

FRAUNHOFER INSTITUTE FOR PHOTONIC MICROSYSTEMS IPMS

MEMS REPORT

1 / 2018



CONTENTS

Fraunhofer IPMS at SPIE Photonics West 2018

Li-Fi instead of Wi-Fi: Multipoint-to-multipoint-capable Optical Data Transmission for Automation

Fraunhofer IPMS Continues Mesoscopic Actuators and Systems Research in Brandenburg

New Standards for Environmentally-friendly Cleaning Technologies Used in the Manufacture of Microchips

Monitoring Security Glass Panes: Smart Alarm System Recognizes Attempted Break-Ins

◀ Cover Picture: Fraunhofer IPMS develops MEMS-based loudspeakers for hearables, hearing aids and in-ear-headphone devices.

Dear Customers, Partners and Friends
of Fraunhofer IPMS,

At the beginning of the new year, Fraunhofer IPMS expanded its research and development activities. After positive evaluation of the MESYS project group and the approval of the Federal-State Committee, the work on mesoscopic actuators and sensors in the new "Monolithic Integrated Actuator and Sensor Systems" business unit has continued as a branch of Fraunhofer IPMS at the BTU Cottbus location. In addition, our new project center "Microelectronic and Optical Systems for Biomedicine" in Erfurt has begun to develop new technological application possibilities, with Fraunhofer IPMS teaming up with the Fraunhofer IOF (Institute for Applied Optics and Precision Engineering) and IZI (Institute for Cell Therapy and Immunology) institutes.

Our calendar has been marked to attend the 2018 Photonics West, the world's largest photonics technology event held in San Francisco at the end of January each year. We invite guests to visit us at our booth significantly larger than in previous years and we will be offering several specialist presentations featuring our latest research and development results. If you are also heading to the US west coast, we look forward to seeing you there!
We wish you an informative reading of the current MEMS report.



Prof. Dr. Harald Schenk



Prof. Dr. Hubert Lakner

FRAUNHOFER IPMS AT SPIE PHOTONICS WEST 2018

The Fraunhofer IPMS presents its latest research and development activities at this year's SPIE Photonics West from January 27 to February 1, 2018 at the Moscone Center in San Francisco, California. The Photonics West is the world's largest annual event for the photonics, laser, and biomedical optics industries.

We will be more than happy to welcome you at our booth No. 4522 or in one of the presentations held by scientists of our institute (see below).

SPIE. PHOTONICS WEST

Upcoming Presentations:

»New way to realize miniaturized complex optical systems in high volume« (*Dr. Peter Reinig*)

January 30, 2018 • 9:20 - 9:40 AM | Part of SPIE OPTO

»Electrically tunable optical filters based on liquid crystal core microring resonators« (*Dr. Florenta Costache*)

January 30, 2018 • 2:20 - 2:40 PM | Part of SPIE OPTO

»Bringing NIR spectrometers into mobile phones«

(*Dr. Peter Reinig*)

January 30, 2018 • 3:00 - 3:20 PM | Part of SPIE OPTO

»Recent advances of external cavity QCLs with MOEMS diffraction gratings« (*Dr. Ralf Ostendorf*)

January 31, 2018 • 8:50 - 9:10 AM | Part of SPIE OPTO

»Translatory MEMS actuator with wafer level vacuum package for miniaturized NIR Fourier transform spectrometers«

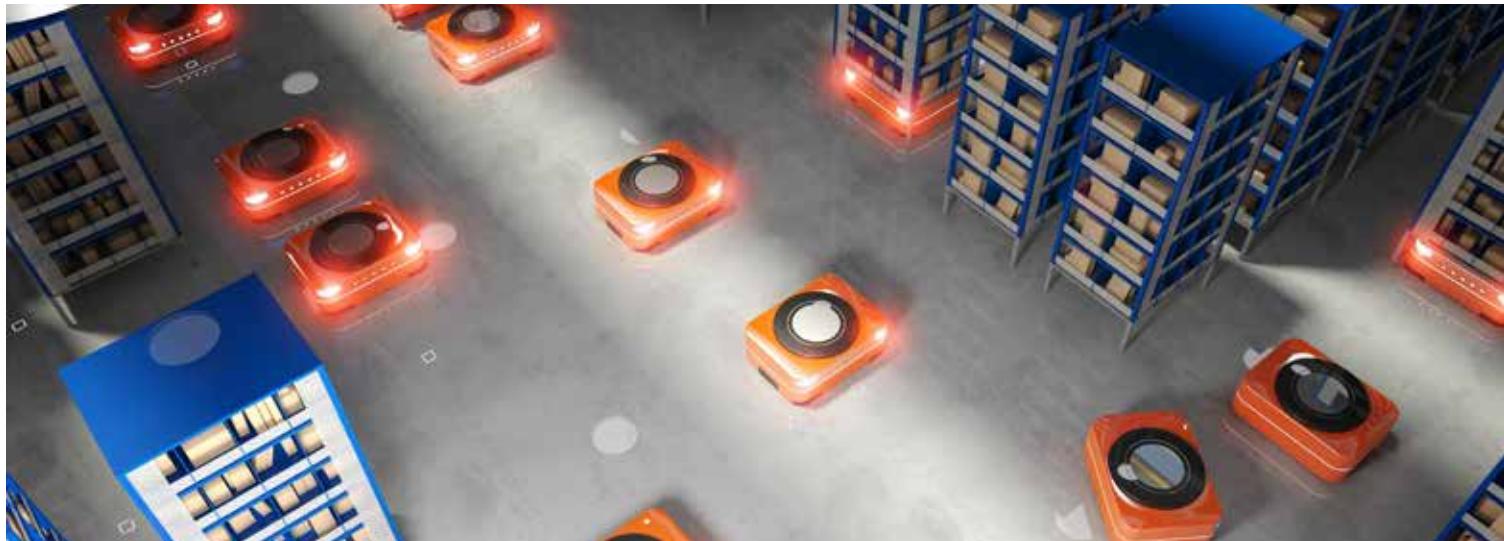
(*Dr. Thilo Sandner*)

January 31, 2018 • 2:00 - 2:20 PM | Part of SPIE OPTO

»Repetitive nonlinear control for linear scanning micro mirrors« (*Richard Schroedter*)

January 31, 2018 • 4:10 - 4:30 PM | Part of SPIE OPTO

LI-FI INSTEAD OF WI-FI: MULTIPONT-TO-MULTIPOINT-CAPABLE OPTICAL DATA TRANSMISSION FOR AUTOMATION



Mobile robots handling logistics in a warehouse could, in the future, communicate with each other via Li-Fi hotspots.

The use of light to exchange large amounts of data will soon become stiff competition to the Wi-Fi networks currently used in industrial environments. In addition to allowing different users to simultaneously use an access point, the IPMS-developed optical transmission technology also enables each user to communicate with several access points. Therefore, Li-Fi is no longer limited to stationary applications.

In the age of smart production, more and more users rely on wireless data transfer between devices used in logistics, industrial manufacturing or machine maintenance. However, those radio solutions (Wi-Fi), which have proven themselves in the consumer sector, quickly reach their limits in highly automated production environments. Wi-Fi networks are susceptible to interference because other wireless methods, such as Bluetooth applications, partially transmit in the same frequency ranges, causing multiple channel assignments and overlapping frequency usages. They are slow as the increased number of users and larger volumes of data to be transferred decelerate both the data rate as well as communication cycle times. Wi-Fi networks are also susceptible to abuse, as it is relatively easy for skilled hackers to crack even encrypted networks.

The Fraunhofer IPMS optical data transmission (Light Fidelity or Li-Fi) performs far better here in every respect. The "Li-Fi-Hotspot" transceiver system uses the spectrum of light, available free of regulations worldwide, thereby eliminating any interference from

radio-based systems. Net-Bandwidths of up to one gigabit per second are much faster than current Wi-Fi wireless solutions. And, simply by closing rooms, every Li-Fi network offers security against hacker attacks.

However, optical data transmission also has a systemic vulnerability: the visual axis between transmitter and receiver must remain unobstructed, a significant shortcoming, especially in mobile applications. In order not to be limited to stationary application scenarios when using Li-Fi technology, Fraunhofer IPMS specialists work on so-called multipoint-to-multipoint solutions. "Our communication modules allow multiple users to act simultaneously in the same spot," explains Dr. Alexander Noack, Project Manager at Fraunhofer IPMS. "At the same time, each user can switch between different, overlapping access points along a production line. Provided the adequate coverage, we are in a position to guarantee mobile users a free viewing axis at all times to accommodate uninterrupted data exchange – faster, more stable, and more secure than possible with radio-based infrastructures."

The Fraunhofer IPMS driverless transmit / receive modules combine an optical transceiver and a protocol controller with a Gigabit-Ethernet interface and can be easily combined with standard industrial systems. In order to let customers personally test the benefits of Fraunhofer IPMS Li-Fi technology for a wide variety of applications, the Dresden-based research institute provides its clients with Customer Evaluation Kits.

FRAUNHOFER IPMS CONTINUES MESOSCOPIC ACTUATORS AND SYSTEMS RESEARCH IN BRANDENBURG



Possible applications are miniaturized loudspeakers for hearables, hearing aids and in-ear-headphone devices.

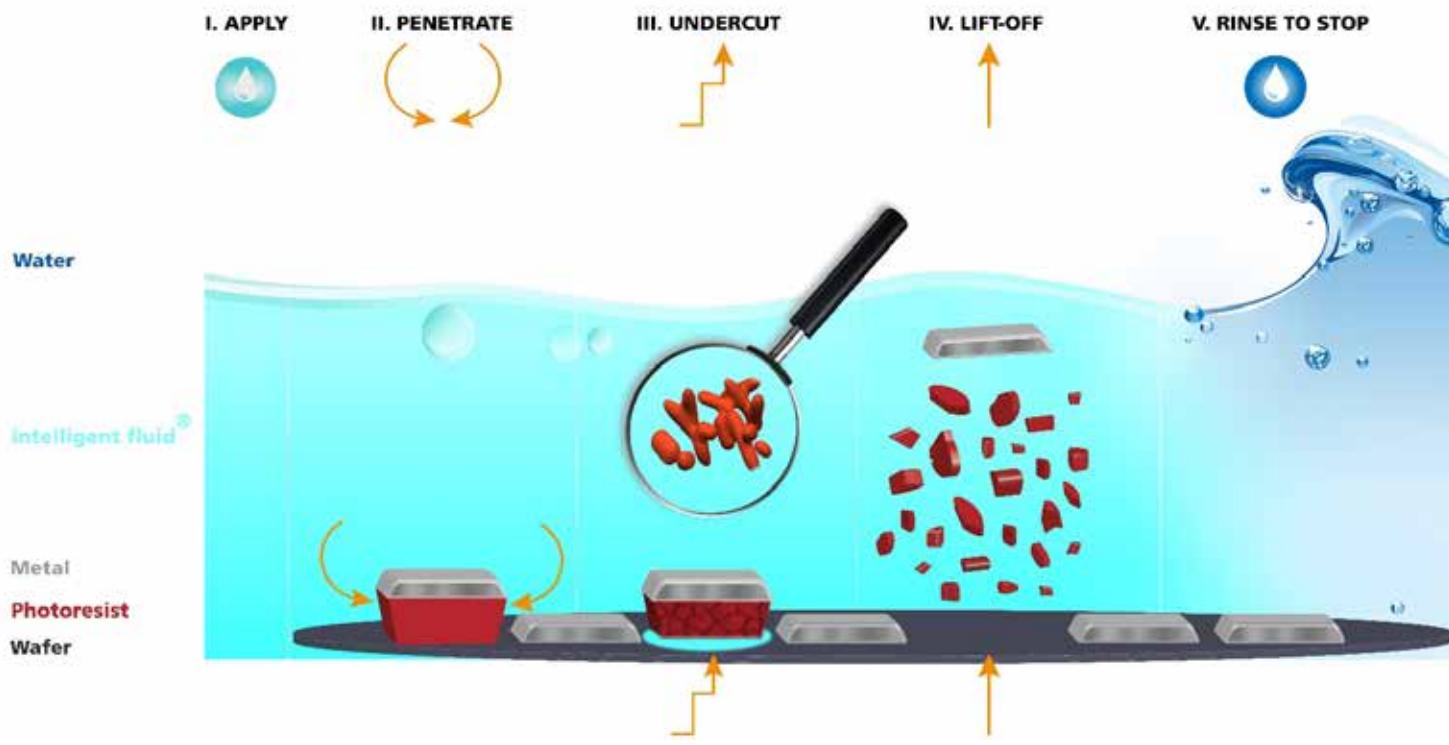
Fraunhofer IPMS has every reason to celebrate. Funded by the State of Brandenburg for the last five years, the Fraunhofer project group for Mesoscopic Actuators and Systems (MESYS) was positively evaluated in September 2017. After receiving approval from the Federal-State Committee in November 2017, the MESYS project group will continue as a branch of the Dresden Fraunhofer IPMS at the Brandenburg Technical University (BTU) in Cottbus and be awarded federal and state funding. This paves the way for the continuation and expansion of the research activities in Brandenburg.

Prof. Harald Schenk, Director of Fraunhofer IPMS and Professor for Micro- and Nanosystems at BTU Cottbus-Senftenberg, is extremely pleased, "The close collaboration between Fraunhofer and the BTU represents an important innovation factor. We are very happy to be able to continue the promising Fraunhofer IPMS research activities in cooperation with the BTU in Brandenburg." Under the direction of Prof. Schenk, the Fraunhofer MESYS project group

of nine scientists at the two sites in Dresden and Cottbus has worked on novel electrostatic microactuators, so-called nanoscopic electrostatic drives (NEDs) since 2012. The MESYS-developed and already patented new actuator class is CMOS compatible and solves fundamental problems of electrostatic actuators. This new class of actuators will improve the performance of and create completely new design solutions for microsystems in the future. Fields of application include micropumps, MEMS loudspeakers or micro-positioning systems.

Following successful evaluation, initial successes have already been recorded in the integration of the new NED actuator technology, making it now possible to produce functional silicon-integrated micro-speakers for the first time. Prof. Schenk views the future with confidence, "We hope that we can quickly transfer the scientific accomplishments we've achieved so far into recycling and industrial use. With this, we are also eager to contribute to the strengthening of the local economy."

NEW STANDARDS FOR ENVIRONMENTALLY-FRIENDLY CLEANING TECHNOLOGIES USED IN THE MANUFACTURE OF MICROCHIPS



Working principle of cleaning technology by intelligent fluids.

In cooperation with the Fraunhofer IPMS Center Nanoelectronic Technologies (CNT) and local microchip manufacturers, Leipzig-based intelligent fluids GmbH (formerly known as Bubbles & Beyond GmbH) has qualified innovative and environmentally-friendly cleaning solutions for industrial volume production.

A major step towards Green Fab in the semiconductor production, this phase-fluid based technology establishes new standards in environmental friendliness, work safety and fab compatibility.

Now, fewer process steps are required during production, saving both time and expendable materials and allowing for new application scenarios in process integration. In contrast to conventional methods in which, for example, aggressive solvents and toxic chemicals are used to dissolve a photoresist to be subsequently disposed of in a costly manner, phase fluids infiltrate, fragment and "lift" corresponding layers defect-free from the water surface. The phase fluid and detached photoresist are rinsed with DI (deionized) water and removed without leaving residue.

Matthias Rudolph, researcher at Fraunhofer IPMS announces, "Intelligent fluids finally provide a physically-effective, CMOS-

compatible cleaning product that can be integrated into semiconductor manufacturing." Igor Eichinger, Category Manager at intelligent fluids GmbH continues, "Because only smart and mild ingredients are used in phase fluid cleaning, our technology sets new standards with regard to performance, pollutant reduction, biocompatibility and workplace safety in microchip manufacturing."

intelligent fluids GmbH has been supplying well-known semiconductor manufacturers throughout Europe, Asia and the USA with products for photoresist removal, metal lift-off and equipment cleaning for years. Today, preliminary work for qualifying the newest intelligent fluids technology for front-end photoresist removal is underway in the Fraunhofer IPMS Screening Fab. Here, phase fluids are being further developed from laboratory scale to industrial application in 300-mm production fabs and tested for their suitability for use in industry-specific production processes. Sponsored by the Saxon State Ministry of Economic Affairs, Labor and Transport (SMWA), the joint project (Registration Number 10284497) aims to qualify products and processes in individual pilot lines for subsequent industrial production over the next two years.

MONITORING SECURITY GLASS PANES: SMART ALARM SYSTEM RECOGNIZES ATTEMPTED BREAK-INS



Test series with the smart security glass in the laboratories of Schott Technical Glass Solutions GmbH.

The window panes of jewelry stores, art galleries and banks are protected by alarm and fitted with security glass. However, the pane or part thereof has to break before the alarm is triggered. Conventional security glass contains metal threads that tear in the event of mechanical damage, activating the alarm. If a cutting torch or a drill is used to damage the glass, conventional systems react either too late or not at all. Burglars exploit this weakness and use a drill or a blowtorch instead of a hammer.

Researchers at the Fraunhofer Institute for Technological Trend Analysis INT and the Fraunhofer Institute for Photonic Microsystems IPMS have jointly developed a smart anti-burglary protection system that overcomes this problem. The new system quickly and dynamically records thermal and mechanical stresses from external causes. Even a gentle knock against the security glass or manipulation through the use of a flame is enough to trigger the alarm.

The external force applied to the pane changes its mechanical characteristics, and the system detects this change. This method of monitoring glass panes is based on a glass break sensor built inside an optical fiber by means of fiber Bragg grating, that is, optical interference filters inscribed in optical waveguides. The fiber optics can be fitted in the corner of the windowpane or in other positions.

Light-assisted surveillance of glass panes

The sensor with the fiber Bragg grating is an optical sensor, which reflects a specific wavelength of light that is changed by deviations in temperature and/or elongation. "If somebody exercises pressure on the glass pane or heats it, the distance between the grating elements changes, which in turn alters the transmitted wavelength. Sensitive optical measuring devices are capable of recording these changes. If the changes are greater than a predefined threshold, signals are transmitted to the alarm system," says Udo Weinand,

UPCOMING EVENTS

SPIE Photonics West

San Francisco, USA January 27 - February 1, 2018
Moscone Center, Booth 4522

Global LiFi Congress

Paris, France February 8 - 9, 2018
Palais Brongniart

Embedded World

Nuremberg, Germany February 27 - March 1, 2018
Nuremberg Convention Center, Booth 3-123

LogiMAT

Stuttgart, Germany March 13 - 15, 2018
Stuttgart Convention Center, Hall 4, Booth F02

OFC

San Diego, USA March 13 - 15, 2018
San Diego Convention Center, Booth 5901

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engineer at Fraunhofer INT, explaining the functioning of this patented system. "We can adjust our system in a very fine-tuned, targeted manner. It can react to slight knocks and to strong ones. As a result, it can be adapted individually to the specific application," adds Dr. Peter Reinig, scientist at Fraunhofer IPMS.

The innovative break-in protection consists of a Bragg grating, a fiber optic supply cable, an interface to the alarm system, and evaluation electronics, which contain the optical measuring device. In future, the evaluation unit, to which various fiber optics can be connected, is to be fitted in the window frames. In high-security zones, the evaluation unit can be located far away from the security glass. "Measurement with fiber optic sensors is a good solution for these requirements, because it uses light instead of electricity and widely available fiber optics instead of copper wires," says Weinand.

Pattern recognition avoids false alarms

Another advantage of the Fraunhofer system is that fiber optics are resistant to electromagnetic interference. Electronics can be disturbed by things such as microwave emissions, whose pulses can incapacitate conventional alarm systems or cause an unwanted alarm. In addition, pattern recognition rules out the potential for false alarms triggered by everyday vibrations. "A football or a bird leave behind a different signature than a hammer or a baseball bat," notes Reinig. The smart alarm system was rigorously tested in various attack scenarios on a wide range of different security glass panes involving hammers, baseball bats, drills, firearms, axes and heat guns to determine when the alarm is reliably triggered.

The effectiveness of the sensor with fiber Bragg grating has been demonstrated in numerous tests, including the VdS test by VdS Schadenverhütung GmbH in Cologne. The independent, notified and accredited testing and certification institute for fire protection and burglary prevention issues the VdS seal of approval, a well-known distinction in German industry.

The burglary protection system created by Fraunhofer researchers currently exists as a demonstrator. Measuring only $14 \times 9 \times 7 \text{ cm}^3$, the evaluation electronics is a small box that can be further miniaturized if required. The system is able not only to protect jewelry stores and other objects liable to be burgled, but is also suitable for monitoring bridges, buildings, pipes, load-bearing structures in the aerospace industry, wind turbines, and much more.

Fraunhofer IPMS is part of the



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