

VISION

focus

Delivering the latest news from the Imaging and Machine Vision markets

Harvard SEAS develops 10cm glass metalens for hi-res astronomical imaging

Stereolabs and Syslogic partner to advance robotic applications



Fraunhofer ILT and IPT develop AI-assisted method to isolate cells

NAITAR AMETEK
SPECIAL OPTICS AMETEK

Pixelink AMETEK

zygo AMETEK

Custom Optical Design & Modular Imaging Components

for Medical, Life Science & Research Instruments

Photon Lines Advanced Machine Vision Solutions



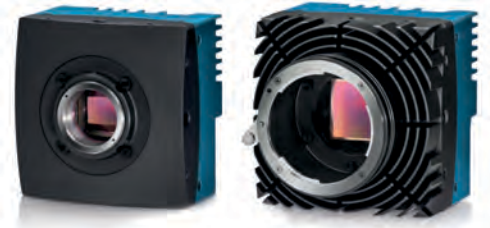
SCAN HERE

Featuring a range of products, including...

HIGH-SPEED CAMERAS

High-Speed cameras for Industrial Image Processing from Mikrotron

- Industrial image processing of events recorded within a few milliseconds
- High precision analysis at frame rates of up to 225,000 fps



HYPERSPECTRAL IMAGING SYSTEMS

Hyperspectral imaging systems for a variety of machine vision applications, including identification and sorting of similarly coloured products with defects undetectable to the human eye.

Applications in the food industry, electronics, automotive, etc.

Products offered include:

- Pushbroom hyperspectral imaging systems from industry leader Resonon
- Low-cost tunable Near Infrared (NIR) camera and image processing from Unispectral



3D AND TRILINEAR CMOS LINE SENSORS

3D and Trilinear CMOS line sensors from Chromasens for automated inspection systems.

Applications include:

- Flat panel display inspection
- Printed circuit boards
- High resolution document scanning
- High quality surface inspection



For more information

+44 (0)333 2427905 | info-uk@photonlines.com | www.photonlines.co.uk

Harvard SEAS develops 10cm glass metalens for astronomical imaging

Researchers at the Harvard John A. Paulson School of Engineering and Applied Sciences (SEAS) have developed a 10 cm-diameter glass metalens that can image the sun, moon and even distant nebulae at high resolution. It is the first all-glass, large-scale metalens in the visible wavelength that can be mass produced using conventional CMOS fabrication technology. "The ability to accurately control the size of tens of billions of nanopillars over an unprecedentedly large flat lens using semiconductor foundry processes opens exciting new opportunities for space science," said flat lens pioneer Federico Capasso, the Robert L. Wallace Professor of Applied Physics at SEAS (page 12).

In this issue

The European Machine Vision Association is organizing the EMVA Business Conference, which will take place – for the 22nd time – between 13 to 15 June in Gdansk, Poland (page 4).

Stereolabs, a developer of vision-based sensing technology, and Syslogic, a provider of rugged AI embedded computers, are partnering to power advanced autonomous robotics solutions for industries that operate in rugged conditions (page 5).

The Fraunhofer Institutes for Laser Technology ILT and for Production Technology IPT have developed an AI-assisted high-throughput process that now makes it possible to automatically isolate specific cell types. Their so-called Liftoscope enables laboratories to identify and analyze dozens of living cells per second (page 6).

A group at the University of British Columbia, Canada, in partnership with pharmaceutical company Pfizer, have developed a chemical processing system combining computer vision with a machine learning monitoring system to conduct chemical workup processes (page 8).

Growing acceptance of medical cannabis has led to a worldwide increase in production of the plant, but some of the associated legal and regulatory framework has not kept pace. Hyperspectral imaging and machine learning have been combined to classify medical cannabis (page 10).

Metalenz, a developer of meta-optics technology, is collaborating with Samsung to bring its novel biometric sensor to smart phones. The partners announced their collaboration at Barcelona's Mobile World Congress (page 11).

Business news

Teledyne is to further expand its already extensive portfolio of imaging technologies, with a deal to acquire the Dutch industrial camera maker Adimec. Cognex has posted sales of \$197 million for the closing quarter of 2023 – better than its earlier forecast but still down 20 per cent on the same period a year earlier (pages 14, 15). Also new Teledyne and Flir product announcements on page 9.

Massachusetts-based Headwall Photonics is set to add to its existing portfolio of hyperspectral imaging technologies, through the acquisition of Germany's inno-spec. And Bruker is set to further expand its offering of optics-based equipment with the acquisition of Arizona-based Spectral Instruments Imaging (pages 16, 17).

Plus our usual round-up of new product launches, and research and development innovations from the vision sector.

Matthew Peach, Editor in Chief.
matthew.peach@optics.org



This Issue

- ▶ 22nd EMVA Business Conference arriving in Gdansk, Poland between 13 to 15 June
- ▶ Stereolabs and Syslogic partner to advance robotic applications
- ▶ Fraunhofers ILT and IPT develop AI-assisted method to isolate cells
- ▶ U British Columbia and Pfizer develop chemical processing with MV and machine learning
- ▶ Teledyne Dalsa Genie Nano-10GigE cameras in full production
- ▶ Hyperspectral imaging and machine learning classify medical cannabis
- ▶ Metalenz joins forces with Samsung to scale polarization ID sensor
- ▶ Harvard SEAS develops 10cm glass metalens for hi-res astronomical imaging
- ▶ Teledyne snaps up Adimec
- ▶ Cognex profits shrink in 'challenging but stable' market
- ▶ Headwall targets machine vision with inno-spec deal
- ▶ Bruker broadens optical portfolio with Spectral Instruments Imaging
- ▶ MVTec presents itself and its software products at Automate
- ▶ Ansys debuts SimAI software for an open design ecosystem

plus the latest product launches from within the industry

Publication and Editorial Schedule 2024/25

Summer Issue 2024 (July/August 2024)

- Bonus Distribution: **UKIVA Machine Vision Conference**,
- Editorial Focus: Industrial and machine vision
- Published in advance of UKIVA Machine Vision Conference 18 - 19 June 2024

Autumn Issue 2024 (October/November 2023)

- Bonus Distribution: **SPIE Photonex**
- Editorial Focus: Sensor technologies
- Published in advance of SPIE Photonex, Manchester Central, UK Exhibition: 30-31 October 2024

Winter Issue 2024/25 (January/February 2025)

- Bonus Distribution: **SPIE BiOS, SPIE Photonics West, SPIE Medical Imaging**
- Editorial Focus: industrial applications, sensing, biomedical analysis and treatments.
- Published in advance of SPIE BiOS, San Francisco 25 - 26 January 2025, SPIE Photonics West, San Francisco 25 - 30 January 2025, SPIE Medical Imaging, San Diego 16 - 20 February 2025

Spring Issue 2025 (April/May 2025)

- Bonus Distribution: **SPIE Defense+Commercial Sensing**,
- Editorial Focus: Defense, thermal and hyperspectral imaging.
- Published in advance of Defense+Commercial Sensing tba 2025

22nd EMVA Business Conference arriving in Gdansk, Poland between 13 to 15 June



Decision-makers from our industry will meet to discuss the current economic situation, network and hear high-level conference program.

Following the successful premiere of the EMVA member booth at Logimat 2024 in Stuttgart, as well as numerous machine vision related presentations at the Logimat Expert Forum during the trade fair, the association's next highlight will follow in June.

For the 22nd time, the European Machine Vision Association is organizing the EMVA Business Conference, which will take place from 13 to 15 June in Gdansk, Poland. Top decision-makers from the machine vision industry will meet there to discuss the current economic situation, initiate business and listen to the high-level conference program.

Two prominent keynote speakers will address burning topics with high impact of today's business life: Cathryn Clüver Ashbrook, who is a renowned expert on transatlantic foreign and trade policy and

Senior Advisor to the Bertelsmann Stiftung, will talk about "Shifting Quicksands: The Impact of the U.S. Election on Geopolitical Stability". The three conference days will be closed by a keynote addressing "The Transformative Power of AI".

Part of the conference program is the Polish provider of vision components and services Avicon. The company's CEO will be introducing the machine vision ecosystem in Poland. The program will also put a spotlight on the dynamic machine vision market in India on the second conference day.

Risks and opportunities the machine vision industry faces over the next decade will be topic of a panel discussion. In the technical part of the conference Siemens will give insights regarding "Machine Vision in Battery Applications" and Hyperspectral Xray Systems will be presented by Xnext.

The presentation of robotics specialist Intrinsic is titled "Democratization of Robotics and its Implications for Machine Vision. The Fraunhofer IOSB explains the advantages of Adaptive Optics.

Last but not least, the winner of this year's EMVA Young Professional Award will be honored and numerous B2B meetings will take place during the conference breaks.

Registration for this key networking event of the machine vision community in Europe in the first half year is still possible at www.business-conference-emva.org.

*Thomas Lübckemeier,
EMVA General Secretary*

SPIE.

WEBINARS

Looking for something?

VIDEO INTERVIEWS

Check out some of the latest webinars and whitepapers on **optics.org** including the latest webinar from imec on how SWIR spectral imaging on a chip can improve your business.

optics.org/pw/videos

You'll also find some of the latest technical papers from Wasatch Photonics, Photon Lines, ADMESY and Teledyne Lumenera.

optics.org/whitepapers



the business of photonics
optics.org

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

WHITE PAPERS

Stereolabs and Syslogic partner to advance robotic applications

Stereo vision-based sensing and rugged AI embedded systems support applications that can withstand outdoor conditions.

Stereolabs, a pioneer in vision-based sensing technology, and Syslogic, a provider of rugged AI embedded computers, have announced a partnership to power advanced autonomous robotics solutions – driven by enhanced sensing capabilities – for industries that operate in harsh outdoor conditions.

Stereolabs develops stereo vision hardware and software, enabling advanced depth sensing and perception solutions for a wide range of applications and industries. The new partnership combines the company's technology with Syslogic's hardware – which includes industrial computers and AI embedded systems – designed to endure unpredictable environments for applications in agriculture, railway, and construction machinery, and mobile robotics.

Cecile Schmollgruber, CEO and co-founder of Stereolabs, commented, "We believe that



Syslogic's rugged AI embedded AR computer, the RPC RML A4AGX model.

robotics is the future of safe and efficient farming, construction, and beyond. By combining our sensing capabilities with

Syslogic's computing solutions that are specified for outdoor conditions, we're ushering in that future."

Syslogic's rugged computers are designed for use in vehicles or mobile robots. They can be coupled with sensors such as lidar or radar, connected to the vehicle via the CAN (bus) and offer multi-band GNSS (global navigation satellite system) with RTK (Real Time Kinematic) corrections. Combined with the Stereolabs camera, Syslogic is suitable for computer vision applications in industrial and mobile robots.

Raphael Binder, CEO of Syslogic, said, "The coupling of our AI embedded systems with Stereolabs' sensing systems allows for significant strides for autonomous technology, to create a continuous all-around view of the environment, while remaining resistant to shock, vibration, moisture, and dust."

This partnership builds on previous collaborations between Stereolabs and Syslogic, including their joint work on Stereolabs' Zed X industrial AI stereo camera, which uses Syslogic's AI rugged computers to operate outdoors, in challenging conditions.

www.stereolabs.com

www.syslogic.com

Author:

Matthew Peach, Editor-in-Chief, optics.org



Stereolabs' Zed X and Zed X Mini vision-based sensors;

Fraunhofers ILT and IPT develop AI-assisted method to isolate cells

Liflescope enables labs to analyze dozens of living cells per second.

Tests on living cell cultures are becoming increasingly important for personalized medicine, drug development and clinical research. The Aachen-based Fraunhofer Institutes for Laser Technology ILT and for Production Technology IPT have developed an AI-assisted high-throughput process that now makes it possible to automatically isolate specific cell types. Using a so-called Liflescope, laboratories can localize, identify and analyze dozens of living cells per second in order to transfer them to microtiter plates with laser-induced forward transfer (LIFT). At Analytica 2024 in Munich, in April, the

Fraunhofer-Gesellschaft presented the innovative process to the public for the first time.

Pluripotent stem cells are the key to personalized medicine. Once they have been isolated from blood and tissue samples, they can be used to grow cell types of different tissues. Since these cultivated cell cultures make it possible to run individual drug and intolerance tests outside the body, they are a powerful tool in selecting highly specific personalized therapies. However, to establish personalized treatment in routine clinical practice, medicine needs efficient methods for isolating pluripotent stem cells.

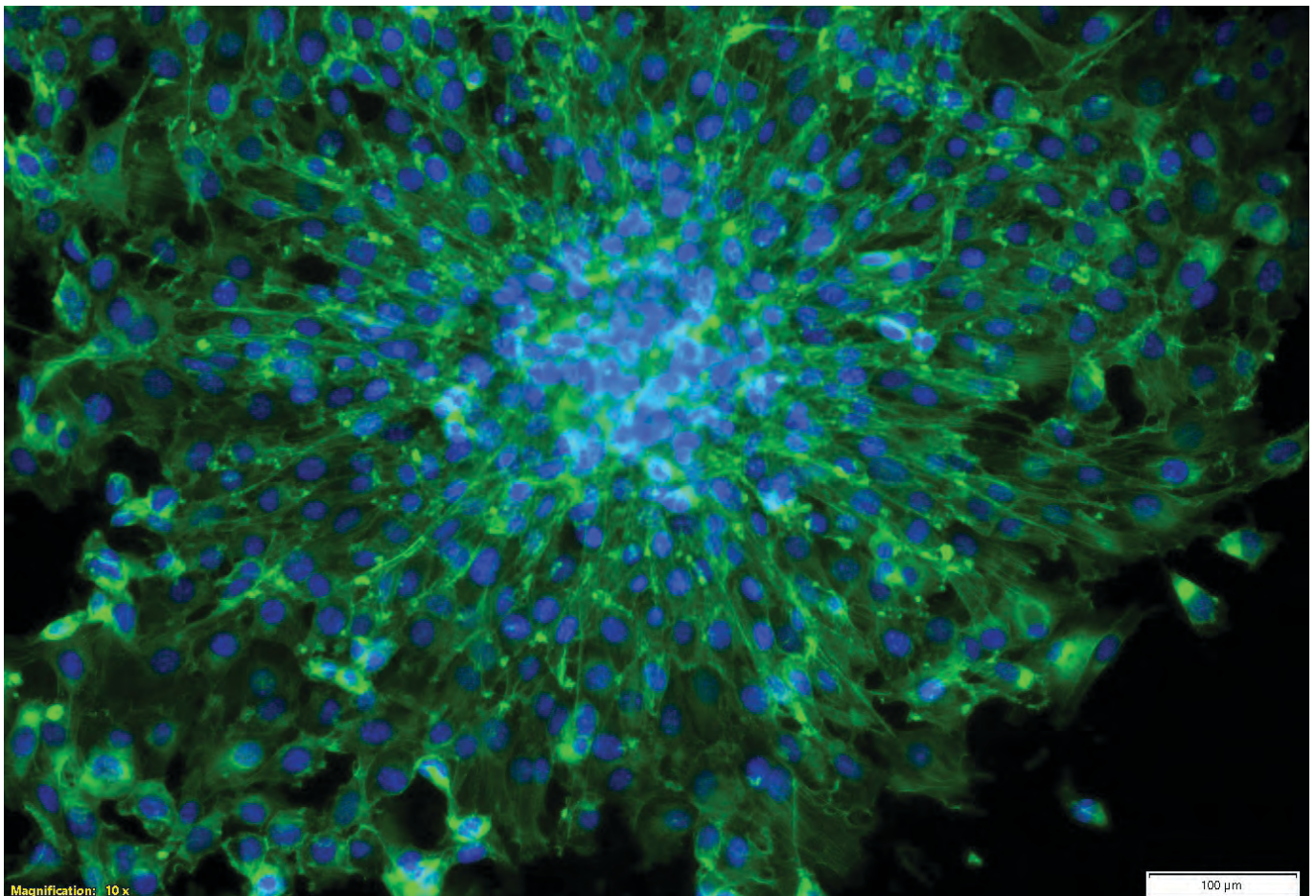
In addition, pharmaceutical research is looking for methods to separate so-called high-producer cells from polyclonal cultures for drug development and to transfer them into monoclonal cultures without impairing cell vitality or the ability to divide. During the pandemic, clinics also had to recognize that the available methods for isolating and analyzing (immune) cells from patient samples are pushing their laboratories to their capacity limits.

This innovation significantly increases efficiency since it sorts and isolates cells fully automatically. The Liflescope integrates an AI-assisted high-throughput process into a commercially available inverted microscope equipped with a high-speed camera and a flash light source. The Liflescope combines three high-tech processes in one device to identify cells within microseconds and transfer them to microtiter plates with the high survival rates of over 90 percent.

Automated cell selection

The project team has integrated the patented MIR LIFT process developed at Fraunhofer ILT directly into the

continued on next page



Actin-stained 3T3 fibroblast spheroid for LIFT transfer, cultivated in laser-fabricated microwells.

continued from previous page

Fraunhofer ILT and IPT develop AI-assisted method to isolate cells

microscope's beam path. A camera system connected to it delivers one hundred high-resolution images per second. The AI developed at Fraunhofer IPT uses semantic segmentation to identify the desired cell types in this image data, and can be trained to recognize pluripotent stem cells, high-producer cells and immune cells. The AI also determines the cells' exact position and center of gravity. In the MIR LIFT process, they are then transferred one after the other at a high frequency rate of up to 100 Hz onto a microtiter plate in a holder developed at Fraunhofer ILT. "Depending on the cell type, up to 100 percent of all cells survive this procedure," said Dr. Nadine Nottrodt, Head of the Biofabrication Group, who is supervising the joint development project at Fraunhofer ILT together with project manager Richard Lensing.

Simple process

A short 9 ns laser pulse with a few microjoules of pulse energy is enough to stimulate the liquid medium directly under the targeted cell to form a vapor bubble. The cell, which has previously been enzymatically released from its bond, is briefly lifted by the bubble.

As soon as the bubble collapses, suction is formed that flushes the cell into the culture vessel of the microtiter plate. "The cells are randomly distributed in the samples. For this reason, our system follows a predefined grid and transfers cells that are within a radius of 50 micrometers of the focal point," said Lensing. If required, the LIFT process can also be combined with fluorescent markers to identify specific cells. However, the process works robustly even without additives.

The project team aims to stabilize the automated cell recognition and LIFT process in terms of high throughput and to limit the process time to complete one microtiter plate to ten minutes. This will require high-precision actuators both for imaging and for positioning the laser focus in the process cycle. A single cell transfer is completed within 200 microseconds. Within 100 seconds, 10,000 cells can be activated with the Liftoscope and transferred to the microtiter plates.

The novel, AI- and laser-based process points the way to a fully automated and highly efficient isolation of living cells. According to Nottrodt, the progress of the project to date shows that synchronization of the cell LIFT with the image frequency of the high-speed camera – and thus a single-cell sorting rate of 100 cells per second – is feasible. The next step is to develop the prototype process to reach market maturity.

Author:
Matthew Peach, Editor-in-Chief, optics.org



Researchers at Fraunhofer ILT are testing the LIFTOSCOPE for AI-assisted, fully automated high-throughput sorting of living cells by pulsed laser radiation.

LINE SCAN CAMERAS AND SCANNER SYSTEMS



CMOS



LASM – LARGE AREA SCAN MACROSCOPE

High resolution imaging of e.g. ice core sample

Resolution 5 µm, 5080 dpi




CORROSION INSPECTOR

A color scanner system for the objective evaluation of filiform and other corrosion phenomena






LASERS FOR MACHINE VISION

Wavelengths 405 – 1550 nm




Schäfter+Kirchhoff 

www.sukhamburg.com

Schäfter+Kirchhoff develop and manufacture laser sources, line scan camera systems and fiber optic products for worldwide distribution and use.

© Fraunhofer ILT

U British Columbia and Pfizer develop chemical processing with MV and machine learning

Smart vision and learning solution monitors and controls workup processes.

A team of chemists and engineers at the University of British Columbia, Canada, working with colleagues at pharmaceutical company Pfizer has developed a chemical processing system combining computer vision with a real-time machine-learning monitoring system for use in conducting chemical workup processes. Their paper is published in the journal *Chemical Science*.

In chemistry, workup processes are activities conducted to isolate a pure product through selective separation from other components. It is often tedious, which, besides being unpleasant, leads to mistakes or omissions. In this new effort, the research

team has attempted to automate the process by combining computer vision with real-time monitoring techniques, a machine-learning system and computer processing, along with appropriate hardware, to carry out a workup process without assistance from human chemists.

The system developed by the team, called Heinsight2.0, as its name suggests, builds on knowledge learned from its predecessor, Heinsight1.0. Its components include a webcam (either overhead or side-mounted), reaction vessel, dosing unit, temperature probe and overhead stirrer. It also has a secondary device that allows for displaying iControl, real-time reaction

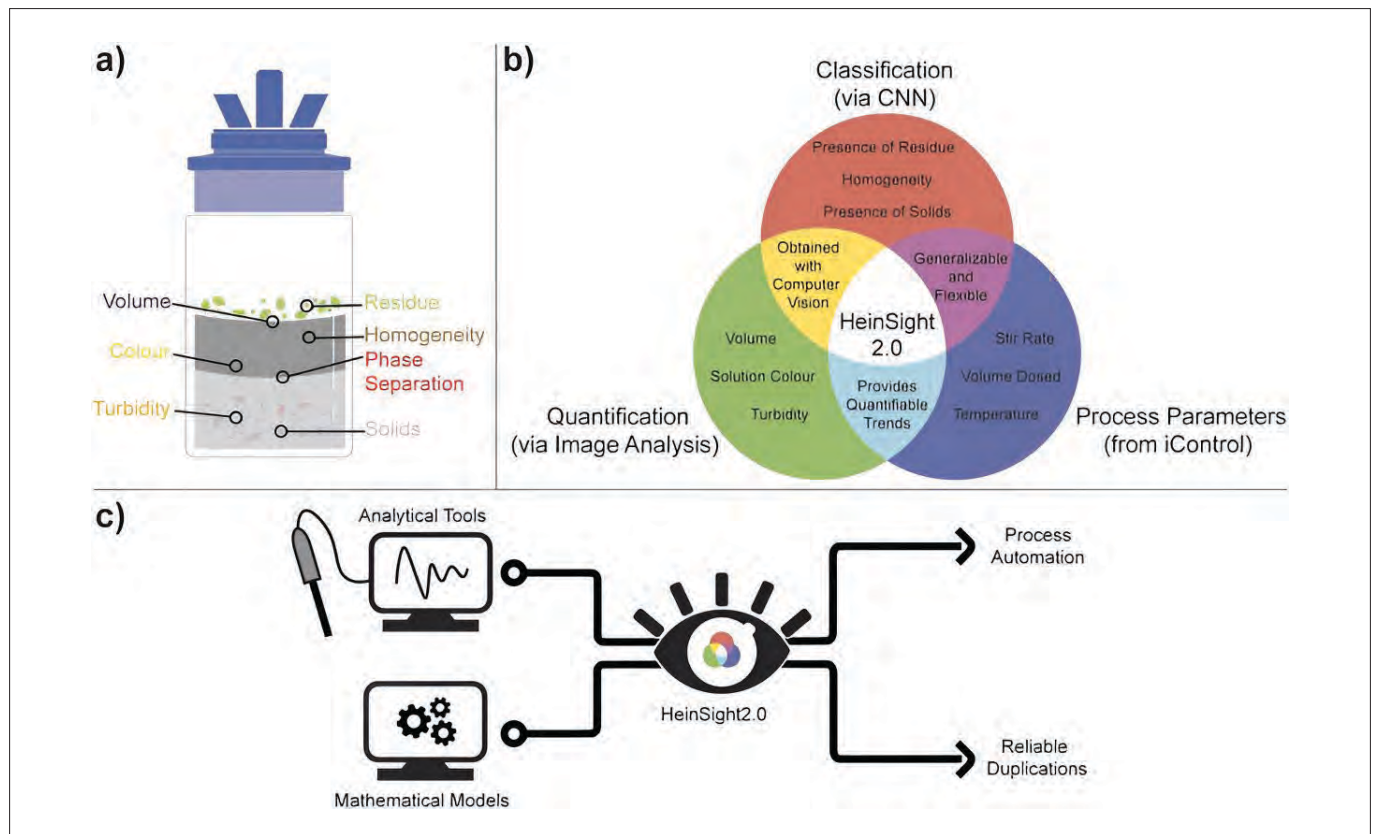
trends, EasyMax and CV model output. The system works by monitoring a workup process and controlling it by sending signals at appropriate times to direct the action as it happens. The system controls the action by responding as a chemist would as events unfold. If a material changes from one desired color to another, for example, the system can recognize that and use it as a cue to instigate a follow-up action.

The researchers note that, like a human chemist, the system is capable of monitoring multiple sensory cues and responding to them in desired ways. It can also operate under many types of scenarios, such as those involving the use of solid-liquid mixing, crystallizations, exchange distillations and liquid-to-liquid extraction.

They also note that they have made the program script publicly available, which means other chemists could build their own units and then use the code to run their systems in the same way. They also plan to continue work on their system to give it more capabilities.

Author:

Matthew Peach, Editor-in-Chief, *optics.org*



(a) Universal vision-based outputs in workups monitored by Heinsight2.0; (b) overview of interrelated components of Heinsight2.0: Classification outputs (from CNN), quantification outputs (from image analysis), and process variables from iControl; (c) integrations and applications of Heinsight2.0 CV system.

Teledyne Dalsa Genie Nano-10GigE cameras in full production...

...and Flir launches Neutrino LC OGI Camera for optical gas imaging.

Teledyne Dalsa has announced that its new Genie Nano-10GigE M8200 and C8200 cameras, based on Teledyne e2v's 67M monochrome and color sensors, have now entered full production.

The manufacturer says that the 67M cameras are "the smallest 10GigE Vision models in the industry achieving full resolution image transfer at up to 14 frames per second". Both offer wider operating temperature ranges, PTP synchronization, and commonality of sizes with other Genie Nano cameras, enabling ease of integration or upgrades across a wide variety of imaging applications.

Coupling a compact 59 mm x 59 mm form factor, system designers can transition from 1, 2.5, 5GigE to 10GigE Vision without the need for software changes. Genie Nano-10GigE cameras are engineered to deliver high-speed, and dependable results for applications such as electronics manufacturing inspection, industrial metrology, intelligent traffic systems, aerial

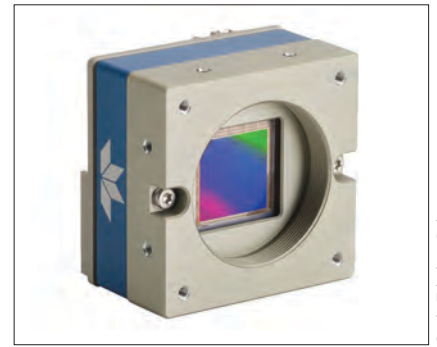
imaging, and sports and entertainment.

A free runtime version of Teledyne's Sopera processing software is included with the 67M cameras. This image processing software provides basic image processing, blob analysis, camera calibration, and area-based search capabilities.

Teledyne Flir launches Neutrino LC OGI Camera for optical gas imaging

Mid-wave infrared imaging module provides rapid leak detection of methane and other hydrocarbons within a SWaP-optimized integration package.

Teledyne Flir has launched the Neutrino LC OGI optical gas imaging camera module, a USA-made, ITAR-free, mid-wave infrared (MWIR) imager for products designed to detect, measure, and visualize harmful gas emissions. Flir says the camera provides "best-in-class performance" within a small, lightweight, and low-power module for integration into unmanned aerial vehicles, small gimbals,



Credit: Teledyne Dalsa.

Teledyne Dalsa's Genie Nano-10GigE 67M camera is industry's smallest 67 MP camera for high-performance image capture.

handheld devices, and fixed-mounted gas leak detection systems.

The MWIR spectral band is used to detect methane and other hydrocarbons, such as volatile organic compounds (VOCs). The Neutrino LC OGI offers multiple modes: a 640 x 512 VGA resolution mode with up to eight times digital zoom to maximize scene awareness; or it can operate in bin mode, which can improve sensitivity to an industry-leading <20 millikelvins (mK) to create a crisper, higher-contrast image for pinpointing leaks.

"The detection and mitigation of harmful hydrocarbon and chemical leaks into the air represents a significant priority for regulators and impacted industries," said Dan Walker, vice president of product management. "The Neutrino LC OGI is the low-risk and high-performing OEM camera module for integrators developing methane monitoring and other gas imaging solutions today."

The size, weight, and power (SWaP)-optimized camera features Flir's High Operating Temperature FPA technology and low-vibration, long-life linear micro cooler. A two-year warranty make it the integrator's module of choice, says Flir, where rapid leak detection and operational uptime are critical within processing facilities, refineries, pipelines, tank farms, and well pads for the oil and gas industry.

Integrators will also gain access to Flir's professional technical support team, a full suite of hardware accessories, and a software development kit.

www.flir.com/neutrinoogi

Author:

Matthew Peach, Editor-in-Chief, optics.org



Credit: Teledyne Flir.

Mid-wave infrared imaging module provides rapid leak detection of methane and other hydrocarbons within a SWaP-optimized integration package.

Hyperspectral imaging and machine learning classify medical cannabis

University of the Basque Country project assists control of cannabis production.

Growing acceptance of medical cannabis has led to a worldwide increase in production of the plant, but some of the associated legal and regulatory framework has not kept pace.

According to a project at the University of the Basque Country (UPV/EHU), the current lack of quality control regulations or standards for correct manufacturing processes could lead to uncontrolled, and even harmful, crop products.

One possible answer could be enhanced optical imaging of the cannabis plants, and the UPV/EHU project has developed a technique based around hyperspectral imaging and machine learning designed to ensure the traceability or quality control of medicinal cannabis plants on an industrial scale.

Published in the journal *Computers and Electronics in Agriculture*, the study could pave the way for non-invasive horticultural quality control in medical cannabis production, serving an emerging industry that will require strict control over the cannabis chemotypes.

The new approach also has the advantage of avoiding destructive and time-consuming analytical techniques such as chromatography, noted the UPV/EHU team.

"Accurate, efficient methods need to be developed to ensure quality control in the plant production process," commented UPV/EHU's Markel San Nicolás. "Medical cannabis must be produced in a very controlled way and there is as yet no clear regulation in this regard."

Rapidly ensure traceability and quality control

Near-IR hyperpectral imaging (NIR-HSI) is attractive as a modality for this application since it enables an object to be visualized in two dimensions as a normal image, while also retrieving a wide electromagnetic spectrum from each pixel.

It also allows researchers to build on recent empirical research into the quantification of the main cannabinoid species of interest, THC and CBD, using NIR-HSI techniques, which indicated that the approach could simplify analysis of cannabis plants without compromising analytical capabilities.

In trials, NIR-HSI images of 57 cannabis plants were taken using a spectral range of 930 to 2500 nanometers divided into 288 spectral channels. Machine learning-based data analysis using trained algorithms then classified the target plants as belonging to chemotypes I, II or III, plant variants known to contain different amounts of cannabinoids.

The project's approach was able to successfully extract the three chemotypes of interest and determine the concentration of THC and CBD in the flower heads with an overall classification trueness of 94.74 percent, according to the team's paper.

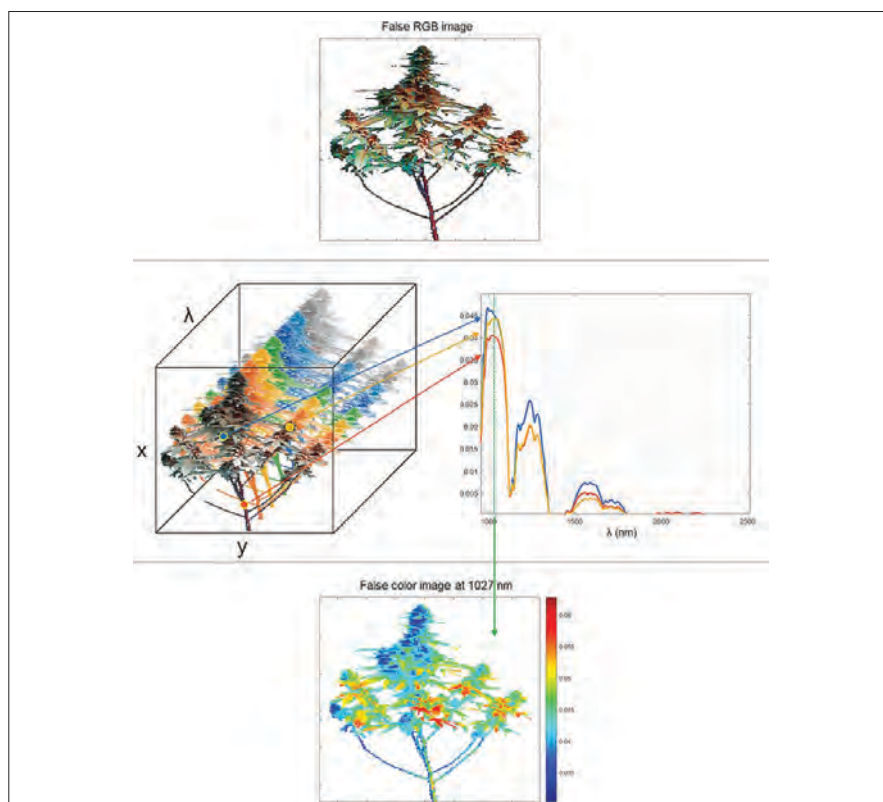
A methodology based on NIR-HSI plus machine learning for chemotype classification can properly deal with the issue of moisture present in the fresh plant tissue, usually the main handicap when using conventional near-IR spectroscopy to analyze cannabinoids according to the project. The new approach also enables representative analysis directly in a complete living plant individual.

"Implementing this technology at medical cannabis production sites would automatically and rapidly ensure the traceability and quality control of the chemotype," commented Markel San Nicolás. "Although, for this to happen, cannabis-related regulation would have to be established and progress would have to be made in this industrial sector."

ehu.eus/en/en-home

Author:

Tim Hayes, Contributing Editor, *optics.org*



Credit: University of the Basque Country.

NIR-Hyperspectral image visualisation of a cannabis plant captured in the 930–2500 nm wavelength range.

Metalenz joins forces with Samsung to scale polarization ID sensor

The US metamaterials startup and Korean industrial giant confirm collaboration at Barcelona's Mobile World Congress event.

Metalenz, the Boston-based developer of meta-optics technology, has confirmed that it is collaborating with Samsung to bring its novel biometric sensor to smart phones.

Revealed during the giant Mobile World Congress event being held in Barcelona, Spain, in February, the partnership pairs Metalenz's polarization-based biometrics with a new version of Samsung's high-performance "ISOCELL" near-infrared sensors.

The idea is to use the unique polarization signature of the human face to create what is claimed to be the world's "smallest, most affordable, and secure biometric face unlock solution for smart phones".

'Polar ID'

Described as the world's only consumer-grade imaging system that can sense the full polarization state of light, Metalenz's "Polar ID" product is unlike other facial biometric solutions, in that it only requires a single image to work.

Launched last year, the approach is said to reduce the size and cost of existing facial identification technologies by half, with the Samsung partnership providing both a supply of high-end image sensors and an obvious route to scale the technology in smart phones.

Rob Devlin, the Metalenz CEO and co-founder, commented: "Polar ID is poised to bring secure face unlock to hundreds of millions of phones and a whole new class of sensing to millions of people.

"Leveraging the performance and scale of Samsung's ISOCELL Vizion 931 image sensor allows our Polar ID cameras to quickly and efficiently determine the polarization information in a scene, from which our imaging algorithms and machine learning models authenticate the Polar ID images.



Metalenz's "Polar ID" technology, now incorporating Samsung's state-of-the-art NIR image sensor, is touted by the meta-optics startup as the world's first polarization-based facial biometric solution for smart phones. It promises to broaden the incorporation of facial identification beyond the high-end phones where it has been deployed thus far.

"The collaboration with Samsung marks a new era for mobile vision systems and provides Metalenz with a partner that has the proven quality and scale required to bring Polar ID to all phones."

According to the two firms, the Samsung sensor enables Polar ID to capture polarized images in the near-infrared spectrum with industry-leading quantum efficiency and advanced global shutter technology.

That performance is thanks to the design of the sensing chip, which incorporates so-called "Front Deep Trench Isolation (FDTI)" to create an insulation layer between pixels along with back-side scattering to maximize overall light absorption and quantum efficiency.

Samsung's VP of sensor sales and marketing, CY Lee, added: "Our collaboration with Metalenz is not just about combining technologies; it marks a pivotal advancement in biometric imaging capabilities, making face unlock solutions

with enhanced security and affordability accessible on a global scale."

Polarization advantage

Formed as a spin-out from Federico Capasso's Harvard University research group, Metalenz has previously collaborated with electronics giant STMicroelectronics on a commercial time-of-flight sensor, and has also agreed a manufacturing partnership with the Taiwanese chip foundry United Microelectronics Corporation (UMC).

Its "Orion" meta-optic dot projectors have since featured in a series of biometric security scanners produced by the Chinese firm Dilusense, before Metalenz unveiled "Polar ID" in October 2023.

At the time, Metalenz said that existing facial security sensors - most commonly associated with relatively recent iPhone models - required expensive, bulky, and often power-hungry optical modules, limiting the technology to a few high-end models.

"Polar ID harnesses meta-optic technology to extract additional information such as facial contour details and to detect human tissue liveness from a single image," it explained.

"It is significantly more compact and cost effective than incumbent 'structured light' face authentication solutions, which require an expensive dot-pattern projector and multiple images."

Author:

Mike Hatcher, Business Editor, optics.org

Harvard SEAS develops 10cm glass metalens for hi-res astronomical imaging

Large-scale flat lens for visible wavelengths can be mass-produced by CMOS method.

Metalenses have been used to image microscopic features of tissue and resolve details smaller than a wavelength of light. Now they are going bigger.

Researchers at the Harvard John A. Paulson School of Engineering and Applied Sciences (SEAS) have developed a 10-centimeter-diameter glass metalens that can image the sun, the moon and distant nebulae with high resolution. It is the first all-glass, large-scale metalens in the visible wavelength that can be mass produced using conventional CMOS fabrication technology.

The research is published in ACS Nano.

"The ability to accurately control the size of tens of billions of nanopillars over an unprecedentedly large flat lens using state-of-the-art semiconductor foundry processes is a nanofabrication feat that opens exciting new opportunities for space science and technology," said Federico Capasso, the Robert L. Wallace Professor of Applied Physics and Vinton Hayes Senior Research Fellow in Electrical Engineering at SEAS and senior author of the paper.

Most flat metalenses, which use millions of pillar-like nanostructures to focus light,



This 10-centimeter-diameter glass metalens can image the sun, the moon and distant nebulae with high resolution.

are about the size of a piece of glitter. In 2019, Capasso and his team developed a centimeter-scale metalens using a technique called deep-ultraviolet (DUV) projection lithography, which projects and forms a nanostructure pattern that can be directly etched into the glass wafer, eliminating the time-consuming writing and deposition processes that were required for previous metalenses.

DUV projection lithography is commonly used to pattern fine lines and shapes in silicon chips for smart phones and computers. Joon-Suh Park, a former graduate student at SEAS and current postdoctoral fellow in Capasso's team, demonstrated that the technique could not only be used to mass produce metalenses but also increase their size for applications in virtual and augmented reality.

But making the metalenses even larger for applications in astronomy and free-

space optical communications posed an engineering problem. "There is a major limitation with the lithography tool because these tools are used to make computer chips, so chip size is restricted to no more than 20 to 30 millimeters," said Park, co-first author of the paper. "In order to make a 100-millimeter diameter lens, we needed to find a way around this limitation."

Park and the team developed a technique to stitch together several patterns of nanopillars using the DUV projection lithography tool. By dividing the lens into 25 sections but using only the seven sections of a quadrant considering the rotational symmetry, the researchers showed that DUV projection lithography could pattern 18.7 billion designed nanostructures onto a 10-centimeter circular area in a matter of minutes.

The team also developed a vertical glass etching technique that allows the creation of high-aspect ratio, smooth-sidewall nanopillars etched into glass. "Using the same DUV projection lithography, one



Image of the Moon taken by the metalens from the roof of the Science Center in Cambridge.

Credit: Capasso Lab/Harvard SEAS.

Credit: Capasso Lab/Harvard SEAS.

continued on next page

continued from previous page

Harvard SEAS develops 10cm glass metalens for hi-res astronomical imaging

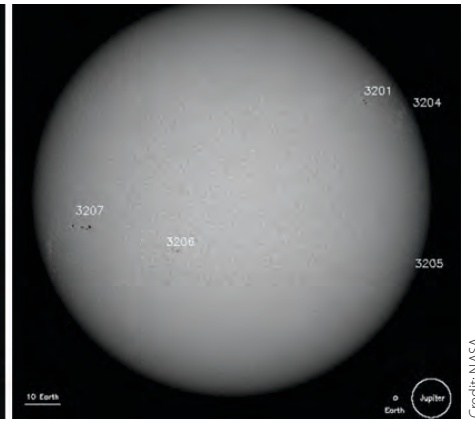
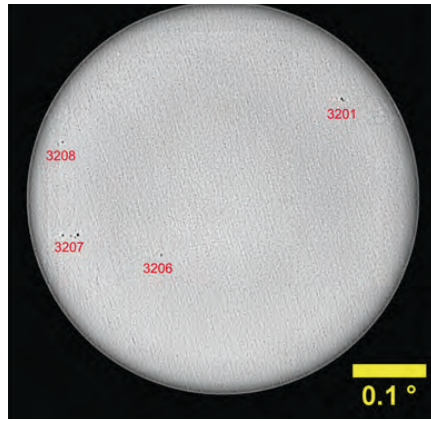
could produce large-diameter, aberration-correcting meta-optics or even larger lenses on larger glass diameter wafers as the corresponding CMOS foundry tools become increasingly available in the industry," said Soon Wei Daniel Lim, a postdoctoral fellow at SEAS and co-first author of the paper.

Lim played a lead role in the full simulation and characterization of all the possible fabrication errors that could arise during mass-manufacturing processes and how they could impact the optical performance of metalenses.

'Powerful imaging'

After addressing possible manufacturing challenges, the researchers demonstrated the power of the metalens in imaging celestial objects.

Mounting the metalens on a tripod with a



Credit: NASA.

Left: Image of the Sun taken by the metalens from the roof of the Science Center in Cambridge. Sunspots are labeled in red. Credit: Capasso Lab/Harvard SEAS. Right: Image of the sun taken by NASA on the same day, with the same groups of sunspots identified.

color filter and camera sensor, Park and the team took to the roof of Harvard's Science Center. There, they imaged the Sun, the moon and the North America nebula, a dim nebula in the constellation Cygnus about 2,590 light years away.

"We were able to get very detailed images of the Sun, the moon and the nebula that are comparable to images taken by conventional lenses," said Arman Amirzhan, a graduate student in the Capasso Lab and co-author of the paper.

Using only the metalens, the researchers

were able to image the same cluster of sunspots as a NASA image taken that same day. The team also demonstrated that the lens could survive exposure to extreme heat, extreme cold and the intense vibrations that would occur during a space launch without any damage or loss in optical performance.

Because of its size and monolithic glass composition, the lens could also be used for long-range telecommunications and directed energy transport applications.

Author:

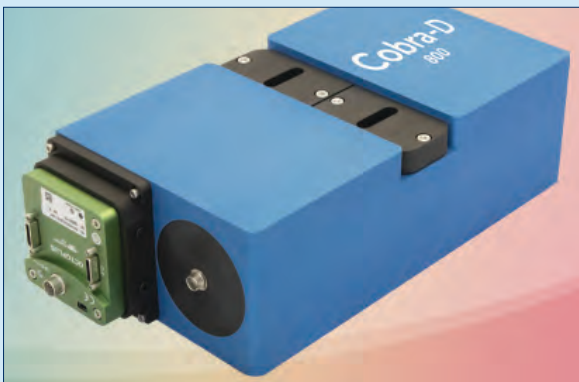
Matthew Peach, Editor in Chief, optics.org

Wasatch Photonics

Introducing the New Cobra-D Spectrometer for Ultra-deep 800nm OCT Imaging

Our NEW Cobra-D OCT spectrometers deliver all the benefits of 800 nm OCT at greater depths than ever before (up to 12 mm!) – including more sensitivity, faster measurements or USB 3.0 interface, and lower camera cost. The Cobra-D's industrial design is ideal for ophthalmology, medicine, and nondestructive process monitoring. Let our expert team put together a configuration that is right for your application.

Contact us to learn more!



Contact Details

Wasatch Photonics
808 Aviation Parkway
Suite 1400, Morrisville, NC 27560

www.wasatchphotonics.com
info@wasatchphotonics.com
Tel: +1 919-544-7785

SPIE

the business of photonics
optics.org

eNewsletters

Put your products in front of your customers and drive traffic to your website every week.

- sent out weekly to 20,000+ subscribers
- extra special editions throughout the year



Contact the Advertising Sales Team
on +44 (0)117 905 5330
or email: rob.fisher@optics.org

Teledyne snaps up Adimec

Eindhoven-based maker of industrial cameras set to become latest addition to Teledyne's sprawling portfolio of imaging brands.

Teledyne is to further expand its already extensive portfolio of imaging technologies, with a deal to acquire the Dutch industrial camera maker Adimec.

Founded in 1992 by Just Smit, Bas Heijn, and Jochem Herrmann, Adimec sells a wide range of cameras typically used in machine vision, healthcare, and defense applications, with products operating in the visible, infrared, and X-ray spectral regions - including custom options.

One example is the firm's 103 megapixel "DIAMOND D-103A12-T" camera for high-resolution metrology, which is aimed at the displays sector for LCD, OLED, and MicroLED inspections.

Another area of expertise is an active lens alignment system that uses real-time measurements to assist in the positioning of the image sensor to optimize the performance of short-wave infrared (SWIR) imagers used in defense applications.

Complementary technology

Those technologies will augment a Teledyne line-up that has expanded dramatically over the past decade through a series of acquisitions of camera and image sensor manufacturers.

Edwin Roks, the Massachusetts firm's CEO, said of the latest deal: "Adimec possesses uniquely complementary technology, products and customers in the shared strategic focus areas of healthcare, global defense, and semiconductor and electronics inspection.

"For decades, and from our own X-ray imaging business headquartered in Eindhoven, I have watched Adimec grow to become a leader in niche applications requiring truly accurate images for precise decision making in time-critical processes."

Alex de Boer, one of Adimec's two co-CEOs, commented: "As a leader in advanced imaging technologies for industrial and scientific markets, Teledyne is the perfect company to build further on the strong foundation the founders and management have established over the past three decades.

"The entire Adimec team is looking forward to contributing to an exciting future with Teledyne while extending technical boundaries to support our customers with cameras - perfectly optimized to their application needs."

Joost van Kuijk, who has led Adimec alongside de Boer since 2014, added: "It is with great pleasure that we are able to announce publicly that Adimec will become part of Teledyne."

Imaging growth

Teledyne's most recent sales figures show that its digital imaging division posted annual sales of \$3.14 billion in

2023, accounting for more than half the NYSE-listed company's total revenues of \$5.64 billion.

In 2010, imaging represented only 7 per cent of Teledyne's \$1.64 billion annual revenues, equivalent to just over \$100 million.

However, since then the company has acquired the likes of Dalsa, e2v technologies, and the Roper subsidiaries Princeton Instruments, Lumenera, and Photometrics. Then in 2021 the firm completed its most significant move in the sector with the deal to buy thermal imaging giant FLIR, at a cash-plus-stock cost of around \$8 billion.

Speaking during Teledyne's most recent investor call, executive chairman Robert Mehrabian said that he expected the overall business to grow its sales revenues by around 4 per cent this year, with the FLIR division set to grow slightly more rapidly than its other imaging subsidiaries.

"FLIR defense especially, is experiencing really good order intake - and we expect the growth there to exceed that of the rest of the imaging [business unit]," he added.

teledyne.com

headwallphotonics.com

Author:

Mike Hatcher, Business Editor, *optics.org*



Eindhoven camera company Adimec has been selling its "TMX" series of products for 30 years. The latest version of the technology features an InGaAs SWIR sensor, and is aimed at applications in long-range, high-end security surveillance.

Image: Adimec.

Cognex profits shrink in 'challenging but stable' market

Machine vision firm posts sharp contraction in earnings in its latest financial year.

Cognex, one of the world's largest providers of machine vision technology, has posted sales of \$197 million for the closing quarter of 2023 - slightly better than its earlier forecast but still down nearly 20 per cent on the same period a year earlier.

The latest result means that the Natick, Massachusetts, company's full-year sales were \$838 million, having dropped by around the same degree from the record-breaking 2022 total of just over \$1 billion.

"Our fourth quarter results reflected a challenging, but stable business environment," commented Rob Willett, the Cognex CEO. "Revenue across most of our end markets was down year-on-year in the quarter, and our largest customers continued a pause in significant capital expenditures."

That fall in demand also hit the bottom line, nearly halving earnings for what is typically a highly profitable business.

Annual net income of \$113 million was

down from \$216 million in 2022 - although the company's executive team has decided to maintain its quarterly shareholder dividend at the same level for now.

AI 'profound' for machine vision

Discussing the latest results in an investor conference call, Willett said that Cognex would focus on strict cost management, while continuing to invest in long-term growth prospects.

"We launched a record number of new products in 2023 and commenced a multi-year investment in our 'emerging customer' initiative to expand our customer base," he said. "We believe these actions position us well to capitalize on exciting industry trends as growth returns."

Citing "broad softness" across several of the firm's key markets, including the automotive and medical sectors, and particular weakness in China largely related to consumer electronics manufacturing, the CEO suggested that things should start to improve in the second half of 2024.

And Willett added that while the electric vehicle market is expected to provide a long-term growth opportunity for Cognex in battery inspection, right now there is ongoing uncertainty regarding the level of end-user demand and political backing for the technology.

Overall, that is likely to mean flat sales in the opening quarter of 2024, with hopes of a rebound in the semiconductor market and perhaps consumer electronics later in the year.

Willett also stressed Cognex's efforts to harness artificial intelligence (AI) techniques like neural networks in machine vision applications, which he says were recognized by the company several years ago.

"[We have] a portfolio of new products incorporating more AI for human-like vision," he told investors, adding that the technology had "profound implications" for machine vision.

The CEO said that with hiring of skilled labor a major issue for manufacturing and tech companies, Cognex technology would ultimately reduce the need for that labor. He cited one major customer that is said to spend \$1 billion on human inspectors every year.

"Cognex can help reduce costs while improving the quality of those inspections," noted Willett.

Author:

Mike Hatcher, Business Editor, optics.org



Launched last year, Cognex's 'Advantage 182' vision system is one of several products now sold by the company that incorporates AI to mimic human-like inspection. Designed to automate complex location, classification, and inspection tasks, it is said to be capable of high-precision alignment and complex color inspections.

Image: Cognex.

Headwall targets machine vision with inno-spec deal

Nuremberg acquisition adds to the imaging firm's hyperspectral portfolio.

Massachusetts-based Headwall Photonics is set to add to its existing portfolio of hyperspectral imaging technologies, through the acquisition of Germany's inno-spec.

Founded in 2005 and based in Nuremberg, inno-spec has developed a variety of hyperspectral systems, with different units targeting the infrared, visible, and ultraviolet spectral regions.

The tools, known as "RedEye", "GreenEye", and "BlueEye", are used in applications ranging from high-volume recycling to industrial sorting, quality testing, biotechnology, and forensics.

Headwall, which since 2022 has been majority-owned by the private equity firm Arsenal Capital Partners, already sells equipment including lightweight hyperspectral systems suitable for drone operation, and also offers key components including spectrometers and gratings for OEM applications.

In July 2022 the firm expanded with the acquisition of both software-focused perClass, and precision optics specialist Holographix.

Industrial applications

Commenting on the latest deal, Headwall's new CEO Mark Willingham - appointed just a month ago - said: "This strategic move marks a significant step forward in our mission to deliver comprehensive hyperspectral imaging solutions.

"By integrating inno-spec's expertise in providing reliable industrial solutions with our advanced spectral imaging technologies, we aim to enhance our offerings and extend our global reach, especially in the rapidly evolving sector of industrial machine vision."

Inno-spec's CEO and founder Oliver Grass added: "Joining forces with Headwall Photonics represents a tremendous opportunity for inno-spec to scale our technology and tap into new markets.

"We are excited to become part of this group that shares our commitment to innovation and quality, and to drive the industrial machine vision segment; together we evolve the next generation of hyperspectral imaging systems."

Headwall says that the deal combines Headwall's cutting-edge optical components and remote sensing technologies with inno-spec's specialist knowledge in industrial applications - and should enable the development of more advanced, efficient, and versatile hyperspectral imaging systems.

Willingham, who brings photonics-related experience from prior roles at Spire, Manz, and Labsphere, among others, added: "Headwall Photonics is committed to ensuring a smooth transition for inno-spec's employees and customers.

"Our top priority is to maintain the high level of service and product reliability that our customers expect from us. We are dedicated to leveraging the strengths of both companies to drive growth and deliver value to our customers and stakeholders."

- Both Headwall and inno-spec are taking part in next week's Photonics West technology exhibition, along with Headwall subsidiaries Holographix and Netherlands-based perClass.

headwallphotonics.com

inno-spec.de/en

Author:

Mike Hatcher, Business Editor, optics.org



Joining forces with inno-spec will add to Headwall's expertise in industrial applications of hyperspectral imaging systems - for the growing field of machine vision in particular. Pictured are inno-spec founder and CEO Oliver Grass (left), and Headwall's new CEO Mark Willingham.

Photo: Headwall Photonics.

Bruker broadens optical portfolio with Spectral Instruments Imaging

Acquisition of Tucson company fills a gap with bioluminescence and fluorescence tools for preclinical disease research.

Analytical instrument vendor Bruker is set to further expand its offering of optics-based equipment with the acquisition of Arizona-based Spectral Instruments Imaging (SII).

Established in Tucson's "Optics Valley" region in 2009, SII has developed a range of scientific tools used in disease research, in particular in vivo animal studies.

Those imaging tools include bioluminescence (BLI), fluorescence (FLI) and X-ray systems, which are said to be engineered with superior optics and proprietary LED illumination designs.

"Intelligently designed around the needs of animal scientists, all Spectral Instrument Imaging systems include a robust build, patented LED illumination source, custom filter options, -90°C cooled camera, and absolute calibration," states the firm.

Bruker added: "This acquisition fills a gap in

the technology and product portfolio of the Bruker BioSpin Preclinical Imaging (PCI) division, broadening its range of preclinical solutions for disease research."

Disease research

In a statement from the two companies, SII's CEO Keith Copeland - who co-founded SII with current CTO and president Gary Sims - said: "Spectral Instruments Imaging systems perfectly complement the Bruker Preclinical offering.

"Joining Bruker represents a significant milestone in our history, and we are looking forward to enabling our customers to benefit from different preclinical imaging modalities to understand biological disease processes even more comprehensively in vivo."

Wulf-Ingo Jung, the president of Bruker's PCI division, added: "We are very pleased to



Photo: Bruker/SII via Business Wire.

SII's offering includes the benchtop AMI HTX system, which provides bioluminescence, fluorescence, and X-ray capability for in vivo imaging of live animals.

welcome the talented SII team. Their advanced BLI, FLI and X-ray imaging systems complement our portfolio to better serve the diverse needs of our preclinical customers.

"We are committed to fostering strong collaborations with our customers for advanced preclinical in vivo disease research."

According to Bruker, in 2023 SII generated a profit on sales in the region of \$10 million. Neither company disclosed the acquisition price or any additional financial details about the transaction.

News of the latest deal comes just a couple of months after Bruker said it was acquiring the Sheffield, UK, microscopy startup Phasefocus. Related recent moves have also included agreements to buy the neurophotonics firms Inscopix and Neurescence.

Author:

Mike Hatcher, Business Editor, optics.org

SPIE.

**connecting
people...**

**optics.org
career center**

The leading recruitment
resource for companies and
professionals in the optics and
photonics community.

...optics.org/jobs

the business of photonics
optics.org

Visit us at

**SPIE Defense+Commercial Sensing
Booth #1137 21 - 25 April 2024**

optics.org
e: rob.fisher@optics.org
t: +44 (0)117 905 5330
f: +44 (0)117 905 5331

MVtec presents itself and its software products at Automate

MVtec Software, a manufacturer of machine vision software, is exhibiting again this year at Automate in Chicago from May 6 to 9, 2024. The software company from Munich, Germany, has had a subsidiary in the USA since 2007.

“Automate is an important trade fair for us, because this is where we meet visitors from all areas of automation. At the trade fair, we want to show the fundamental advantages of machine vision and how our software products enable profiting from them,” said Dr. Olaf Munkelt, Managing Director of MVtec. Heiko Eisele, President of MVtec USA, added, “This year, we will again be represented with a large booth. This will allow us to showcase our comprehensive product portfolio.”

Applications in battery and semiconductor manufacturing

At the trade fair booth, MVtec will be demonstrating how machine vision, as the “eye of production”, can optimize and automate processes. MVtec offers a wide range of functionality based on deep learning and classic machine vision, which customers can use to implement their applications flexibly and efficiently. The company will be demonstrating how this is possible in concrete terms



Credit: MVtec

Heiko Eisele, President of MVtec USA.

with three demos at its booth. Two new MVtec software versions Halcon 23.11 and Merlic 5.5 are also being presented. Halcon is a software package for machine vision with an integrated development environment (HDevelop). It enables cost savings and improved time to market, says MVtec. The flexible architecture facilitates rapid development of many kinds of machine vision application.

Merlic combines reliability and speed with ease of use, says the developer. An image-centric user interface and an intuitive operating concept ensure an efficient workflow. This significantly shortens the creation and deployment of machine vision applications.

“Our goal is to provide our customers with the best possible machine vision software at all times,” said Eisele. “This means that we maintain a very close relationship with our customers through our local service and actively support them in creating solutions based on HALCON, MERLIC and the Deep Learning Tool. We are also actively expanding our presence in the North American market by continuously hiring employees for our Boston office.”

Further information is available at [mvtec.com](https://www.mvtec.com)

Author:
Matthew Peach, Editor-in-Chief, optics.org



Credit: MVtec

Dr. Olaf Munkelt, Managing Director of MVtec; (R) Heiko Eisele, President of MVtec USA.

Ansys debuts SimAI software for an open design ecosystem

Ultra-fast AI-based addition to the portfolio enables “virtual testing and creative design”.

Ansys has launched its newest artificial intelligence-based technology, Ansys SimAI, a physics-agnostic, software as a service application that is said to “combine the predictive accuracy of Ansys simulation with the speed of generative AI.” The new solution supports an open ecosystem and predicts performance “within minutes — democratizing simulation through intuitive interfaces and processes,” says the company.

By infusing advanced generative AI into the design process alongside simulation, users can redefine and gain more value out of existing processes to meet the needs of a dynamic market. “Operating at extreme speeds, Ansys’ latest AI solution accelerates research and development, shortens product development cycles, and promotes human creativity by enabling expansive design exploration opportunities,” states the new product announcement.

The Ansys SimAI solution is designed for

users without coding experience or deep learning expertise. Instead of relying on geometric parameters to define a design, Ansys SimAI uses the shape of a design itself as the input, facilitating broader design exploration even if the structure of the shape is inconsistent across the training data.

The application can boost prediction of model performance across all design phases by 10-100X for computation-heavy projects, the company says. Users can train the AI using previously generated Ansys or non-Ansys data. Training and predictions are hosted on a state-of-the-art cloud infrastructure to ensure that user data is secure and kept private.

“With Ansys SimAI, we can easily test a design within minutes and rapidly analyze the results, ultimately redefining our digital engineering workflow and reshaping our perception of what is possible,” said William Becamel, leader in numerical modelling and simulation, at

Renault Group. “By enhancing simulation speed, we can explore more technical possibilities during the upstream phase of our projects and reduce the overall time-to-market.”

Shane Emswiler, senior vice president of products at Ansys, said, “Customers across diverse industries are becoming more reliant on generative AI to improve their design processes. The increased demand for cloud-native solutions signals momentum in the shift from siloed workflows to a more open, collaborative approach to simulation. Ansys SimAI, in combination with other Ansys solutions, opens a world of possibilities — helping organizations develop comprehensive, end-to-end processes for diverse applications with inherent time and cost saving benefits.”

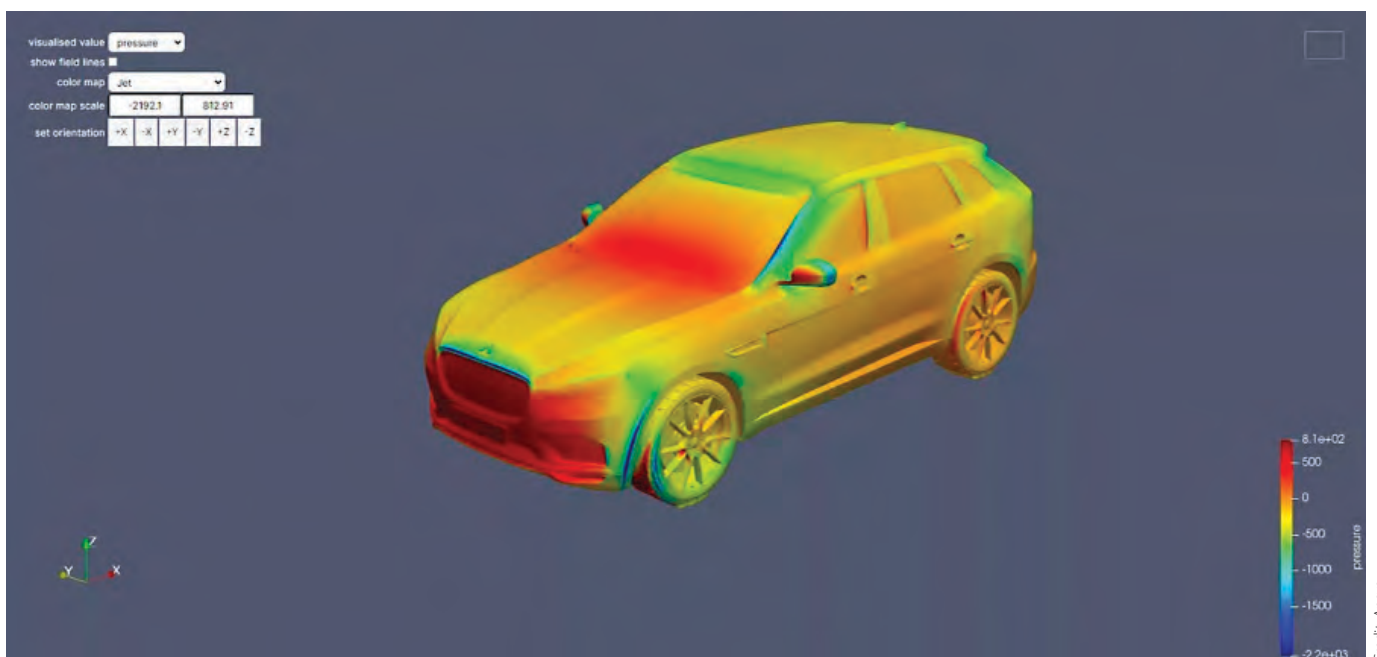
Ansys partners with SynMatrix

Ansys has also announced a new OEM partnership with SynMatrix to streamline RF filter design workflows for wireless communications applications. SynMatrix develops industry-leading RF filter design and optimization tools that integrate with HFSS electromagnetic simulation. The Ansys SynMatrix Filter software enables accelerated development, helps reduce project risk, and fosters the design exploration of new filter technologies.

[ansys.com](https://www.ansys.com)

Author:

Matthew Peach, Editor-in-Chief, [optics.org](https://www.optics.org)



The SimAI interface is user-friendly and enables rapid performance prediction.

2024 | PLAN TO ATTEND

SPIE. SENSORS+ IMAGING

REMOTE SENSING | SECURITY + DEFENCE

Programme: 16-19 September 2024

Exhibition: 17-18 September 2024

Edinburgh International Conference Centre (EICC)

Edinburgh, United Kingdom

Plan to Join your colleagues in Edinburgh

SPIE Sensors + Imaging combines two of Europe's best photonics conferences — SPIE Remote Sensing and SPIE Security + Defence. The premier yearly European event that showcases the latest sensor and photonic technologies for imaging and monitoring the Earth's atmosphere and environment, as well as sensor technologies that address homeland security, defence, and counterterrorism. These two unique meetings will offer opportunities to network with colleagues from a variety of disciplines in academia, industry, and government from all over the world.

Meet face-to-face with top companies at the free two-day exhibition. These leading companies are providing new capabilities and innovative products to help move your projects forward.

Register today. We look forward to seeing you in Edinburgh.



www.spie.org/esi