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VISION focus

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Visionary ideas

Welcome to the latest issue of VISION Focus, the quarterly digital magazine that covers all aspects of vision and imaging, produced by the team that brings you optics.org. The editorial focus of this issue is centered on the AIA Vision Show, taking place in Boston, MA, between May 3-5 at the Hynes Convention Center – North America's leading showcase of machine vision and imaging components and solutions.

This bumper issue offers several special features connected with industrial, manufacturing and R&D aspects of automated and machine vision systems, followed by a round up of selected new products.

Our cover feature is about the vision systems deployed on the European Space Agency's first ExoMars mission, launched in March, which will begin searching for signs of life on the red planet towards the end of 2016. Among the probe's high-tech hardware is the first retroreflector to be sent to the Martian surface, plus a variety of visible, infrared and Raman spectrometers and imaging tools. Read all about it on page 8.

Fast-growing camera developer Basler says its has "laid the foundations for the next five years" as the digitization of industry becomes a dominant theme. The German giant of industrial cameras sold more than 200,000 units in 2015 boosting its 2015 sales to €85 million. Find out how on page 4.

Head-up displays (HUDs) are increasingly deployed in both military and commercial aircraft. These systems enable pilots to keep track of data and make decisions quickly without having to look away from their skyview. HUD systems depend on advanced optical coatings, such as those developed by the UK's Orion Photonics, which is profiled on page 6.

Other articles cover the growing impact of the UAV ("drone") and robotics market on the vision systems marketplace; new multi-million euro investment in European photonics and vision projects; and improving medical imaging using fiber-optic endoscopes.

Each issue of VISION Focus magazine is promoted to more than 25,000 industry professionals. We also publish printed copies at major events and exhibitions, so if you're visiting the AIA Vision show, make sure to grab a copy of the latest issue.

You can also meet our editorial and sales teams at key industry events throughout the year and let us know about your latest innovations and how you see the vision industry.

Matthew Peach, Contributing Editor
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This Issue

plus the latest product launches from within the industry

Publication and Editorial Schedule 2016/17

August/September Issue

- Bonus Distribution: **SPIE Optics + Photonics, Photonex, UK**
- **Editorial Focus:** optical components, academic research, software applications
- Published in advance of Optics+Photonics, 30th – 1st Sept and Photonex, 12th- 13th Oct

October/November Issue

- Bonus Distribution: **Vision, Stuttgart**
- **Editorial Focus:** machine vision applications, production line management and quality control, associated products and developments.
- Published in advance of VISION Stuttgart, 8th – 10th Nov

February/March Issue 2017

- Bonus Distribution **SPIE BiOS + Photonics West**
- **Editorial Focus:** industrial applications, sensing, biomedical analysis and treatments.
- Published in advance of BiOS, 28th Jan – 2nd Feb 2017 and Photonics West, 31st Jan – 2nd Feb 2017

Basler focused on 3D development as sales, headcount rise

Camera developer says it has laid the foundations for the next five years as the digitization of industry becomes a dominant theme.

Industrial camera vendor Basler says that it sold more than 200,000 units in 2015, as the German company posted a rise in sales to EUR85.4 million for its full financial year. That corresponded to an 8% jump in revenues on 2014, although with more than 500 employees now on its books Basler's net income fell to EUR6.2 million, down from EUR8.2 million in 2014.

"The high profitability and cash flow level of the previous year was deliberately reduced and invested in the company's future," explained Basler, which also announced a cut in shareholder dividend.

The company says that its sales of industrial cameras rose by 15%, outstripping the 9% growth of the wider German image processing industry and indicating that it has gained some market share. However, after a strong start to 2015 demand from key customers in Asia began to slow down, and this year the company is predicting a smaller rise in sales, to around EUR91 million.

Last year those sales remained dominated by the key application areas of semiconductor and electronics production, although Basler says it is now expanding its business outside of factories and targeting the less cyclical markets of medicine and traffic technology.

The 2015 figure means that over the past decade Basler's camera shipments have risen by a factor of nearly 20, up from only 11,000 back in 2005. By 2020 the company, based in Ahrensburg, near Hamburg in northern Germany, expects unit shipments to rise to more than 500,000 as machine vision benefits from the trend of industrial digitization and becomes an increasingly pervasive technology.

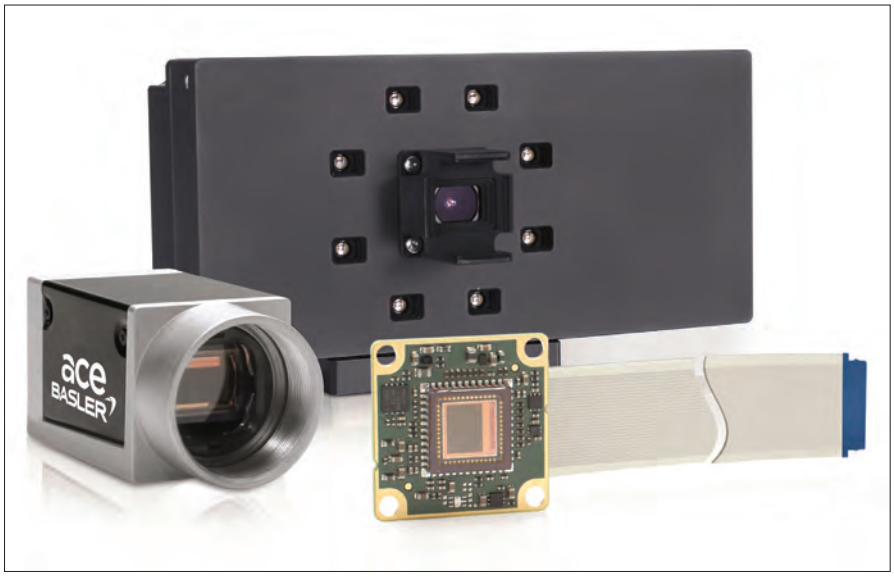

Photo credit: Basler.

Basler's new time-of-flight 3D camera (the gray rectangular device at the back of this image) will make an appearance at next month's AIA-organized The Vision Show in Boston.

Looking to that future path, Basler is focusing on new 3D cameras based around time-of-flight imaging technology. During the past year its prototypes, incorporating feedback from potential customers, have been in late-stage development – with the emerging technology making an appearance at SPIE's Photonics West exhibition in San Francisco.

The idea behind these new cameras is to measure the time taken for photons to travel from the illumination source to a target object and back again, thus generating a spatial "map". That might sound simple enough in principle, but in practice it means that a huge amount more data is generated than with a conventional 2D imager. Detailed information in the form of depth mapping and intensity profiles is yielded, but successful deployment relies on high-precision control over the timing of light pulse generation and detection, and electronic shutter components. A delay of just a nanosecond would translate to a mapping error of around 30 centimeters.

At The Vision Show in Boston next month, the biennial trade show and

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Basler focused on 3D development as sales, headcount rise

conference organized by the Automated Imaging Association (AIA), Basler is set to unveil what it describes as the first high-resolution time-of-flight camera on the market – said to offer 3D imaging technology suitable for the "mass market" for the first time.

Featuring a pulsed near-infrared LED light source and a CCD sensor from Panasonic, the camera operates over a working range of 0.5-5 meters, with a claimed depth accuracy of +/- 1 centimeter. Basler sees a range of potential applications in sectors already familiar with machine vision, like pallet stacking and box routing, factory automation and robotics. However, new vision applications in medicine – for example patient monitoring and positioning in MRI scanners – and the exciting area of autonomous vehicles, where the approach could be used for avoiding obstacles or navigation, are also envisaged.

3D imaging promises to be something of a theme at the Boston event, with Mattias Johannesson from Basler's rival SICK hosting a tutorial on 3D vision system development for applications across multiple industrial sectors, and keynote speaker Steve Varga from consumer goods giant Procter & Gamble's imaging and measurement team discussing the need for greater capability in high-speed 3D cameras and motion analysis.

Fitted with integrated optics and a GigE interface, Basler's 15 frames-per-second 3D camera is said to be able to capture the spatial dimensions of scenes and objects without the need for moving components like laser scanners. "That makes the ToF camera more robust and less susceptible to interference," reports Basler – although the company adds that scattered and ambient light should be avoided as much as possible, especially bright daylight conditions.

While the company is anticipating a solid enough year of growth for 2016, a wider economic slowdown looks likely to hit the machine vision sector more generally. Germany's Engineering Federation (VDMA) expects the global engineering industry to be stagnant at a growth rate of only 1%. Lower demand from key markets like Russia and Brazil as a result of the recent slump in oil prices is also likely to outweigh any benefits relating to decreased raw material costs.

On the other hand the currently weak value of the euro against other major currencies ought to help make exports from the largely Europe-based machine vision sector more attractive around the world.

In its annual report, Basler's executives boasted that an "excellent" company culture, characterized by a substantial willingness to accept change, saw some bold steps towards a more modern, efficient, and future-oriented company emerge last year. "Their implementation will take many more months, but the effectiveness of this restructuring can clearly be felt already," they added.

While 2015 was seen a challenging financial year, the addition of more than 60 new employees and further development of the company strategy are said to have laid the foundations for the future success.

Mike Hatcher, Contributing Editor

Optical coatings herald new era for avionic head-up displays

Avionic head up displays are undergoing a renaissance thanks to lightweight digital displays and advanced optical coatings on combiners, such as those developed by the UK's Orion Photonics.

Pilot's screen-projected view of HUD; the green wavelength is used because it is the range of greatest sensitivity of the human eye.

Head-up displays (HUDs) in both military and commercial aircraft enable pilots to keep track of data and make decisions quickly without having to look down and refocus. The HUD provides the ability to project information onto a transparent glass screen called the combiner such that it almost appears to be floating in space behind the screen as a virtual image. With suitable optics, the virtual image is combined with the view of the real world seen through the screen so that both images appear to be superimposed and at the same focusing distance.

The flight data generated electronically is converted into a visual display, which is usually green in colour – where the eye is most sensitive. The display image is projected onto the combiner where it is reflected towards the pilot. To make the display work effectively, the reflection from the combiner must be enhanced by a semi-reflective thin film coating, which in turn reduces the transmitted view, as seen through the combiner. Advances in narrow bandwidth green phosphors and LEDs have led to the development of HUDs with increased display brightness. This in turn has generated the need for colour-selective combiner coatings that reflect only the green wavelengths emitted by the display and transmit the rest of the visible spectrum.

Orion Photonics, based in Beaworthy, Devon, UK, is at the forefront of rugate filter technology for design and manufacture of HUD combiners. This involves design techniques where the refractive index of the thin films varies in a periodic way to produce spectral properties that are not possible using conventional thin films. The technique is particularly suitable for generating colour-selective optical coatings with narrow bandwidth reflection "notches" exhibiting high transmission at all other wavelengths.

The implementation and control of the process enables the manufacture of thin film coatings with special performance capabilities. For HUDs, this gives the freedom to tailor a design for any configuration. It is possible, for instance, to change the

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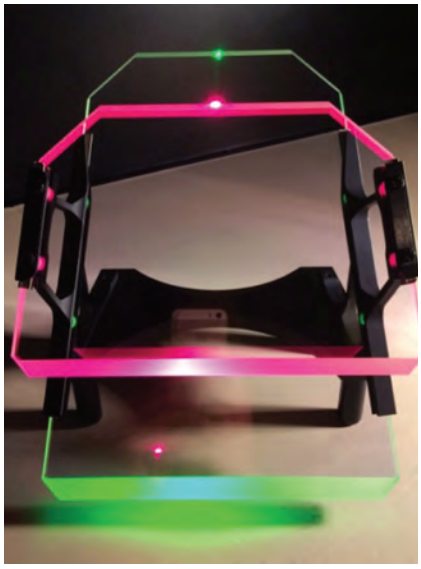
Optical coatings herald new era for avionic head-up displays

performance progressively across the combiner surface to compensate for changes in angle of incidence, ensuring that the brightness of the virtual image is constant for different viewing positions

Dual-graded combiner HUDs

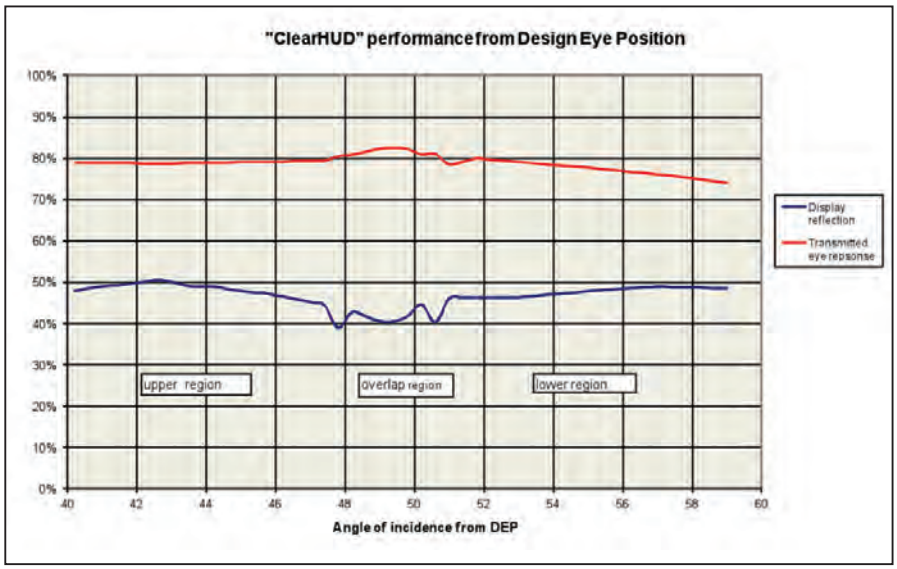
In many aircraft, dual combiner HUDs can be used to extend the vertical field of view (FOV) in the cockpit, where space is limited. This allows the display image to be shared between two inclined combiners parallel with each other but vertically displaced (see photo). Where the image is transferred between combiners it is important that the pilot does not see any transition features, which could be interpreted, as an artificial



Schematic ray trace lay-out of the dual combiner.

horizon. To maintain a uniform display, the reflection of each combiner in the overlap region is required to progressively reduce, to make the transition of the image between each combiner smooth, and the combiner edges almost invisible. The overlap region in the dual combiner assembly is called the "grade".

This presents a challenge for colour-selective combiners, but with the flexibility of Orion's rugate technology, the depth of reflection can progressively reduce across the surface of each combiner, eventually becoming an antireflection coating. This is achieved without changing the perceived wavelength or colour. From the pilot's perspective, this results in a HUD that has uniform display reflection across the field of view, and



ClearHUD" combiners maintain a neutral transmitted view, eliminating the more normal pink view with conventional combiners.

a uniform view through the combiners irrespective of eye position.

Pretty in pink

A feature that is common to most HUDs is that a colour-selective green combiner coating means that the transmitted view though the combiners appears pink, and although this colour distortion is not liked by pilots, it has largely become accepted, provided that the colour is not too pronounced.

In recent times, LED displays have been integrated as the light engine for HUDs because these sources are more robust, occupy less space and weigh less than traditional CRT displays. The spectral output of green LEDs is wider than the green CRT phosphor, and therefore to reflect more of the green display, the combiner coating bandwidth must be wider, resulting in lower transmission and a more saturated pink colour to the transmitted view.

This however is not acceptable and to maintain an acceptable level of outside world colouration seen through the combiners, the level of display reflectivity must be reduced, and this inevitably compromises display efficiency. This has created a dilemma in that reducing reflectivity in turn reduces display efficiency.

Color-corrected

Orion Photonics has pioneered a two-colour display graded combiner assembly, which called "ClearHUD", which extends the capabilities of dual-graded HUDs. Not only is this colour-corrected to give a clear neutral view through the HUD, it has a second fully-graded red reflection notch thereby providing the possibility of introducing a red warning or "attention getter" superimposed on the green display. This warning signal would not only be visible to the naked eye from the HUD but would be visible to the pilot when wearing night vision goggles.

Colour neutrality is the preference of many pilots for mission-critical visual sighting through the cockpit. The colour balancing technique has minimal effect on photopic transmission and in transmission mode it is virtually impossible to see any colour change between the reflective and antireflective areas of the combiner. The combiners also maintain high display reflection efficiency.

HUDs are designed around the pilots "driving position" so that the pilot is at the optimum position to see the display. This is known as the design eye position (DEP) and the allowed head movement for seeing the display is called the eye motion box (EMB). The performance of each combiner coating is optimised to compensate for different angles of incidence so that the transmitted view and display reflection look uniform in colour and intensity from any eye position within the eye motion box.

"ClearHUD" combiners are in the pre-production stage at Orion Photonics and pairs of upper and lower graded combiners are currently being evaluated by international manufacturers of Head up Displays. Already the company has received significant interest in the new designs, and the concept could have a significant impact on the future development of avionic head-up displays.

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Matthew Peach, Contributing Editor

Optical payload blasts off with ExoMars mission

Suite of photonics-based equipment, including the first laser retroreflector to be placed on the red planet, begins journey to Mars.

A host of optics and photonics equipment has been launched into space aboard the European Space Agency's first ExoMars mission, to begin searching for signs of life on the red planet towards the end of this year.

Among the various pieces of hardware are – assuming a successful flight and touchdown - what will be the very first retroreflector on the Martian surface, plus a variety of visible, infrared and Raman spectrometers and imaging tools.

That kit was launched from the Baikonur cosmodrome in Kazhakstan early on March 14, with the ESA confirming successful separation of the three Proton rocket stages used to blast into space, and completion of the first of four "burns" that will propel ExoMars to its final destination.

This launch is in fact the first of two ExoMars missions, with the second scheduled for 2018. The payload inside the first launch includes a trace gas orbiter (TGO) that will look for the sources of methane previously discovered, and an "entry, descent and landing module" known as Schiaparelli.

The second mission will carry a rover and more complex suite of scientific instruments to Mars that will look directly for signs of microbial life on the planet's surface.

Photo: ESA–S. Corvaja, 2015.

The first of two ExoMars missions features a whole host of optics and photonics equipment to search for sources of methane and other signs of Martian life, as well as recording what promises to be a dramatic descent by the Schiaparelli module. The landing module (at the top of the image) and the larger trace gas orbiter are seen here during vibration testing at Thales Alenia Space, in Cannes, France, last year.

Main objective: what's the Martian methane source?

Ahead of the launch, ESA explained: "The main objectives of the TGO mission are to search for evidence of methane and other trace atmospheric gases that could be signatures of active biological or geological processes on Mars."

The TGO has four suites of science instruments: ACS (Atmospheric Chemistry Suite), CaSSIS (Colour and Stereo Surface Imaging System), FREND (Fine Resolution Epithermal Neutron Detector) and NOMAD (Nadir and Occultation for MArs Discovery).

ACS and NOMAD both rely heavily on photonics equipment, each comprising three spectrometers covering complementary wavelengths. They are set to take a detailed inventory of Mars' atmospheric trace gases, monitoring seasonal changes in both composition and temperature to create detailed atmospheric models.

The instruments also have the capability to detect minor atmospheric constituents that may exist but have yet to be detected, ESA says.

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Optical payload blasts off with ExoMars mission

To complement these measurements, CaSSIS will image and characterize features on the Martian surface that may be related to the trace-gas sources, like volcanoes.

Retroreflector

Meanwhile the Schiaparelli module payload includes a cube corner laser retroreflector (CCR) on its zenith-facing surface. It will enable Schiaparelli to be located from Mars orbiters by laser ranging, both during the mission lifetime and afterwards.

"This will be the first time that a retroreflector has been placed on Mars," ESA said, adding that the CCR would act as a fixed point on the Martian surface that could be used in the longer term for optical detection by future experiments, for example in the fields of Martian geodesy or general relativity.

The device is similar to the retroreflectors that were placed on the Moon by the Apollo astronauts and Lunokhod rovers, and which are still in use today.

The lightweight device, just a couple of inches in diameter and weighing only 25 g, could also support testing and diagnostics of any future attempts at laser communications between Mars orbit and instruments on the surface.

The retroreflector could also help detect trace atmospheric species performed by lidar equipment in orbit around the planet.

Laser desorption

In another echo of the Apollo missions, the Schiaparelli module also features a descent camera that will image the Martian surface as the landing site is approached, and help to generate a 3D topography model of the landing region.

The rover module that should be launched in May 2018 will feature a laser-desorption mass spectrometer that is part of the largest single instrument featuring in ExoMars. It is likely to become the primary focus of attention on board the mission's rover as it roams the planetary surface looking for organic molecules.

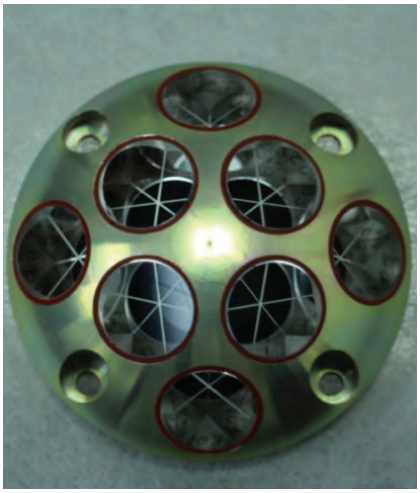


Photo: INFN.

In an echo of the Apollo lunar missions more than 40 years ago, ExoMars will deposit this optical retro-reflector on the Martian surface. It will enable the Schiaparelli module to be located, using laser ranging, from Mars orbiters.

Thanks to advantageous positioning of Earth and Mars at the moment, the first of the ExoMars missions should take only seven months to reach the red planet. Shortly before arriving at the Martian atmosphere on October 16, the Schiaparelli module will be ejected from the TGO – and should land three days later for a brief, four-day scientific mission.

Scientific work by the TGO will not start until a year later, after the craft has changed inclination and lowered its orbiting altitude to 400 km. The TGO is then scheduled for five years of work, including data relay operations supporting the rover mission once it arrives in early 2019.

Mike Hatcher, Contributing Editor

http://optics.org/news/7/3/16

AIA launches startup competition for vision technology innovators

$10,000 prize awaits winning company using vision systems in "new and unique ways". Winner to be announced at Boston show grand finale.

AIA, which claims to be the world's largest trade association for vision and imaging, is inviting vision systems companies to participate in its startup competition to be staged at forthcoming Vision Show, to be held in Boston, MA between May 3-5, 2016. Companies interested in submitting an application should be utilizing vision and imaging in "innovative ways". The contest will be presented as a part of the Vision Show on the exhibition floor of Boston's Hynes Convention Center.

Image: Basler.

Visionary: BCON is Basler's newly-developed interface. This connection to LVDS-based technology offers reliable image data transfer.

The AIA says that vision and imaging technologies "are being used more today than ever before in areas such as robotics, military, security, drones, life sciences and consumer devices", adding that "in recent years there has been a groundswell of startup companies introducing new products leveraging vision technologies."

The Vision Show Startup Competition is seeking out startups to generate awareness of their new solutions. Jeff Burnstein, President of AIA, commented, "We recognize the critical role of startups in driving innovation and bringing forth new technologies to foster continued growth in the vision and imaging industry. We encourage them to take advantage of this competition opportunity to spread awareness and take their company to the next level."

Now with startup competition, AIA's Vision Show 2016.

Shortlisted pitches

Eight semi-finalists will have five minutes each to pitch their technology to a panel of investors and vision experts, where they will compete for a grand prize of $10,000. Eligible companies should be leveraging vision and imaging in their products in an innovative way; have been around for five years or less; raised less than US $2 million since launching; and not be affiliated with a larger group.

All semi-finalists will be provided booth space on exhibition floor, putting them in front of an expected audience of more than 3,000 industry professionals interested in vision and imaging technology. To enter the Vision Show Startup Competition, intetested parties can apply online here.

Founded in 1984 to advance the understanding and use of imaging and vision technologies and to drive global expansion and growth through education and promotion, the AIA now represents over 330 vision suppliers, system integrators, users, researchers, and consulting firms from 32 countries.

As well as the Vision Show, the AIA is known for developing vision and imaging standards such as GigE Vision, Camera Link, Camera Link HS and USB3 Vision; it also presents the Automate Show (April 3-6, 2017 in Chicago); the annual AIA Business Conference (January 18-20, 2017 in Orlando) and a range of other industry events.

http://optics.org/news/7/3/42

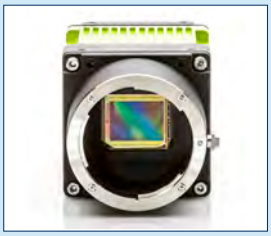
JAI A/S

JAI introduces the world's fastest 12 megapixel camera

JAI has expanded its Spark Series of high performance industrial area scan cameras with SP-12000M-CXP4 (monochrome) and SP-12000C-CXP4 (color). Both camera models are based on the CMOSIS 12-megapixel sensor (CMV12000) featuring 189 FPS and global shutter technology. Applications include machine vision, sports/entertainment and traffic/outdoor.

- 12 megapixel resolution
- CMOS global shutter
- 4096 x 3072 pixels
- 189 frames/s
- 5.5 µm square pixels
- CoaXPress (4-connector) and GigE Vision interface

Read more on: http://www.jai.com/en/newsevents/news/new-spark-sp-12000-cxp4-machine-vision-camera-with-coaxpress-interface



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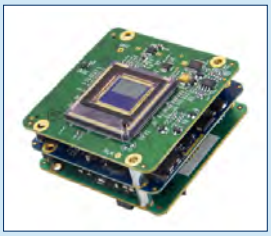

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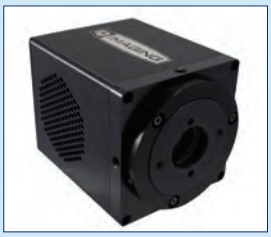

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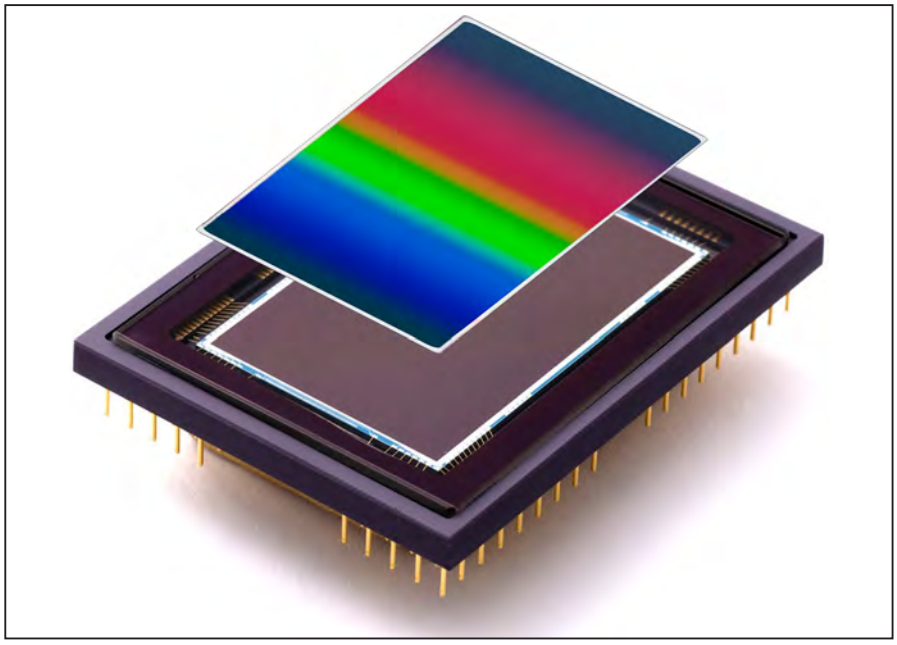
Sponsored Editorial

Linear Variable Bandpass Filters for Hyperspectral Imaging

Hørsholm, Denmark, March 21st 2016 - Delta Optical Thin Film A/S announces the launch of several Linear Variable Bandpass Filters that are specifically designed for Hyperspectral Imaging.



Hyperspectral imaging (HSI) has been used for a couple of decades in applications such as satellite imaging, air reconnaissance and other not overly price sensitive markets. Classical Hyperspectral imaging cameras use prisms or grating as dispersive elements. These cameras are bulky, sensitive to misalignment and very expensive. The advent of alternative approaches makes HSI attractive for volume markets or even consumer products, for example cancer detection, precision farming, food testing in supermarkets and many more.

Delta Optical Thin Film A/S develops and manufactures custom Linear Variable Bandpass Filters (LVBPF) for mid-size and full-frame CCD/CMOS sensors (e.g. 25mm x 25mm or 24mm x 36mm). These filters offer very high transmission and are fully blocked in the light sensitive wavelength range of silicon-based detectors (200nm to 1150nm). The combination of LVBPFs with silicon detectors allows the design of very compact, robust and affordable HSI detectors that offer several advantages and benefits over conventional approaches:

- Huge aperture compared to grating and prism
- Higher transmission than grating and prism
- Short measurement time
- High suppression of stray light
- Excellent signal to noise ratio

Delta Optical Thin Film A/S welcomes requests for custom designed Linear Variable Bandpass Filters. Available for immediate testing are filters with the following specifications:

- Centre wavelength range 450nm to 880nm, bandwidth approximately 2% of centre wavelength, transmission 60% to 90%, blocking range 200 nm to 1150nm, blocking level OD4, size 24mm x 36mm
- Centre wavelength range 450nm to 850nm, bandwidth approximately 4% of centre wavelength, transmission 70% to 90%, blocking range 200nm to 1100nm, blocking level OD4, size 25mm x 25mm
- Centre wavelength range 800nm to 1000nm, bandwidth approximately 0.6% of centre wavelength, transmission >70%, blocking range 200nm to 1200nm, blocking level OD4, size 19mm x 8mm
- Centre wavelength range 800nm to 1000nm, bandwidth approximately 1% of centre wavelength, transmission >70%, blocking range 200nm to 1200nm, blocking level OD4, size 19mm x 8mm

The sizes are given as height x length, where height is perpendicular to the wavelength gradient and length is along the wavelength gradient. The filters can be diced to smaller sizes.

About Delta Optical Thin Film A/S

Delta Optical Thin Film A/S *(www.deltaopticalthinfilm.com)* is the leading supplier of advanced, high performance linear variable filters commonly used in a variety of biomedical imaging applications including fluorescence microscopy, flow cytometry, monochromators and micro-plate readers among others.

Delta Optical Thin Film A/S also provides single, multiband, laserline and broadband band pass filters; long pass filters; short pass filters; notch filters; dichroic and polarizing beam splitters along with other custom coated optical components.

Delta Optical Thin Film A/S offers a wide range of high efficiency durable ultra-hard coated filters that have set the standard for high performance and precise operation. With its unique design tools and decades of experience, Delta is able to provide highly competitive standard filters and customized filters and optical components tailored to customers' specific applications.

Trade shows:
SPIE Defense + Commercial Sensing 2016 - booth #344
AIA The Vision Show - booth #1134

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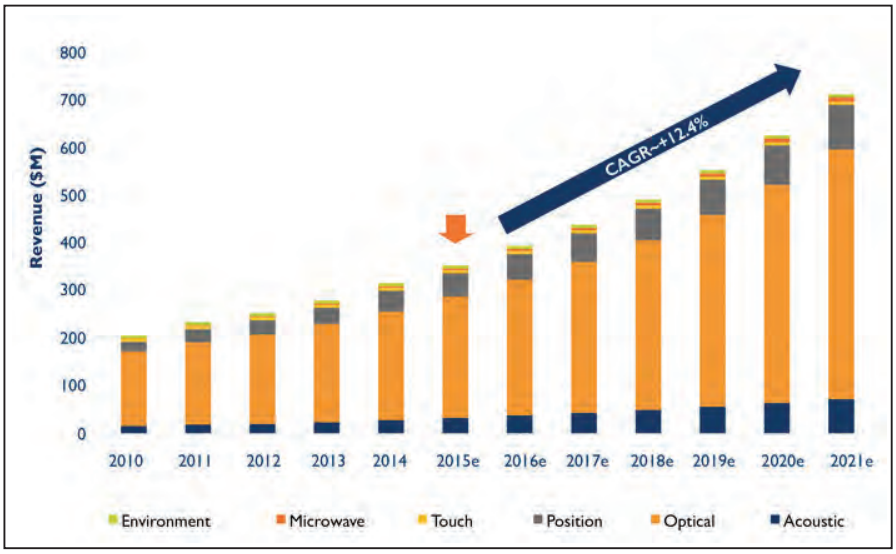
Sensors and cameras leading drones and robots revolution

Analyst Yole says the already-robust $350m sensors for drones and robots market will double by 2021.

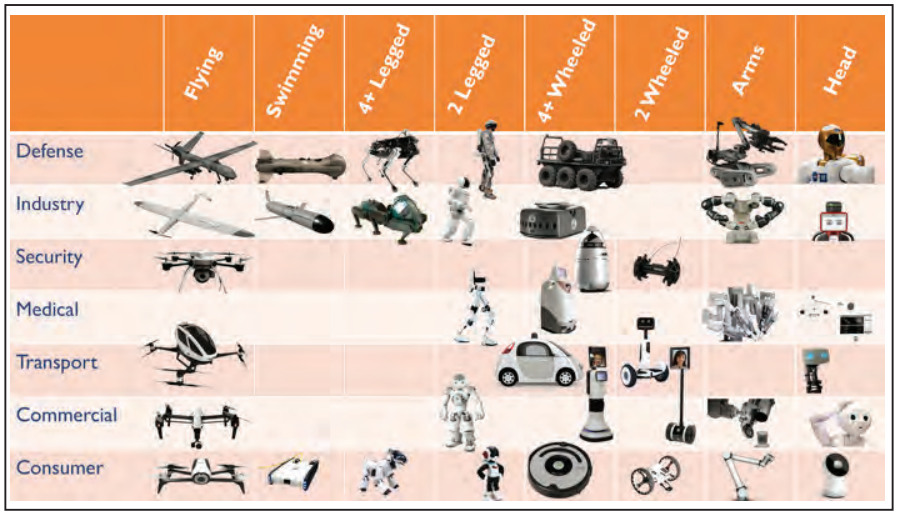
The sensors for drones and robots market is expected to grow at a CAGR of 12.4% between 2015 and 2021, reaching a total revenue of US$ 709 million by 2021, according to a new market report from Yole Développement (Yole). The report, entitled Sensors for Drones and Robots: Market Opportunities and Technology Revolution, reveals that the market is clearly being driven by full applications range of available technologies.



Source: Yole Développement.

Sensors for drones and robots: revenue forecast, by technology 2010-2021.

"Defense and manufacturing have been the traditional drones and robot markets," explained Pierre Cambou, Activity Leader, Imaging at Yole. "Within five years, the emerging robotic market segments will grow from 14% to 28% of the global drones and robots market share." Yole predicts that these new markets will represent double the share of the current defense market and half the share of today's industrial market.



Source: Yole Développement.

Drones and robots: Market segmentation.

Yole's analysis identifies the overall drones and robots applications with a market and technology approach; this report lists the key players for each application and their market positioning. The technology for drones and robots is also well detailed. The company is presenting "a deep analysis of sensor forecasts per application and technology, the related market drivers and a dedicated roadmap" (see third graphic, below). Currently, the two largest markets for drones and robots are defense and industrial, both of which owe much to the global policies of the United States and China.

Military share reduction

"Through our research, we've identified at least ten new applications for which drones and robots that will generate more than $1 billion in revenue per year", added Cambou. "As numerous new applications covering the full market spectrum emerge, including consumer drones, autonomous vehicles, hospitality robots, exoskeletons, and telepresence, the drones and robots markets will become less military and manufacturing-oriented." These new applications, which are expected to enjoy a compound growth rate of 40% and above over the next five years, are all detailed in the full report.

For each market, a huge diversity of robots and applications are being explored by numerous emerging players. Yole comments that there is a complexity inherent to early-stage markets, where a diversity of competing technologies can coexist.

Cambou commented, "Sensors, which are key enablers for the emerging robotics revolution, will play a role in all applications. Indeed a robotic device is a closed loop of actuation, computation, and perception or sensing. The previous two digital and industrial revolutions ushered in the first two capabilities, with sensing the only one still outstanding."

Mobile and automotive markets have been instrumental in the maturation of acoustic, optical, and positional sensors, while new sensor categories like touch, microwave, and environmental will serve drones and robots.

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Sensors and cameras leading drones and robots revolution

Optical systems as enablers

Dr Eric Mounier, Senior Technology & Market Analyst at Yole, commented, "Optical sensors, in particular visible cameras, lidar, and 3D cameras, are the major enablers," asserts. And he adds: "Acoustic and positional sensors will also enjoy double-digit growth rates for drones and robots applications."

The Sensors for drones and robots report highlights the extremely diverse sensor revenue distribution amongst the markets Yole analyzed. From consumer, commercial, and transport to medical, security, industrial, and defense, every market will generate sensor revenue, they say. "Marketing-wise, this is especially beneficial to smaller companies focused on a few specific niches. The drones and robots markets are the perfect target for emerging sensing technologies," Yole comments.

Among the numerous applications relevant to sensors for drones and robots, Yole suggest there is not yet a clear case for cheap volume-oriented sensors versus high-end expensive ones: "The drones and robots markets are still emerging, and first must prove their benefit. In this context they are particularly price-conscious at the beginning of product expansion."

By Yole's observation, once they have proven themselves the unit average selling price will stop shrinking and start rising again. Performance at low cost is an enabler, but cost for performance is a driving force. This is currently evident in the consumer drone space, along with vacuum cleaner robots and hospitality robots. In the future, we expect to see this trend across the board.

Matthew Peach, Contributing Editor

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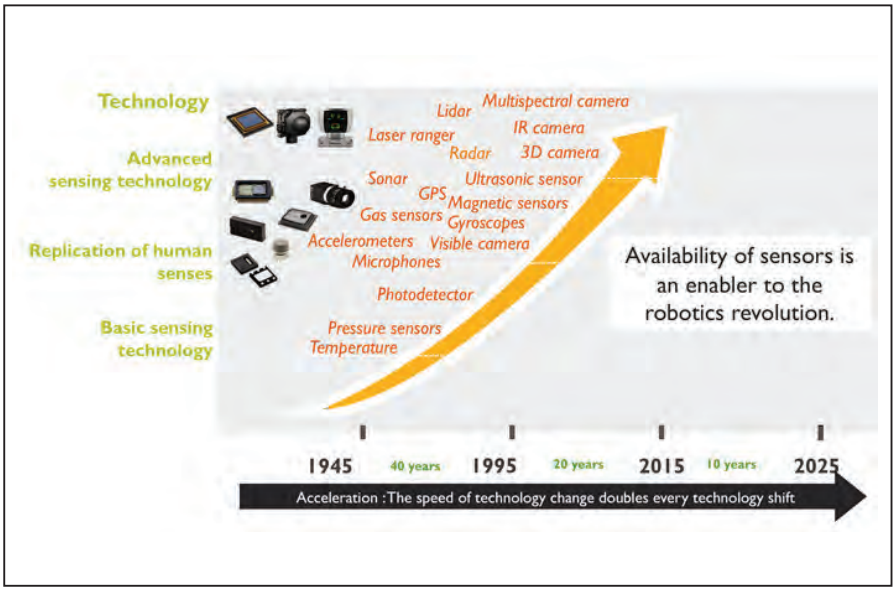


Sensors for drones and robots: technology roadmap through 2025.

Source: Yole Développement.

European photonics research wins € millions of funding

EC invests €30m to speed access to market of 15 innovative technologies - including 5 based on photonics.

A range of European photonics-related research and development projects are to benefit from the investment of several million euros, newly announced by the European Commission. The photonics projects range across: railway safety techniqes; a laser–based system to treat glaucoma, a novel type of highly-integrated optical sensor; and intelligent sensor-enabled "smart" eyewear.

Image: Imoss.

Rail systems and technologies are a key focus of the new projects.

These are among 15 newly-announced projects which are to receive €31 million funding to speed market access for a wide range of new technologies. The source of the money is the third round of the Fast Track to Innovation scheme. The selected projects involve 68 partners in 16 countries.

Carlos Moedas, European Commissioner for Research, Science and Innovation, commented, "Through Horizon 2020, we want to give innovative businesses the support they need to fast-track their innovations to market. These latest results bring the total investment to nearly €100 million in fast-access EU funding for close-to-the-market innovation activities."

Photonics focus

The photonics-related projects are as follows:

- **AutoScan** – "Rail inspection by autonomous systems"; value €1,518,000 Project coordinator is Imoss NV, with partners Nomad Tech LDA, Automatitzacio de Processos i Mediambient SL; TWI Ltd (UK); and the University of Birmingham, UK.
- **GLAUrious** – "An External Automatic Glaucoma Laser (EAGLE) for the first-line glaucoma treatment'; value €2,480,000 . The project is intended to develop and validate a commercial prototype development and validation. The coordinator is Belkin Laser with partners Frankfurt Laser, Queen's University Belfast, and University of Genoa, Italy.
- **HIOS** – Highly Integrated Optoelectronic Sensor; value €3 million. The coordinator is AMS AG, with partners Bühler Alzenau; Boschmann Technologies BV; and Advanced Packaging Center BV.
- **I-SEE** – Intelligent Sensor Enabled Eyewear; value €2,590,000. Coordinator is Luxottica Group Spa; Fondazione Centro San Raffaele; Sigma Connectivity AB; Alten Nederland BV; and Ernst & Young Financial Business Advisors spa.
- **WheelWatcher** – Advanced wheel measuring system for greater rail sector's profitability; value €2.1 million. Coordinator is Danobat with partners: Dr. Neumann Peltier-Technik; ProPhotonix (UK), Euskotrenbideak-Ferrocarriles Vascos S.A.; and Ideko.

Fast Track to Innovation

Launched in 2015, the third round of the Fast track to Innovation scheme attracted 403 projects proposals involving 1700 participants. Almost half of the project participants are SMEs. The Fast track to Innovation scheme promotes mature innovative concepts that have already been tested. Supported innovation activities include systems validation in real working conditions, testing piloting, validation of business models and standard setting and pre-normative research.

With a budget of €200 million the scheme runs until the end of 2016 and supports any topic under the "Societal Challenges" and "Leadership in Enabling and Industrial Technologies" pillar of Horizon 2020. Proposals can be submitted at any time through one continuously open call. The next cut-off dates for applications are 15 March, 1 June and 25 October 2016.

http://optics.org/news/7/3/24

Twente achieves super-sharp images from fiber endoscopes

European project achieves lensless imaging of human body interiors through thin optical fibers.

Making super-sharp images from within the human body collected through tiny endoscopes has come a step closer following a joint research project by scientists from the University of Twente's MESA+ research institute, the Max Planck Institute for the Science of Light (MPL), FOM and Carl Zeiss.

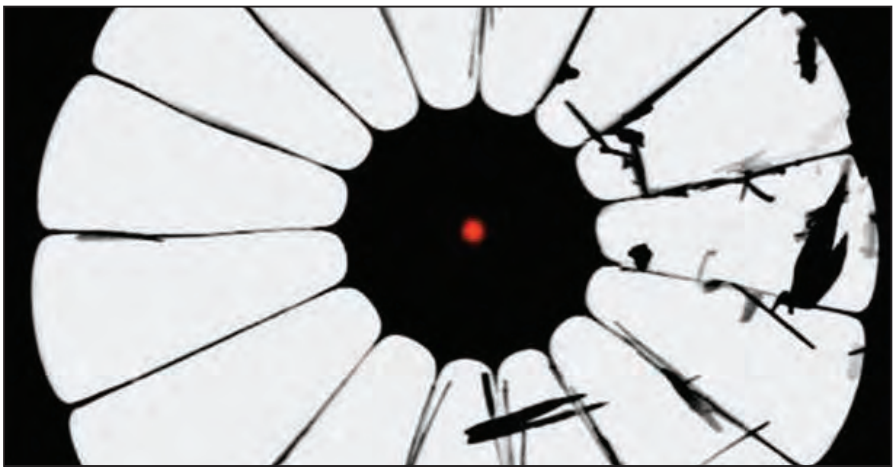


Image: U Twente / Optics Letters.

High-numerical-aperture photonic crystal fiber allows lensless focusing in a tiny endoscope - at an unparalleled resolution by complex wavefront shaping.

An advanced wavefront shaping method developed at Twente combined with unique optical fibers from MPL make it possible to focus lensless light at what the development team is calling "an unparalleled resolution". FOM postdoc Dr Lyubov Amitonova and her colleagues published their findings on 29 January in Optics Letters.

Optical imaging via ultrathin fiber probes is useful for looking inside the human body in a minimally invasive manner. Unfortunately, the resolution of conventional fiber endoscopes is 1µm at best, which is not sufficient to inspect interesting and important fine features in biological cells, for example. Some endoscopes use many separate fibers bound together into a bundle. Each fiber then acts like a discrete pixel to form the final pixelated image. However such bundles tend to be quite thick, typically 1mm in diameter.

An alternative approach is to construct fiber endoscopes based on multimode fibers. These could offer imaging with a better view and be as thin as 0.1mm across. A multimode fiber uses only a single fiber core that can transmit an entire image. Howver, such images tend to become scrambled as they pass through the fiber. But certain tricks are available for unscrambling these images.

Improved performance

The main limiting factor for the resolution of such multimode endoscopes is that the fibers only transmit light that propagates along the fiber's axis. Light entering the scope at a small offset from the core's orientation can still bounce through the fiber between its walls. But if the angle of entry gets too large, the light will simply leak out of the side. Dr Amitonova and her colleagues at UT and MPL have shown that with photonic crystal fibers this limitation can be overcome.

Conventional, so-called "step-index", fibers consist of two zones of different material (an outer cladding and an inner core) with distinct refraction indices, which enable light transmission along the fiber axis by total internal reflection. Photonic crystal fibers are constructed differently: they are made of one material only and light guiding is achieved by the presence of a specific pattern of holes in the cladding, which are filled with air.

Tailoring the cladding structure of such a fiber provides a unique tool for engineering specific fiber-optic properties. In this project, the scientists have designed and

Dr. Lyubov Amitonova.

made such a fiber to focus the laser beam through the fiber down to 0.52µm, using visible red light.

A photonic crystal fiber acts as a multimode fiber in which the image typically gets scrambled due to light bouncing off the possibly irregular inside wall of the fiber. The technique of complex wavefront shaping, invented at UT, is able to undo such scrambling and make a sharp focus. This is achieved by pre-shaping the light into the precise form needed to make a sharp image behind the fiber before the light actually enters.

By this approach, the Twenty-led team has succeeded in focusing light at the output facet of different multimode fibers including several unique photonic crystal fibers. They have shown that the complex wavefront shaping technique together with a properly designed multimode photonic crystal fiber allows the creation of a tightly-focused spot at the desired position on the fiber output facet with a subwavelength beam waist.

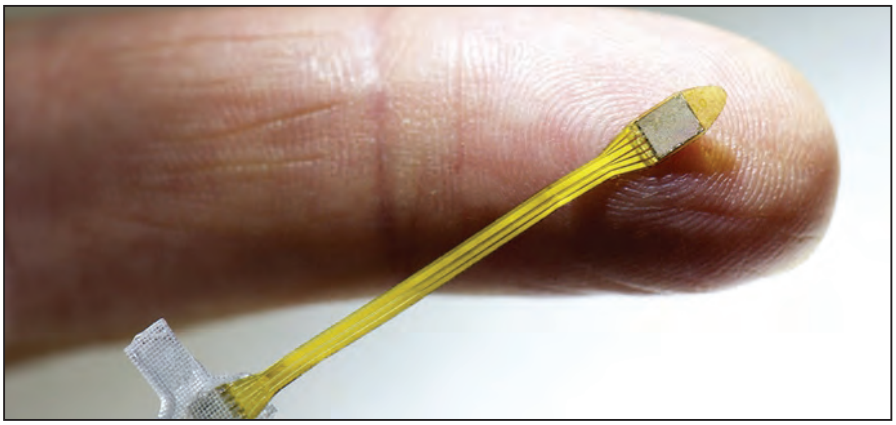
The scientists say this paves the way towards high-resolution endoscopic imaging via fiber probes so thin that they could be inserted, for instance, into tiny blood vessels not much thicker than a human hair. The research was been made possible by funding from the Foundation for Fundamental Research on Matter (FOM), Technology Foundation STW, and the Netherlands Organization for Scientific Research (NWO).

http://optics.org/news/7/2/10

Retina Implant wins €26 million in round of private funding

To establish new clinical centers worldwide and develop market potential for its Alpha IMS subretinal microchip.

Retina Implant, Reutlingen, Germany, a developer of subretinal implants for patients blinded by retinitis pigmentosa (RP), has announced the completion of an €26 million round of private equity funding. The company said the funding represents a "significant recommitment by both its long-standing investors and new investors". The cash will be used to establish new clinical centers around the world and help the company to initiate reimbursement applications for its CE-marked Alpha IMS subretinal microchip in key markets.



Credit: Retina Implant.

Retina Implant's microchip is implanted below the retina, in the macular region where light-sensitive photoreceptor cells are located.

Retina Implant has a long-standing relationship with its investors with many having been among the early investors in the company's subretinal implant technology in 2005. The investors have a proven track record of participating in various successful ventures. A key investor is Max Reindl, founder and CEO of Wavelight Laser Technologies, now part of eyecare technologies company Alcon.

"The results of Retina Implant's clinical trials and the receipt of CE Mark approval of the Alpha IMS device demonstrate the company's ability to restore some artificial vision to those living with RP," he said. "This is one of the most fascinating projects I have ever seen and I am convinced that this company has a bright future."

This €26 million investment follows a strong year in 2015 for the company; new trials have commenced in Germany and the UK. This has been further bolstered by a pipeline of clinical trial results. "The latest data shared at the American Academy of Ophthalmology Annual Conference last year, demonstrated further efficacy of our subretinal Alpha IMS Device," the company said in the funding announcement.

Dr. Walter-G Wrobel, CEO, said, "This re-investment is incredibly important to us as it indicates our investors' belief in our vision. This continued commitment will allow us to make great leaps forward to take this technology to the people that need it most. We are simultaneously developing the resource of skilled retinal surgeons who can perform the procedure while working with the local insurance agencies to establish reimbursement for the device."

About Retina Implant

Retina Implant develops its subretinal implants for both partially sighted and blind patients. After extensive research with German university hospitals and institutes which began with a large grant from the German Federal Ministry of Research and Education.

The company was founded in 1996 by Dr. Eberhart Zrenner, professor of Ophthalmology, at the University of Tübingen and his colleagues in 2003. Their aim is to develop a fully-functioning electronic retinal implant to restore useful vision to the blind. Retina Implant began implanting human patients in 2005 and started a second, larger, clinical trial in 2010. In July 2013, Retina Implant's wireless subretinal implant technology, Alpha IMS, received CE mark.

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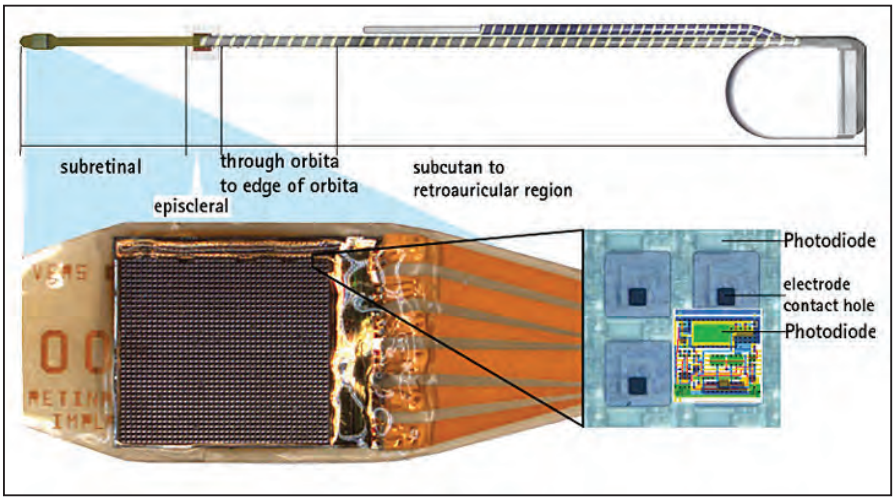

Credit: Retina Implant.

The Alpha-IMS device developed by Retina Implant comprises 1500 photodiodes. Each is used to analyze the brightness of incoming light, and also features an amplification circuit and electrode for transferring charge to adjacent retinal layers.

Optical pump boosts lung MRI

Laser-based technique under development at the University of Nottingham promises new way to image inside lungs.

A laser-based enhancement to conventional magnetic resonance imaging (MRI) scanners could allow physicians a far clearer picture of lung disease, say researchers working on the technique at the UK's University of Nottingham.

Thomas Meersmann and colleagues at the Sir Peter Mansfield Imaging Centre, named after the Nobel winning physicist who is still an emeritus professor at Nottingham, have developed an optical process that uses krypton gas as an inhalable contrast agent.

Known as spin-exchange optical pumping (SEOP), it allows the otherwise inert gas to be "hyperpolarized", meaning that a detailed view inside the lung can be generated when a patient inhales the gas and holds their breath during an MRI scan.

"Traditional MRI uses hydrogen protons in the body as molecular targets to give a picture of tissue but this does not give a detailed picture of the lungs because they are full of air," explains the Nottingham team. MRI works by using a radio-frequency probe to distinguish between different states of nuclear spin, and the "hyperpolarisation" technique aligns the noble gas nuclei in such a way that they show up on a scan.

Meersmann told optics.org that relatively recent advances in laser technology have been critical to the development of the technique, which it is hoped will begin clinical trials within a couple of years.

Thanks to funding from the UK's Medical Research Council (MRC), the laser system's power is currently being upgraded from 25 W to 100 W, so that it can produce larger quantities of hyperpolarized krypton for the Nottingham center's whole-body 7 Tesla MRI scanner.

That is partly because rubidium allows for an efficient spin exchange, but also because high-power, solid-state, laser diode arrays are available to provide the required rubidium transition at a wavelength of 794.7 nm.

"Over the years the advances with these devices have improved laser output power and cost efficiency," Meersmann says. "SEOP has much benefited from the advances laser technology over the past two decades, reminiscent of the development of MRI as a whole that benefited from the advancements of computational power."

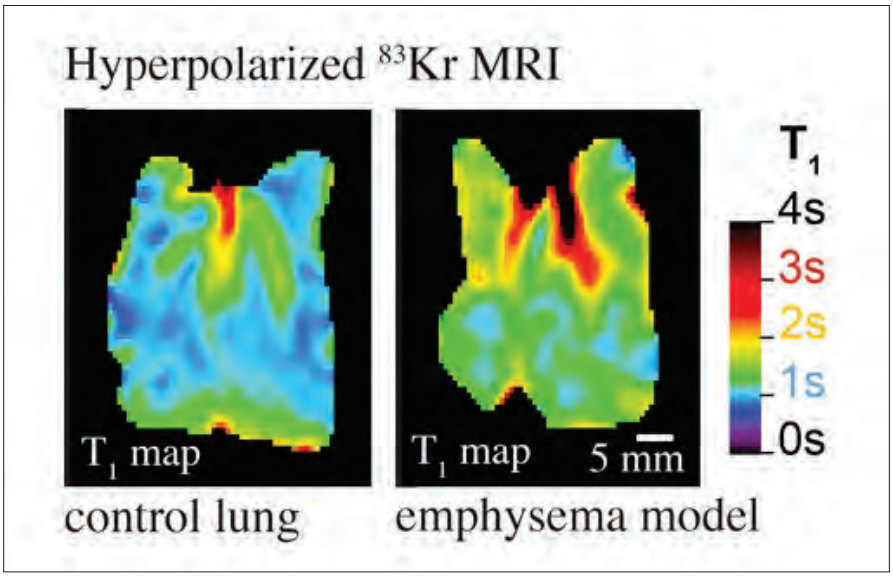

Image: University of Nottingham.

This hyperpolarized 83Kr MRI of excised rat lung shows a healthy control lung on the left and a lung that serves as a model of emphysema on the right. The dominance of the green color in the right image indicates a reduction in the lung's surface-to-volume ratio caused by alveolar degradation in this emphysema model.

Laser hyperpolarization technique

By targeting specific electronic transitions in gas-phase alkali metal atoms, the "optical pumping step" of SEOP promotes a single electron in the outer s-orbital of these atoms into the p-orbital.

"Alkali metal electron spin alignment occurs if the light is circularly polarized and the light path is aligned with a weak external magnetic field," Meersmann explains, adding that the generated "electron spin hyperpolarization" can then be transferred via gas-phase collisions to the nuclear spins of noble gas atoms.

That transfer creates the desired "nuclear spin hyperpolarization" that means the noble gases can be imaged using MRI.

"Very high laser power (typically ranging from 10-200 W) in continuous-wave mode is needed," Meersmann said. "For SEOP, rubidium is typically used as the alkali metal."

And even though the linewidth of diode arrays is typically about 2 nm – described by Meersmann as "terrifying" for any self-respecting laser spectroscopist – holographic gratings reduce that linewidth figure by a factor of ten, which is narrow enough for efficient SEOP.

The array's output is typically bundled through fiber optics and passed through a cube to ensure linear polarization, and then through a λ/4 filter to produce circularly polarized light. Telescopic optics produce a parallel beam with a diameter of 2-7 cm to illuminate the cylindrical SEOP cell.

Combustion breakthrough

The latest work by the Nottingham team, which has pioneered the technique, has demonstrated that it is possible to maintain the hyperpolarized state of krypton long enough for the noble gas to

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Optical pump boosts lung MRI

be inhaled, held in the lungs and scanned to generate a diagnostic image.

In a Proceedings of the National Academy of Sciences paper published earlier this month, they detailed how a new approach based on combustion generates hyperpolarized krypton gas at high purity, a critical requirement for pulmonary MRI.

Meersmann points out that krypton-83 and xenon-129, the two isotopes that tend to work best in terms of contrast imaging, also tend to lose their hyperpolarized state very quickly.

That problem can be solved by introducing a chemically reactive separation process, replacing the various gases that dilute krypton during SEOP with hydrogen. The hydrogen can then be removed through combustion, leaving behind a combination of benign water vapor and purified, hyperpolarized krypton.

"Remarkably, the hyperpolarized state of krypton-83 'survives' the combustion event," Meersmann said, also telling optics.org:

"The krypton stays hyperpolarized throughout this rapid process, providing an approximate seven-fold MRI signal increase for this breathable MRI contrast agent. The concept can also be applied to produce hyperpolarized xenon to simplify its production and to reduce associated costs."

Clinical target

Following that breakthrough, the research team is now upgrading the 7 Tesla whole-body MRI scanner with a 100 W laser system at Nottingham for hyperpolarized krypton work.

"The construction and the costly upgrade of the 7T scanner to enable krypton detection is currently ongoing," Meersmann said. "Within the next year we envision having the system running and [able] to collect all necessary preliminary data within the following year. That will help us for the approval process for a phase 1 trial."

And although the regulatory approval process for contrast agents can be very lengthy and extremely costly, he believes that the new approach with krypton will benefit from previous work with other hyperpolarized gases that have moved further along the approval process.

Another remarkable possibility envisaged by Meersmann is that the technique could provide pulmonary screening diagnostics without the need for an MRI scanner.

"Hyperpolarized krypton may serve as screening agent in low-cost, bench-top devices, but this subject needs further exploration," he said. "Conceptually, the screening procedure would identify patients for whom further investigation through the more costly MRI methods is justified."

Although the work remains at a relatively early stage of development, the Nottingham team has just filed a patent on the new hyperpolarized production technique, in addition to an earlier patent that protects the basic diagnostic approach.

http://optics.org/news/7/3/28