help you.

Contact Details

Optometrics
Tel: +(978) 772-1700
sales@optometrics.com
tinyurl.com/jzz7evvp

TRIOPTICS GmbH

Visit us at Booth #519

Does your objective lens production give you a headache?

Learn how we can help and talk to our experts at the SPIE Optics+Photonics Conference and Exhibition in San Diego, California, USA, booth #519.

TRIOPTICS products set the standard for optical metrology, thus book an appointment with us (sales@trioptics.com) to discuss how to optimize the production process for your objective lenses.

Learn how we will assist and guide you through the implementation of this process.

Contact Details

TRIOPTICS GmbH
www.trioptics.com
sales@trioptics.com
Tel: +49 4103 18006-0

optikos

Visit us at Booth #635

Bring your next optically-based product from design through production with Optikos

Optikos provides complete optical product design, contract manufacture and testing with full performance verification for defense clients who need a custom imaging solution they can depend on in critical applications.

Our expert optical engineering and IQ Lab™ teams ensure superior lens performance—and clients own the design.

Learn more at booth #635 at SPIE Optics + Photonics or email sales@optikos.com

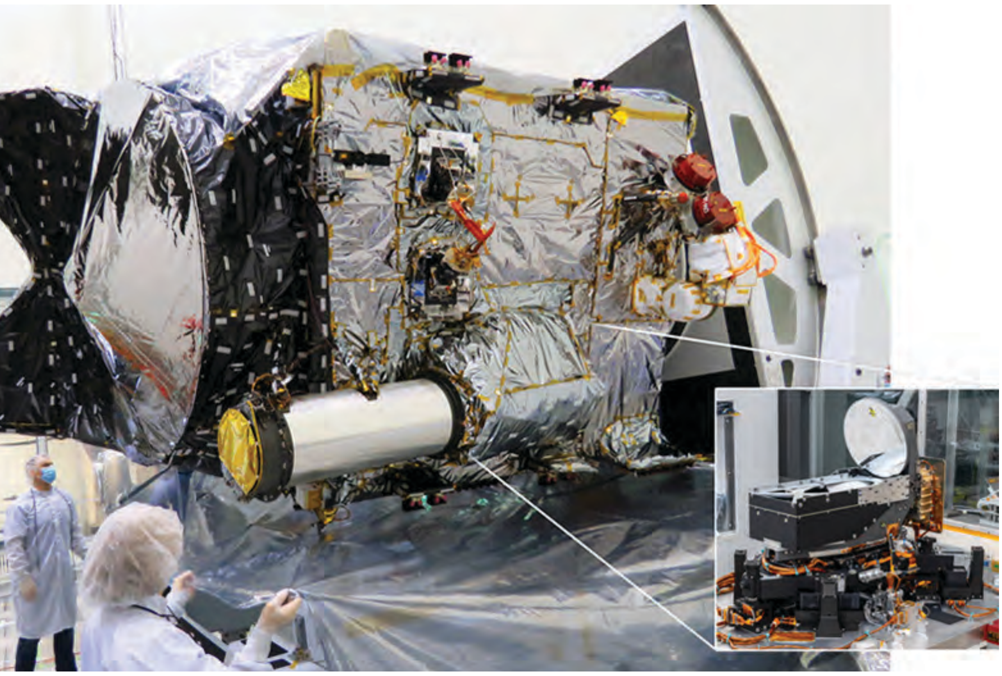
Optikos®

Contact Details

Optikos Corporation
107 Audubon Road, Bldg. 3
Wakefield, MA 01880
www.optikos.com
sales@optikos.com
Tel: +1 (617) 354-7557
Fax: +1 (617) 354-5946

NASA's deep space communications to get a laser boost

New source could transmit more complex science data, and even stream video from Mars.



Credits: NASA/JPL-Caltech.

The Deep Space Optical Communications (DSOC) flight transceiver is inside a large tube-like sunshade and telescope on the Psyche spacecraft, as seen here inside a clean room at JPL. An earlier photo, inset, shows the transceiver assembly before it was integrated with the spacecraft.

Set to launch this fall, NASA's Deep Space Optical Communications (DSOC) project will test how lasers could speed up data transmission far beyond the capacity of current radio frequency systems used in space. What's known as a technology demonstration, DSOC may pave the way for broadband communications that will help support humanity's next giant leap: when NASA sends astronauts to Mars.

The DSOC near-infrared laser transceiver (a device that can send and receive data) will "piggyback" on NASA's Psyche mission, when it launches to a metal-rich asteroid of the same name in October. During the first two years of the journey, the transceiver will communicate with two ground stations in Southern California, testing highly sensitive detectors, powerful laser transmitters, and novel methods to decode signals the transceiver sends from deep space.

NASA is focused on laser, or optical, communication because of its potential to surpass the bandwidth of radio waves, which the space agency has relied on for more than half a century. Both radio and near-infrared laser communications use electromagnetic waves to transmit data, but near-infrared light packs the data into significantly tighter waves, enabling ground stations to receive more data at once.

"DSOC was designed to demonstrate 10 to 100 times the data-return capacity of state-of-the-art radio systems used in space today," said Abi Biswas, DSOC's project technologist at NASA's Jet Propulsion Laboratory in Southern California. "High-bandwidth laser communications for near-Earth orbit and for Moon-orbiting satellites have been proven, but deep space presents new challenges."

There are more missions than ever headed for deep space, and they promise to produce exponentially more data than past missions in the form of complex science measurements, high-definition images, and video. So experiments like DSOC will play a crucial role in helping NASA advance technologies that can be used routinely by spacecraft and ground systems in the future.

"DSOC represents the next phase of NASA's plans for developing revolutionary improved communications technologies that have the capability to increase data transmissions from space – which is critical for the agency's future ambitions," said Trudy Kortes, director of the Technology Demonstrations Missions (TDM) program at NASA Headquarters in Washington. "We are thrilled to have the opportunity to test this technology during Psyche's flight."

Groundbreaking technologies

The transceiver riding on Psyche features several new technologies, including a never-before-flown photon-counting camera attached to an 8.6in (22cm) aperture telescope that protrudes from the side of the spacecraft. The transceiver will autonomously scan for, and "lock" onto, the high-power near-infrared laser uplink transmitted by the Optical Communication Telescope Laboratory at JPL's Table Mountain Facility near Wrightwood, California. The laser uplink will also demonstrate sending commands to the transceiver.

"The powerful uplink laser is a critical part of this tech demo for higher rates to spacecraft, and upgrades to our ground systems will enable optical communications for future deep space missions," said Jason Mitchell, program executive for NASA's Space Communications and Navigation (SCaN) program at NASA Headquarters.

Once locked onto the uplink laser, the transceiver will locate the 200in (5.1m) Hale Telescope at Caltech's Palomar Observatory in San Diego County, California, about 100 miles (130 kilometers) south of Table Mountain. The transceiver will then use its near-infrared laser to transmit high-rate data down to Palomar. Spacecraft vibrations that might otherwise nudge the laser off target will be dampened by state-of-the-art struts attaching the transceiver to Psyche.

continued on next page

continued from previous page

NASA's deep space communications to get a laser boost

To receive the high-rate downlink laser from the DSOC transceiver, the Hale Telescope has been fitted with a novel superconducting nanowire single photon detector assembly. The assembly is cryogenically cooled so that a single incident laser photon can be detected and its arrival time recorded.

Transmitted as a train of pulses, the laser light must travel more than 200 million miles (300 million kilometers) – the farthest the spacecraft will be during this tech demo – before the faint signals can be detected and processed to extract the information.

"Every component of DSOC exhibits new technology, from the high-power uplink lasers to the pointing system on the transceiver's telescope and down to the exquisitely sensitive detectors that can count the single photons as they arrive," said JPL's Bill Klipstein, the DSOC project manager. "The team even needed to develop new signal-processing techniques to squeeze information out of such weak signals transmitted over vast distances."

The distances involved pose another challenge for the tech demo: The farther Psyche journeys, the longer the photons will take to reach their destination, creating a lag of up to tens of minutes. The positions of Earth and the spacecraft will be constantly changing while the laser photons travel, so this lag will need to be compensated for.

"Pointing the laser and locking on over millions of miles while dealing with the relative motion of Earth and Psyche poses an exciting challenge for our project," said Biswas.

https://optics.org/news/14/8/12

Credits: Caltech.

The Hale Telescope at Caltech's Palomar Observatory in San Diego County, California, will receive the high-rate data downlink from the DSOC flight transceiver. The telescope is fitted with a novel superconducting detector that is capable of timing the arrival of individual photons from deep space.

First Solar to build fifth US factory

US module maker to spend $1.1BN on new domestic manufacturing site scheduled to begin production within three years.

The major photovoltaic module maker First Solar has revealed plans to build another manufacturing facility in the US - the fifth in its home country

Costing an anticipated $1.1 billion, the new site is expected to be up and running in the first half of 2026, and will produce the firm's "Series 7" cadmium telluride (CdTe) modules.

The announcement is the latest in a major expansion of the firm's US manufacturing footprint, partly facilitated by the Inflation Reduction Act (IRA), with a new facility in Ohio completed, and another in Alabama under construction.

Bifacial panels

Revealing news of the planned expansion alongside the firm's latest financial results, First Solar's CEO Mark Widmar said that the additional investment would put it on track to a production capacity of 25 GW globally by 2026 - of which 14 GW would be in the US.

Widmar added that the new Ohio factory had produced a total of 425 MW in the second quarter, with the best-performing Series 7 modules now producing a maximum output of 540 W - equivalent to an efficiency of 19.3 per cent.

"We sold 215 MW of Series 7 modules in Q2 and are pleased to note that the product is already being deployed in three projects: in Arkansas, Arizona, and Mississippi," he said.

Meanwhile, First Solar is making a number of moves to increase PV module efficiency with technological advances including the future incorporation of perovskite and cadmium indium gallium diselenide (CIGS) layers in tandem cell designs.

Widmar pointed out that the latest quarter saw an initial production run of the firm's first bifacial module panels, which utilize what he called an advanced thin-film semiconductor.

"The bifacial model features an innovative transparent back contact," explained the CEO. "Pioneered by First Solar's research and development team, the transparent back contact, in addition to enabling bifacial energy gains, allows infrared wavelengths of light to pass through rather than be absorbed as heat.

Photo: First Solar/Business Wire.

First Solar is set to invest up to $1.1 billion in further expanding its US manufacturing footprint to produce its own photovoltaic solar modules. The latest facility, the location of which is yet to be determined, is expected to grow the company's nameplate manufacturing capacity by 3.5 GW, to reach approximately 14 GW in the US and 25 GW globally in 2026.

"This is expected to lower the operational temperature of the bifacial module, resulting in higher specific energy yield. We believe that the transparent back contact is a foundational step toward the development of future tandem products."

Perovskite possibilities

Widmar also commented on the firm's recent acquisition of Sweden's Evolar, which has expertise in both perovskite and CIGS technology, and is expected to accelerate First Solar's development of tandem devices offering potentially much higher module efficiencies.

Discussing the deal with investors, he said: "Efficiency is obviously important, but you also need something that's stable. And perovskite, in general, has historically had issues and challenges with trying to demonstrate long-term durable stable devices."

Regarding CIGS, Widmar said Evolar had "very deep" capabilities, having demonstrated efficiencies greater than 23 per cent.

"We think that there's a potential for a [thin-film CIGS] tandem technology that can get to market sooner than maybe perovskites can at this point in time."

First Solar's stock price was little-changed after the latest results showed that the company had posted a net income of $170 million on sales of $811 million in the three months ending June 30 - with both figures up strongly on the same period last year.

"With half of 2023 behind us, we continue to see strengthened commercial, operational, and financial foundations, both in 2023 and in the coming years as we continue to grow," observed Widmar.

https://optics.org/news/14/8/3

Department of Energy announces $28.5 million for LaserNetUS

LaserNetUS is North America's high intensity laser research network – for scientists from U.S. and abroad.

Earlier this month, the U.S. Department of Energy's Office of Science announced $28.5 million in new funding for LaserNetUS to advance discovery science and inertial fusion energy.

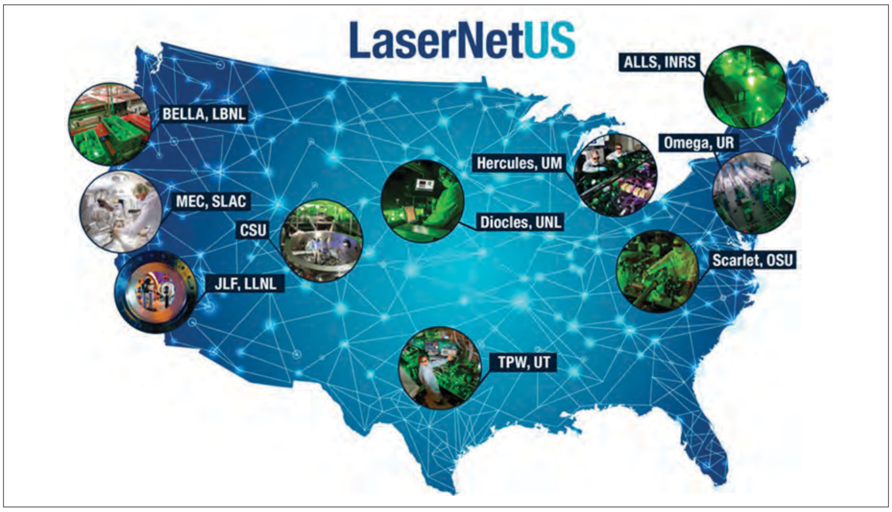
The LaserNetUS facilities are located at universities and national laboratories distributed geographically throughout the U.S. and Canada. The network currently has more than 1200 members.

"LaserNetUS has been extremely successful in providing opportunities and capabilities that were largely unavailable to the broad community prior to the formation of this network," said Jean Paul Allain, Associate Director of Science for Fusion Energy Sciences (FES). "In this new phase, the network will play an important role in advancing inertial fusion energy in addition to discovery plasma science."

Projects funded under this announcement will explore astrophysics and planetary science, laser-produced plasmas, laser Wakefield acceleration, EUV lithography, cancer radiotherapy with laser-driven radiation, radiography and tomography, materials science, and inertial confinement fusion.

LaserNetUS was established by the FES program in response to a recommendation from the National Academies of Sciences, Engineering, and Medicine report, "Opportunities in Intense Ultrafast Lasers: Reaching for the Brightest Light."

The projects were selected by competitive peer review under the DOE Funding Opportunity Announcement for LaserNetUS for Discovery Science and Inertial Fusion Energy. They are scheduled to last up to three years, with total funding of $28.5 million: $11.4 million in FY23 and $17.1 million in outyear funding – contingent on congressional appropriations.



Graphic: LaserNetUS.

LaserNetUS includes the most powerful lasers in the United States and Canada, some of which have powers approaching or exceeding a petawatt.

DoE pledges $450M for solar power in Puerto Rico

The DOE has also announced up to $453.5 million [investment] from the Puerto Rico Energy Resilience Fund (PR-ERF), which is aimed at increasing residential rooftop solar PV and battery storage installations across the region, "with a focus to reach and support Puerto Rico's most vulnerable residents."

This round of funding is intended provide consumer protection and education initiatives to support residents' long-term use of solar systems as well as a Solar Ambassador Prize for community groups to help the DOE identify and connect with eligible households – "helping achieve Puerto Rico and President Biden's goal of lowering energy costs with a resilient grid powered by 100% renewable energy," as the DOE statement said.

U.S. Secretary of Energy Jennifer M. Granholm commented, "A future powered by renewables will offer the residents of Puerto Rico more energy security and more reliability—all while leaving households with cheaper bills. DOE is using every tool at our disposal to expand access to clean energy, especially for the communities most at risk, giving families the peace of mind knowing that their communities are resilient in the face of the climate crisis."

https://optics.org/news/14/8/8

Photo courtesy of Maria Gallucci / Canary Media.

Raúl González, left, and Marisel Robles help maintain the solar system on the Mutual Support Center's rooftop in Caguas, Puerto Rico.

Sandia Labs invents method to integrate micro-optical devices on silicon

New Mexico-based lab awarded patent for technique of integrating multiple materials onto silicon.

A novel type of silicon-integrated micro-laser, developed by scientists at Sandia National Laboratories, based in Albuquerque, NM, can be combined with other micro-scale optical devices. Its developers say it promises improvements for self-driving cars safer, data centers, biochemical sensors, and defense technologies.

Sandia has been awarded a patent for its new method of integrating many different materials onto silicon.

The new method enables the creation of high-bandwidth, high-speed optical devices, including indium phosphide lasers, lithium niobate modulators, germanium detectors and low-loss acousto-optic isolators.

Sandia's statement of August 1st notes, "Building a laser on silicon is a challenging and unusual feat that could extend America's leadership in semiconductor technology. Other organizations, including the University of California, Santa Barbara, and Intel, have built similar lasers, but Sandia has broadened the class of devices that can be integrated. For the first time, these devices could work together on optical microchips, also called photonic integrated circuits."

Sandia scientist Patrick Chu explained, "This [development] allows the U.S. to lead and have less dependency on foreign manufacturing capabilities." Chu co-leads the U.S. National Security Photonics Center, a group of more than 60 photonics scientists and engineers based at Sandia's Microsystems Engineering, Science and Applications complex.

Integration with silicon

"Silicon is the lifeblood of the semiconductor industry and a great material for making computer chips. However, by itself, it's a lousy material for making lasers," commented Sandia research scientist Ashok Kodigala, a co-inventor of the new integration process.

Kodigalala's challenge was to design a way for optical components made from a variety of materials to coexist on a silicon microchip. Kodigala fused them to silicon in complex layers, in a process also called heterogeneous integration.

The Sandia team successfully demonstrated heterogenous integration techniques to create hybrid silicon devices: hybrid lasers and amplifiers made from both indium phosphide and silicon, and similarly modulators made of both lithium-niobate and silicon, which encode information in light generated from the lasers.

Now Sandia says that semiconductor fabs could exploit its new integration technique. The lab built its chip-scale lasers with a goal of transferring the technology to industry. The team used many of the same tools found at commercial semiconductor plants, and the lasers generate light in wavelengths commonly used in the telecommunications industry, known as C-band and O-band.

Kodigala said, "Once we demonstrate this photonic platform at a national lab, we can then pass this technology on to U.S. companies, where they can focus on even larger-scale production for commercial and U.S. government applications."

He conceived his method with funding from Sandia's Laboratory Directed Research and Development program and developed it under a Defense Advanced Research Projects Agency program called Lasers for Universal Microscale Optical Systems.

Photo credit: Craig Fritz.

More than a thousand experimental lasers and amplifiers adorn a three-inch, gold-electroplated silicon wafer made at Sandia National Laboratories' Microsystems Engineering, Science and Applications complex.

Supporting the CHIPS and Science Act

In 2022, U.S. President Joe Biden signed the CHIPS and Science Act – a nonpartisan, $52.7 billion boost for the semiconductor industry. While the legislation is expected to increase production of American-made computer chips, it also directs funding for photonic semiconductors.

Sandia added that it is also investing in optical microchips because they transmit more information than conventional ones. But manufacturing challenges have prevented their widespread adoption,

continued on next page

continued from previous page

Sandia Labs invents method to integrate micro-optical devices on silicon

Chu said: "Even though the technology is well known in scientific circles, on most microchips, he said, electronic technologies still reign supreme."

Sandia has positioned itself to support industry and other institutions performing photonics research and development in the coming years, although Sandia research is not currently funded by the CHIPS Act.

Chu added, "We know our process is scalable, so that's one way we're supporting the CHIPS Act mission. Sandia is eager to collaborate with others and start building new technologies together."

https://optics.org/news/14/8/9

Photo credit: Craig Fritz.

Sandia National Laboratories scientist Ashok Kodigala aligns a fiber to a chip-scale, heterogeneously integrated laser under a microscope at the MESA complex.

SPIE.

Make some noise at PHOTONICS WEST 2024

- over 20,000 attendees and 1,300 exhibiting companies

PHOTONICS WEST PREVIEW

27 - 28 January 2024

- the official magazine incorporating BiOS Expo, LASE, OPTO, AV, VR, MR and BRAIN
- latest news pre Show

PHOTONICS WEST SHOW DAILY

31 January - 1 February 2024

- extensive distribution during the Show
- published on site and printed overnight, each day, every day
- latest news from the Show floor

Exhibition Promotions

- expand the exposure of your brand and products beyond the exhibition
- product demo video
  3 - 5 mins per video
- editor interview
  3 - 5 min Q&A with Editor In Chief Matt Peach

Contact our Sales team today to discuss how optics.org can help you create a targeted customer experience and put your brand and products in front of key decision makers at SPIE Photonics West 2024.

optics.org

e: rob.fisher@optics.org
t: +44 (0)117 905 5330

e: dylan.byrne@optics.org
t: +44 (0)117 905 5351

the business of photonics
optics.org