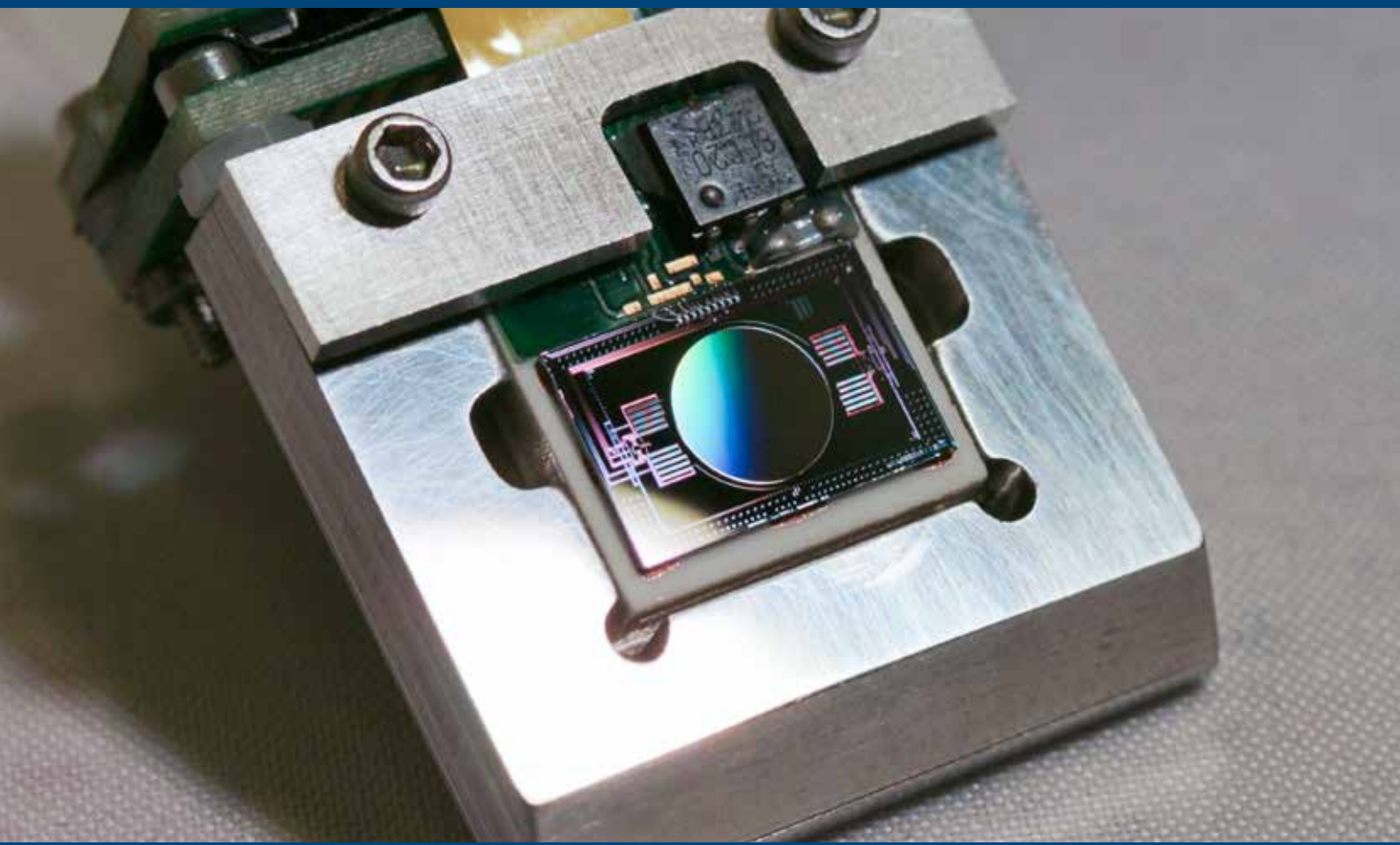
Fraunhofer
IPMS

FRAUNHOFER INSTITUTE FOR PHOTONIC MICROSYSTEMS IPMS

MEMS REPORT

1 / 2015



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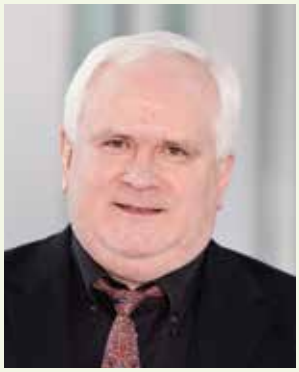


Prof. Dr. Hubert Lakner
Director of Institute

Dear Customers, Partners and Friends
of Fraunhofer IPMS,

Again, we can look back on a very successful year. As in previous years, we achieved an overall positive annual result and we were able to cover more than half of the budget with direct revenue from industry. We have been working with many of our clients for a lengthy period of time, strategic partnerships have been formed. I would like to take the opportunity to thank our customers for their confidence and loyalty and I look forward to continuing our successful cooperation in the future.

Certainly, there need to be continuous innovation from our side to be and to remain attractive for current and future customers. Some examples can be found in this MEMS Report. With our SLM technology that is used successfully in optical lithography, we are now able to serve applications in the field of Life Science. MEMS based solutions for spectroscopy can also be applied in the MIR (mid infrared) wavelength range that is important for numerous applications. Within the field of system development we were able to realize such diverse applications, as the optical test of banknotes and the optical data transfer with high data rates. We will present many of these R&D results at national and international fairs in the coming weeks and months. Our experts are looking forward to having a conversation with you.

Prof. Dr. Hubert Lakner

QUICK NOTES

Fraunhofer IPMS-CNT certified according to ISO standard

The Fraunhofer IPMS has been certified according to the international quality management standard DIN EN ISO 9001 since November 1995. Thus, the Institute proves its expertise and performance capabilities nationally and internationally. By yearly audit processes the high efficiency of the quality management system is regularly monitored and confirmed. Since November 2014 the certified quality management system also covers the business unit "Center Nanoelectronic Technologies (CNT)". The high standard of the quality management system of the Fraunhofer IPMS is reflected by the good certification outcomes by the DEKRA Certification LLC as well as by high satisfaction and confidence of our long-time customers.

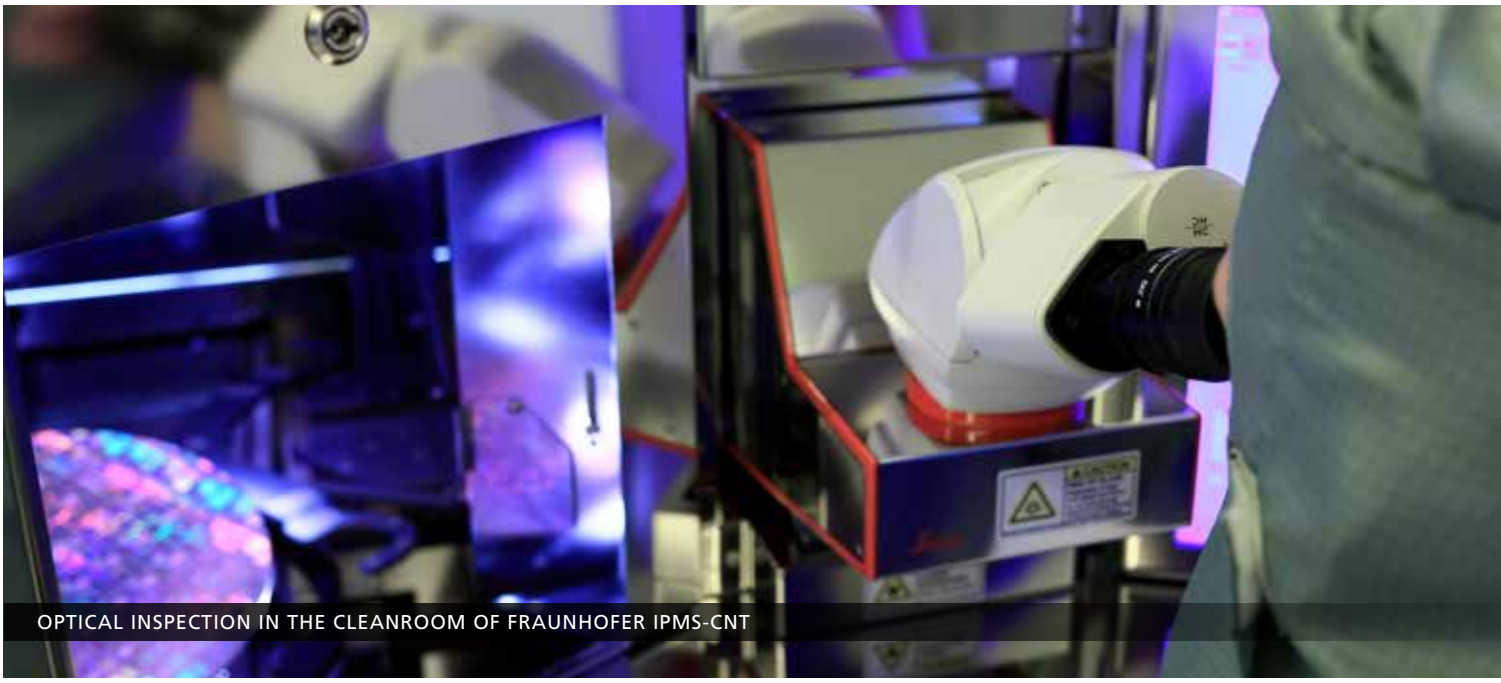
Experts in the field of Micromachined Ultrasonic Transducers (MUT) will meet in Dresden

The Fraunhofer IPMS organizes the 14th international conference on Micromachined Ultrasonic Transducers (MUT) to be held in Dresden, Germany on May 19 - 20, 2015. Micromachined Ultrasonic Transducers (MUTs) are MEMS based structures that can be used to generate and sense acoustic signals in the ultrasonic range. At Fraunhofer IPMS scientists are working on bridging the gap between research and commercial applications for MUT technology in the fields of new medical imaging techniques, non-destructive testing or gas and chemical sensors, just to name a few.

The event is designed for companies dealing with medical technologies, nondestructive testing, industry automation, bio analytics, environmental technologies, life sciences as well as food or chemical industry. More over, the workshop addresses universities, research institutions and students who are dedicated to the research and development of MUTs or who are interested in an opportunity to share experiences on the topic. The call for papers is now open. Attendees may submit their abstracts by March 2, 2015.

Further information can be found on the organizer's website:
www.mut2015.org

EVALUATION OF A NEW DEFECT INSPECTION SYSTEM



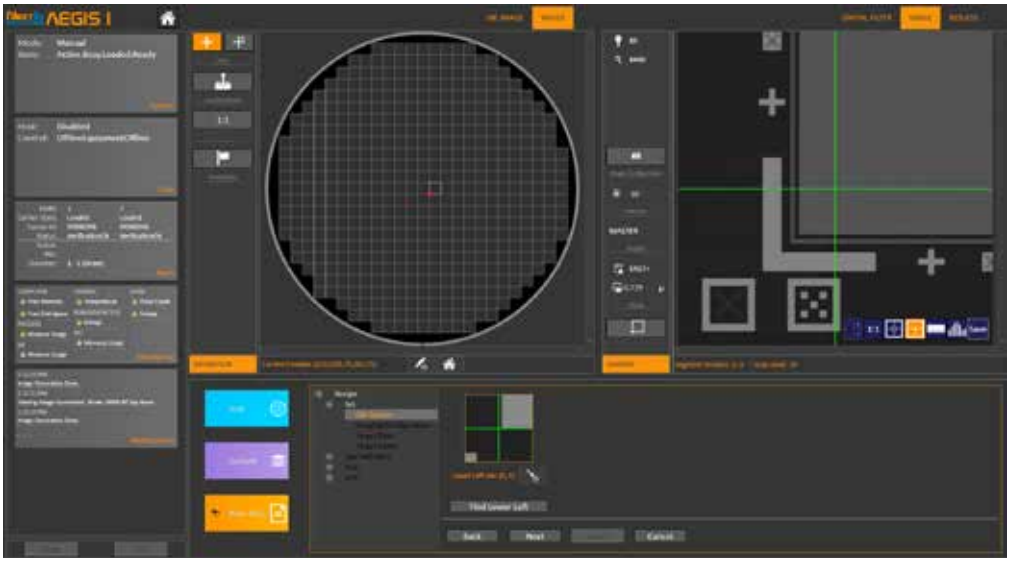
OPTICAL INSPECTION IN THE CLEANROOM OF FRAUNHOFER IPMS-CNT

The Fraunhofer IPMS-CNT has entered into a collaborative relationship with "NextIn" – a South Korean manufacturer of defect inspection equipment for semiconductor and flat panel display industries. As part of the one-year cooperative effort, a new defect inspection system will be evaluated in the clean room of Center Nanoelectronic Technologies (CNT); the tool allows for the visual detection, automatic classification and characterization of different defect types on structured wafers (200 mm and 300 mm).

The NextIn Aegis I Wafer Inspection System makes it possible to combine bright field and dark field imaging in one tool, which significantly increases the number of different applications in semiconductor research and development. Once the evaluation has been completed, NextIn will therefore offer a flexible metrology tool for the 2x nm technology node.

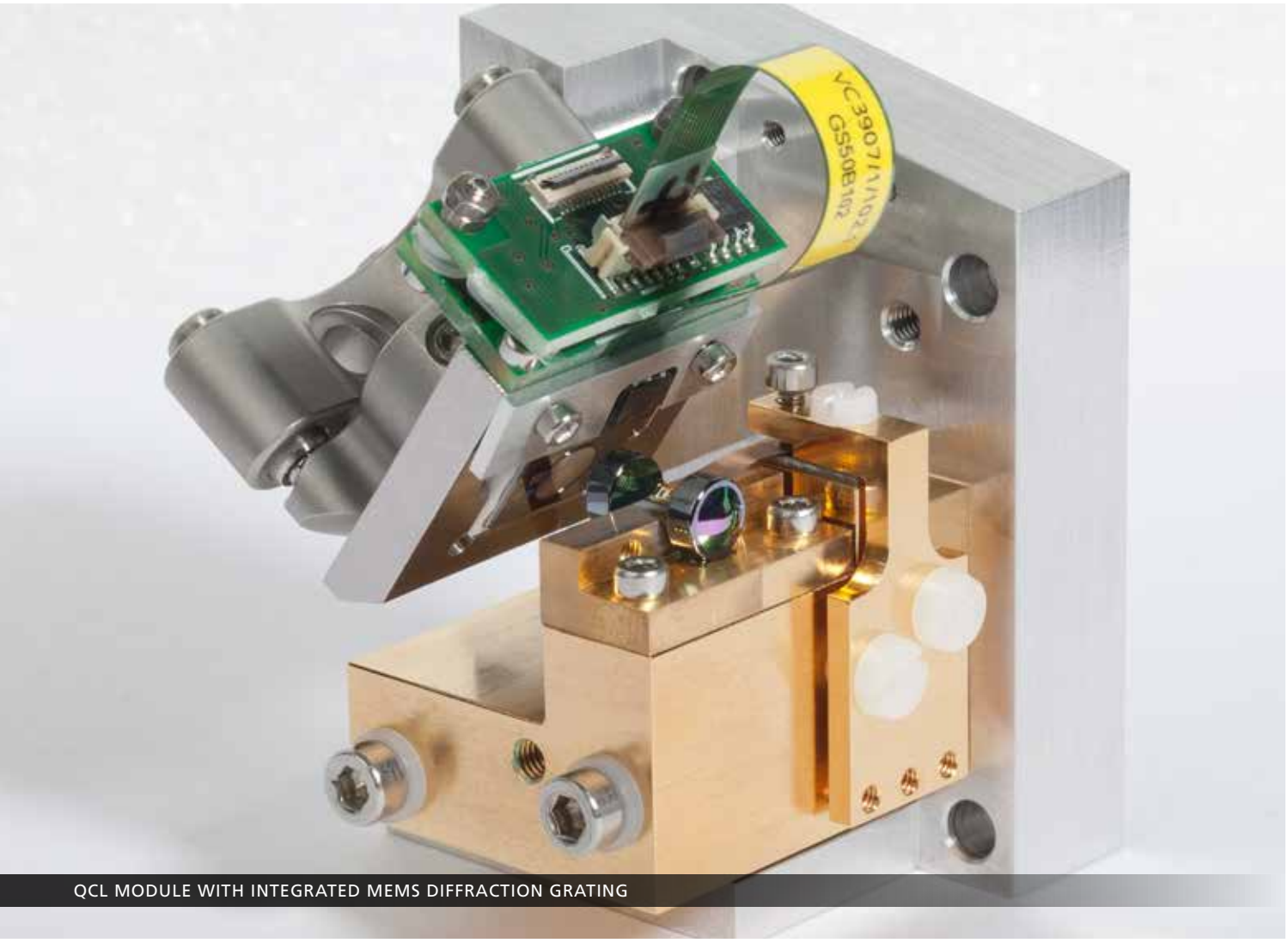
"As a research institution, this project creates synergy effects because this type of equipment is very important for the research and development of FEoL, MoL and BEoL processes. Additionally, this collaboration serves to expand our business relationships into Asia." says Dr. Benjamin Uhlig, head of the Interconnects group at Fraunhofer IPMS-CNT.

Thus, the Center Nanoelectronic Technologies is continuing the successful collaboration between the semiconductor industry and applied science in the segment of 300 mm wafer technology, which allows manufacturers to implement new developments at the industrial level.



User interface of the Aegis I Defect Inspection Tool. Assessable using a Remote Control System.

MEMS TECHNOLOGY FOR SPECTRAL ANALYSIS IN THE MID-IR



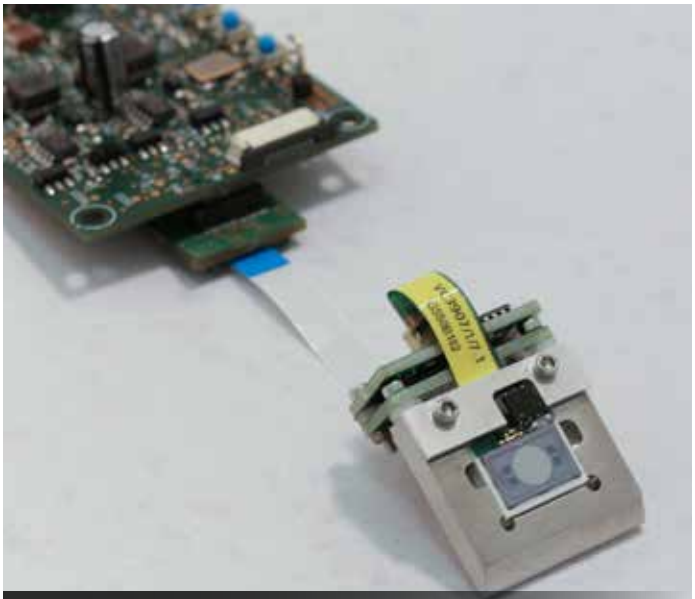
QCL MODULE WITH INTEGRATED MEMS DIFFRACTION GRATING

At this year's "Photonics West" – the leading international trade show for optical technologies – the scientists of the Fraunhofer IPMS will be introducing a novel approach that also uses MEMS technology for spectral analysis in the medium infrared range (3 µm to 12 µm). In this region many chemical substances that are important for security monitoring purposes feature unique and characteristic absorption lines. Thus different hazardous materials can be quickly detected and quantified using a compact mobile sensor system. Last year, the Fraunhofer IPMS already presented a mobile MEMS scanning grating spectrometer in sugar cube format at Photonics West; the spectrometer can be used to study gaseous, liquid and solid materials by analyzing light in the near infrared range (950 nm to 1900 nm).

Environmental contamination, industrial accidents or terror attacks: there are many types of events that can put the health of humans and the environment at risk due to the leakage of hazardous substances. The assessment of and timely response to possible risks requires that the type and concentration of potentially hazardous substances can be qualitatively and quantitatively determined as quickly as possible. Spectroscopy, which involves the illumination of materials followed by an analysis of the intensity and spectral composition of the light that is affected by the sample, is predestined for this purpose. This is possible because the measurement process using electro-magnetic radiation represents a noncontact procedure and can also be applied to many different solid, liquid or gaseous materials as each molecule has its own unique infrared spectrum ("fingerprint"). The challenge for researchers is to combine this measurement technology into a robust and compact design, and enable it to cover the largest possible wavelength range in the medium infrared range, in order to identify the greatest number of relevant gases or more complex molecules.

To meet these requirements, Fraunhofer IPMS and 17 other project partners from nine countries are working on the development of a novel, handy variable frequency monochromatic light source for the medium infrared range as part of the European joint venture

research project "MIRIFISENS – Mid Infrared Innovative Lasers for Improved Sensor of Hazardous Substances". It forms the technological basis for the development of handy spectrometers that can detect the concentration of diverse hazardous materials quickly on location. The heart of the system consists of a miniaturized quantum cascade laser (QCL), which is being developed by researchers of the Fraunhofer Institute for Applied Solid State Physics IAF in Freiburg. The QCL covers a large range of the wavelengths that are important for the spectroscopic "fingerprint" in the medium infrared range. To set the light of the QCL to the defined wavelengths, scientists at Fraunhofer IPMS developed a highly reflective diffraction grating with a diameter of 5 mm as well as the belonging control electronics. The micro-mechanically manufactured diffraction grating acts as the quantum cascade laser's variable frequency external resonator. It allows for the tuning of laser wavelengths with a frequency of 1000 Hz, with a variable frequency range of up to 20 percent of the central wavelength.



MEMS DIFFRACTION GRATING WITH DRIVING ELECTRONICS

In this way, the sample can be irradiated with different wavelengths in the time multiplex, and conclusions can be drawn with regard to the type and concentration of the hazardous materials using the "fingerprint". Fraunhofer IPMS` project manager Dr. Jan Grahmann explains the benefits of MEMS technology as follows: "Electrostatically-driven MEMS grating mirrors are much more compact than galvanometer scanners, make almost no sound and allow for very high scanning frequencies due to their low weight. In combination with miniaturized laser sources, they are ideal for integration into mobile handy sensor systems, simple measurements on location and for integration into industrial measurement technology at production and processing facilities."

At the Photonics West in San Francisco, which is held on February 7-12, 2015, Dr. Jan Grahmann will present the technology to a scientific community on February 12, 2015 as part of a presentation with the title "Large MOEMS diffraction grating results providing an EC-QCL wavelength scan of percent". Visitors to the accompanying exhibition, which takes place from 10 - 12 February 2015, will also have an opportunity to get a first-hand look at the possibilities of miniaturization using MEMS Scanning Grating Technology at the Fraunhofer IPMS` stand 4409 in the North Hall. That is where the Institute will present a further development of the scanning grating spectrometer for the NIR range, which was first introduced two years ago. With a volume of only 2.1 cm³, this system, which is demonstrated using the example of distinguishing various white powders such as sugar, salt or artificial sweetener, is 30 percent smaller than a regular sugar cube, and is controlled with a normal smartphone. It provides measurements in the wavelength range of 950 nm to 1900 nm, with a spectral resolution of 10 nm. Thus the technology is interesting for the analysis of a variety of different organic compounds and numerous applications, such as portable measurement devices for the food industry, mobile medical and pharmacological analysis devices, industrial in-situ quality testing or early warning and monitoring systems in security applications and building management.

Fraunhofer IPMS exhibits at the BiOS Expo 2015

The Fraunhofer IPMS will exhibit for the first time at the BiOS Expo 2015 to be held in San Francisco between 7 and 8 February. The BiOS Expo – the world's largest biomedical optics and biophotonics exhibition with more than 220 companies kicks off the Photonics West week. On a joint exhibition booth together with researchers of the French research organisation Institut Pasteur the Fraunhofer IPMS will present a programmable microelectromechanical (MEMS) chip. Installed in an optical microscope, the chip, which consists of an array of 65,536 separate micro mirrors which can each be tilted separately and virtually in a continuous way, can be used to illuminate multiple targeted areas, which can be smaller than single cells and thereby stimulate specific light sensitive molecules as ensemble. In addition it is possible, by using a second chip, not only to select specific areas precisely but also the angle at which these are illuminated. This technique is able to reach objects that appear as structures to be highlighted with even greater precision and to significantly reduce the many undesired environmental influences. The presentation can be found at booth 8707.

LI-FI HOTSPOT – WIRELESS COMMUNICATION IN REAL TIME

The Fraunhofer IPMS has developed a communication module that can wirelessly transfer data at a speed of up to 1 Gigabit per second over a distance of up to 10 meters. The optical technology which is especially designed for industrial customers and can already be tested as a compact customer evaluation kit.

This wireless communication technology can do much more than supplement or replace cable-bound transmission technologies – it is also superior to conventional wireless technologies such as WLAN and is therefore predestined for all application areas in which large data volumes must be transmitted virtually in real time.

The solution developed by Fraunhofer IPMS uses light in the infrared range as the wireless transmission medium. The so-called optical wireless communication uses the internationally non-regulated spectrum of light with bandwidths of several Gigabits per second and – provided there are no obstructions between sender and recipient – has the potential to transmit data up to ten times faster than available wireless solutions, with minimal bit error rates ($<10^{-9}$). To do this, it only needs 15 percent of the energy per transmitted byte of user data. The first Li-Fi hotspot that serves as a prototype for optical wireless communication for distances of up to 10 meters was presented to a trade audience for the first time at Electronica 2014.

FUNCTIONAL PRINCIPLE OF THE OWC HOTSPOT

PROJECT EUROTHENTIC – TECHNOLOGY FOR TESTING BANKNOTES

In an effort to warrant the authenticity and usability of banknotes, the Fraunhofer IPMS joined six partners from six countries as part of the European alliance project "EUROTHENTIC", with the aim of developing a module that automatically checks and retains banknotes e.g. at the cash register of a supermarket. In turn, the system would also make it possible to give out the banknotes as change. Therefore the device must first test whether the banknote is authentic, and then decide whether it is still suitable or too worn for future circulation. This assessment can be made mainly on the basis of the banknote's visual characteristics, as it is first scanned with a suitable scanning device and then analyzed with software.

BILLS AT VARIOUS WAVELENGTH RANGES

Besides the integration of a line-shaped image acquisition unit into an electro-mechanical cartridge system for obtaining the required image information during the banknote transport, the scientists of the Fraunhofer IPMS also inserted high-performance control and processing electronics into the overall system. A micro-processor and associated software analyze the image information, and provide information as to whether the banknote is authentic and not too worn shortly after the banknote is inserted the system.

MEMS-BASED 3D LASER SCANNING TECHNOLOGY

Fraunhofer researchers have developed a 3D laser scanner with a time of flight (TOF) system that is based on the human eye and that can focus on key sections of an image and capture them with a correspondingly higher resolution. The system functions independently of ambient light and delivers high-quality 3D information in real time, even over greater distances. A novel MEMS scanning technology developed by the Fraunhofer IPMS is the key hardware component.

Together with the Fraunhofer Institute for Physical Measurement Techniques IPM in Freiburg and the Fraunhofer Institute for Intelligent Analysis and Information Systems IAIS in Sankt Augustin, scientists of the Fraunhofer IPMS have combined pulse run time laser distance measurement and an adaptive operating micro mirror component (MEMS) into a novel laser scanning system. Adaptive means that the image section can be quickly adjusted to the respective area of interest, in accordance with the fovea that is located in the human eye, which ensures that we can see small sections of an overall image in greater focus. Efficient software algorithms analyze a quickly recorded 3D overview image and direct the scanner (the "attention" of the system) to interesting image sections, so they can be scanned at a high resolution. This is the first time that situation-based high-quality 3D information can be obtained within such a short time period.

The Fraunhofer IPMS was responsible for the scanning system concept, while Fraunhofer IPM provided the TOF laser measurement technology and Fraunhofer IAIS contributed its software development competence for attention control into the system development process. The scanning system concept is based on a 1D MEMS array that performs resonant scanning in a vertical direction, which can be pivoted and rotated with a conventional electro-dynamic drive. We were able to significantly increase the visual fill factor with the use of 22 receiving mirrors with individual apertures of 8.4 × 2.3 mm² and integrated mirror position sensors, and thus created the technical conditions for performing measurements from distances of up to 30 meters. Similar to conventional laser scanners, and in contrast to camera-based technologies, the strength of the laser scanning technology is its ability to disregard the presence of different light conditions, which predestines the technology for outside applications. The extremely high scanning speed of the Fraunhofer scanner of 1.6 kHz makes it possible to scan images almost in real time, and thus it is also suitable for scanning moving objects such as air planes on the runway, or vehicles on construction sites.

UPCOMING EVENTS

SPIE BiOS Expo Feb 7 - 8, 2015
San Franscisco, USA
Moscone Center, Hall South, Booth 8707

SPIE Photonics West
San Franscisco, USA Feb 10 - 12, 2015
Moscone Center, Hall North, Booth 4409

Embedded World
Nuremberg, Germany Feb 24 - 26, 2014
Nuremberg Exhibition Centre, Hall 4, Booth 4-583

Smart Systems Integration
Copenhagen, Denmark March 11 - 12, 2015
Crowne Plaza Copenhagen Towers, Booth ATH-A-02

OFC
Los Angeles, USA March 24 - 26, 2015
Los Angeles Convention Center, Booth 2638

www.ipms.fraunhofer.de/en/events.html

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