

# MEMS REPORT

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Dear Customers, Partners and Friends  
of Fraunhofer IPMS,

Everyone is talking about Industry 4.0 and the Internet of Things. Contrary to the common notion that everything revolves around defining appropriate business processes and cloud applications, practical developments in both hard- and software are also needed to provide the industry access to these fields of the future. The automation of production lines and the seamless monitoring of supply chains cannot be achieved, for example, without self-sustaining energy sensor technology. Sensor-collected data must be wirelessly transmitted to a central server by means of either radio-based RFID strategies or light solutions with low latency periods. In order to provide users optimal solutions for particular circumstances, these technologies should be able to implement a mix of sensor nodes from more than one manufacturer. At the same time, effective cyber security must be in place to protect data being transferred from manipulation and hacker attacks. Detailed information on all of these topics can be found in the current issue of our MEMS report.

Recent achievements have positioned Fraunhofer IPMS as a comprehensive research and development partner in these fields, which are extremely important for the future viability of the industry. We wish you an informative reading of the current MEMS report.



Prof. Dr. Harald Schenk

Prof. Dr. Hubert Lakner

## FRAUNHOFER IPMS PARTNERS WITH CORNELL UNIVERSITY

The Cornell NanoScale Science and Technology Facility (CNF) has entered into a partnership with the Fraunhofer IPMS in Dresden, Germany, to help small companies accelerate product research and development. The partners have completed a tool map – a list of tools and fabrication-process steps that both labs support – that allows companies to plan the growth of their R&D prototyping activities by minimizing technology disruptions as they transfer their micro/nanofabrication processes from lab to foundry.



Each year CNF attracts approximately 600 users, many from outside the university. CNF now adds the Fraunhofer IPMS to its list of partners that can provide a significant commercial ramp-up and volume manufacturing for clients who wish to grow their silicon-related and MEMS (micro-electro-mechanical systems) businesses beyond what CNF can provide. Fraunhofer IPMS offers microelectronic R&D and pilot manufacturing tools for various application fields and at institutes across Germany. In this partnership, the CNF-Fraunhofer tool map is focused on silicon-related processes available at Fraunhofer IPMS facilities in Dresden, which will make two clean room facilities available: a 200mm-wafer MEMS clean room and a 300mm-wafer advanced CMOS (complementary metal-oxide-semiconductor) clean room. “We are excited to have a partner where we can refer our small business customers to get the assistance they need to fully commercialize their concepts and prototypes in the CMOS, silicon photonics and MEMS space,” Don Tennant, CNF director of operations, said in a statement. “We also hope that cross referrals to CNF will allow us to provide services to Fraunhofer clients who are not yet at the scale-up stage and require the flexibility to explore a variety of approaches.” Martin Landgraf, Fraunhofer IPMS program coordinator, echoed Tennant’s sentiments. “We are delighted to have this cooperation in place,” he said. “With our recent multi-million-dollar investments in new process equipment and tool upgrades, we have enlarged our wafer processing capacity significantly. Clients also benefit from our vast experience in lab-to-fab services, our strong network and the quick availability of our semiconductor consumables screening platform capabilities.”

## LI-FI FOR WIRELESS COMMUNICATION IN THE INDUSTRIAL ENVIRONMENT: FASTER, INTERFERENCE-FREE AND MORE SECURE INFRASTRUCTURES



In recent years, Wi-Fi has become increasingly important in both private as well as highly-automated industrial environments. In the age of digitalization demanding ever larger amounts of data to be transferred, the installation and maintenance of wired networks have become more and more complex.

Because wired systems such as Ethercat or Profibus cannot be used everywhere, wireless systems are often more suitable, especially for moving equipment or mobile machinery. Many wireless technologies such as Wi-Fi, however, quickly reach their limits in environments with multiple network partners. These technologies are often too slow and susceptible to interference, making it difficult to reliably transmit security applications with fast cycle times over Wi-Fi in large industrial environments. Because radio signals can penetrate walls as well as machine casing and can be heard over foreign receivers within range, Wi-Fi also poses serious questions with regard to privacy issues.

Able to transfer data via light, Li-Fi (light fidelity) technology solves many of these problems. "Li-Fi makes use of the globally unregulated spectrum of light," explains Fraunhofer IPMS Chief Developer Dr. Alexander Noack. "Limited only by the optoelectronic components selected for modulation or demodulation, the available bandwidth of this spectrum allows for extremely high net data rates."

The system also features real-time capability. Noack continues, "Wi-Fi provides packet-based, asynchronous data transmission. In contrast, Li-Fi allows to send data continuously in a stream. Li-Fi therefore provides reliable operation for applications in which data

calculation and transmission are not allowed to exceed a predetermined time limit. Several data links can be parallelly built in spatial multiplexing so that no interference between individual data links exists, enabling a very high density of transmission cells to operate in an interference-free industrial environment."

Li-Fi technology is bound by the one basic requirement that data transmission only works when the visual axis between the transmitter and receiver is free and clear. This is an extremely important advantage from a security standpoint. Because light cannot penetrate walls or other obstacles, foreign actors outside are unable to access and record data being transmitted.

Testing conducted under real-world conditions is often the only way to determine whether Li-Fi offers a viable alternative for a specific application. Fraunhofer IPMS offers customers its Li-Fi HotSpots evaluation kit. Optical data links can be set up at a data rate of 1 Gbit / s over a distance of five meters. The module can be simply integrated into existing systems via a CAT5 cable. Point-to-point connections can be built in half- or full-duplex mode. Depending on the application, the size, data rate, transmission distance and interfaces of the Li-Fi HotSpot can be optimized and further developed according to specific customer requirements. USB 3.0, Ethernet and Gigabit-Ethernet interfaces have already been implemented in industrial applications. Point-to-point, point-to-multipoint or multipoint-to-multipoint connections may also be used. In addition, Li-Fi technology may be applied in moving or rotating systems, wherever the use of cable, slip rings and connectors is limited and in situations demanding large amounts of data such as video to be transmitted for process control.

## NO INDUSTRY 4.0 WITHOUT RFID AND SENSORS



Fraunhofer IPMS will demonstrate a system made up of various wireless RFID sensors and a specially-developed RFID OPC UA middleware.

Cost reductions resulting from transparent supply chains, workpiece-controlled production lines or preventive maintenance measures would not be possible without the interaction of identification methods, sensors, software, and secure data storage concepts. In addition to RFID Auto-ID technology, sensors play a key role in the Industry 4.0 world. Real objects must be clearly identifiable for correlation in the virtual world and sensors must be able to monitor various conditions affecting them. Researchers at Fraunhofer IPMS have combined both, thereby linking the two technologies of automatic object identification and wireless acquisition of temperature, inclination, humidity and other sensor-provide data.

Because some RFID technology currently found in today's industrial processes are often manufacturer-bound, hardware alone cannot solve the problem.

### RFID systems often bound to manufacturer

Fraunhofer IPMS Head of Wireless Microsystems Frank Deicke explains, "Companies with RFID technologies already integrated

in their processes repeatedly face limitations due to being tied to specific manufacturers. Some components are unable to assimilate over diverse frequencies and manufacturers and therefore cannot be connected to the superordinate control system or cloud services without investing strong integration efforts." RFID middleware based on the OPC UA – Auto-ID companion specification provides a solution for simplified system integration. RFID sensor system applications are typically found in areas relying on wireless measured value acquisition and data transfer. Such areas of application can include monitoring the temperature of goods moving along the logistics chain, the mechanical conditions placed on rotating components of machine tools, or the moisture and temperature levels in hard-to-reach or harsh environments.

### Blockchain as data storage concept

Global business and industry demands today exceed simply collecting and processing data. Modern production processes involve numerous manufacturers, logistics companies and other participants. Often, data from manufacturing and delivery processes needs to be shared among partners across the entire supply chain. Blockchain technology offers a transparent and tamper-proof approach currently under research.

## RFID & BLOCKCHAIN THROUGHOUT THE SUPPLY CHAIN



*RFID sensor data in the blockchain.*

Blockchain is the new magic word in logistics, providing all members a transparent supply chain in which goods and status data are securely recorded and exchanged. Fraunhofer IPMS has developed wireless RFID sensor systems to be used for identification and status purposes in a wide range of industries and also offers software solutions based on these systems that can be extended by blockchain concepts.

In a blockchain, data is chronologically stored in blocks so that they are visible and understandable to all participants of a network. The technology allows involved stakeholders to interact without regulative intermediaries. Trust is built with cryptologically secured data being transparently distributed among network members rather than being stored in a central database. Changes to completed transactions can therefore not be made. Known from Bitcoin cryptocurrency, blockchain also has great potential for data management in supply chain automation and logistics processes to accelerate transport and shipping, prevent fraud and error, and reduce waste and costs.

RFID technology, more precisely RFID transponders (antenna, identification and sensor technologies connected on a chip), is suitable for determining relevant parameters in the delivery process. Fraunhofer IPMS Team Leader, Dr. Andreas Weder explains, "Our passive RFID sensor transponders measure physical parameters

such as humidity, vibration, or temperature and transmit this information to a reader that also provides the energy. Because they are small, light, maintenance-free and do not require a personal power supply, these transponders can be easily integrated into different containers or carriers."

Fraunhofer IPMS sensor transponders support the already well-established identification and shipment tracking of goods at any specific time as well as provide information detailing everything that happened to raw materials, semi-finished good and end products as they progressed through the supply chain. If data is stored in a blockchain, it is both reliable and traceable for all those operating within the supply chain network.

A proof of concept evaluation conducted in advance typically determines which sensor is suitable for a particular application. According to Andreas Weder, the environment, carrier material and antenna positioning play roles, as do the design of the RFID-Sensor-ASICs for various frequency ranges and the integration of data into existing systems. Fraunhofer IPMS experts therefore analyze application-specific environments and provide customers evaluation kits for individual testing. The Fraunhofer IPMS offer is completed with individual hardware and software solutions to ensure compatibility with existing systems and evaluate large amounts of data accumulated during long-term measurements according to specific requirements.

## NEW FRAUNHOFER IPMS BRANCH AT THE BTU IN COTTBUS TO PROVIDE MORE SPACE FOR APPLIED RESEARCH



*Ceremonial opening of the new "Integrated Silicon Systems" branch of the Fraunhofer IPMS at the BTU in Cottbus with Fraunhofer President Prof. Reimund Neugebauer, Director of Fraunhofer IPMS Prof. Harald Schenk, Brandenburg's Minister of Science Dr. Martina Münch, and BTU President Prof. Jörg Steinbach (from left to right).*

On April 19, 2018, the Dresden-based Fraunhofer IPMS officially opened its new branch "Integrated Silicon Systems" (ISS) located on the central campus of the Brandenburg University of Technology (BTU) in Cottbus, welcoming guests from politics, science and industry. The work at the new branch led by Dr. Sebastian Meyer had already started at the beginning of the year, encompassing the "Monolithically Integrated Actuator- and Sensor-Systems" business unit as well as the "Terahertz Micro Modules and Applications" working group.

Developments foreseen to be made at the new Fraunhofer IPMS-ISS location will support people in many areas of their lives.

### **Future technologies at the new "Integrated Silicon Systems" facility**

Scientists in the new business unit are working on micro-loudspeakers with perfect sound and low energy consumption that are only a few millimeters in size to be used for hearables or medical hearing aids. Micro-dosage units such as insulin pumps are also being researched and developed. This is all made possible through novel actuators and sensors being developed at the Fraunhofer IPMS-ISS based on a previously-researched new drive principle for micro-mechanical components.

Researchers in the "Terahertz" area are working to solve everyday problems and find a way to significantly expand the use of terahertz-radiation through the introduction of novel components. In contrast to X-rays, for example, terahertz-radiation is non-ionizing and therefore does not damage the tissue being penetrated. Fraunhofer IPMS-ISS will use this advantage to develop compact and mobile test systems that can be used for medicine and biotechnology, safety technology, the detection of hazardous substances, or non-destructive materials testing. Elaborate, random procedures will be relegated to the past.

Fraunhofer IPMS Director Prof. Harald Schenk, who also holds the professorship of "Micro and Nanosystems" at the BTU Cottbus-Senftenberg, initiated the bi-institutional cooperation in 2012 with the establishment of the Fraunhofer "Mesoscopic Actuators and Systems" (MESYS) project group at the Cottbus campus, thereby founding the institute's new branch. Schenk states, "What we have created and accomplished here in the last six years is enormous. A completely new class of micro-actuators was developed and patented within the project group. At the moment, there are eight other patent families, and our first results are being put into practical use. In recent years, we have received several awards for our work and we are now planning to found a new company. The path we have chosen is both representative and indicative of Fraunhofer. However, without the support of the State of Brandenburg, especially the Ministry of Science, Research

and Culture (MWFK) and the BTU, all of this would not have been possible. I would like to take this opportunity to thank you again and wish us all much success in the future."

### **The Fraunhofer/BTU cooperation is an important innovation factor**

President of the Fraunhofer-Gesellschaft Prof. Reimund Neugebauer agrees with Prof. Schenk, "Launched as a Fraunhofer project group, the successful cooperation with the BTU Cottbus-Senftenberg will now continue with new Fraunhofer IPMS institute section to consolidate Fraunhofer research in Brandenburg. The field of novel actuators and sensors provides a promising area of research with a variety of industrial applications. By transferring our research results to the industry, we lay the foundation for innovative, new high-tech applications and make a decisive contribution to strengthening the local economy and sustainability of the region."

Neugebauer's view is reaffirmed by the State of Brandenburg's Minister of Science, Dr. Martina Münch, "The successful promotion of application-oriented research is an investment in the future and contributes to the sustainable strengthening and further development of the Lusatia region and beyond. This cooperation can also serve as an example for other research activities, give new impetus to economic developments, and make an important contribution to the creation of highly qualified jobs in the region – a matter of key importance against the challenging backdrop of structural change in Lusatia. That is why we have supported setting up this first phase of Fraunhofer's institute at the Brandenburg University of Technology, providing approximately three million Euro over the past five years."

Prof. Jörg Steinbach, President of the BTU Cottbus-Senftenberg, is also extremely pleased. He concludes, "The establishment of the new Fraunhofer IPMS department at the BTU is an important step in expanding and consolidating our partnerships with renowned non-university research institutions. Because Fraunhofer IPMS-ISS research activities will be strengthened with the new "Adapted Integrated Systems" project funded again by the State of Brandenburg, I am sure that this cooperation and the resulting high-tech applications will have a positive influence on the region and society. This and the planned establishment of two additional Fraunhofer polymer materials and biotechnology research groups at the BTU makes me proud, and shows that we on the right path with our research strategy in only the fifth year of this young university."

## **UPCOMING EVENTS**

### **Sensors Expo & Conference**

San Jose, CA, USA June 26 - 28, 2018  
McEnery Convention Center, Booth 1318

### **Sensor & Test**

Nuremberg, Germany June 26 - 28, 2018  
Nuremberg Convention Center, Hall 5, Booth 5-248

### **Semicon West**

San Francisco, CA, USA July 10 - 12, 2018  
Moscone Center

### **European MEMS Summit**

Grenoble, France September 19 - 21, 2018  
MINATEC innovation campus

### **Photonik Tage**

Berlin, Germany October 18 - 19, 2018  
Bunsensaal of WISTA

[www.ipms.fraunhofer.de/en/events.html](http://www.ipms.fraunhofer.de/en/events.html)

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