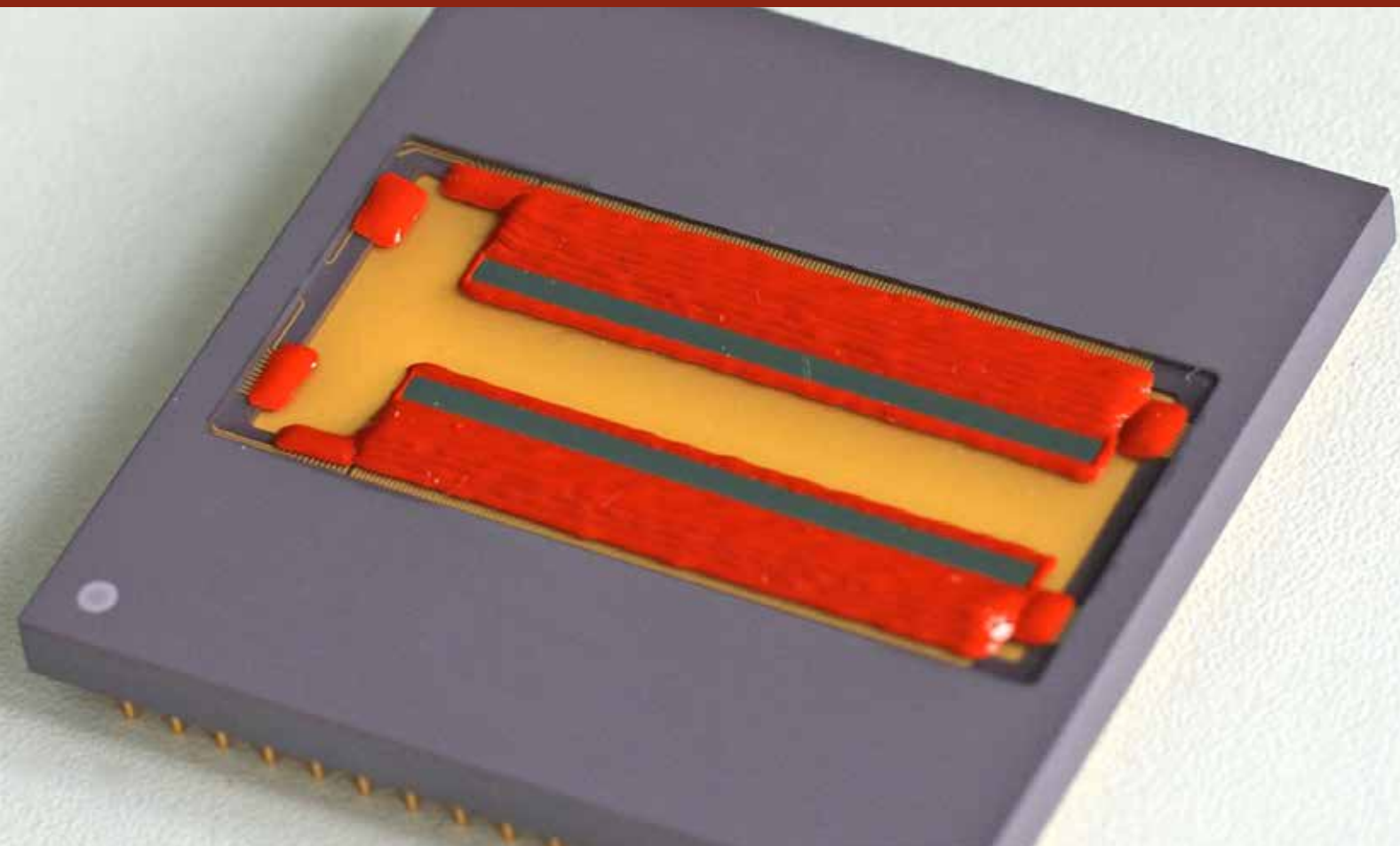


# MEMS REPORT

2 / 2015



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Prof. Dr. Hubert Lakner  
Director of Institute

Dear Customers, Partners and Friends  
of Fraunhofer IPMS,

On the occasion of its anniversary in May 2015, the Center Nanoelectronic Technologies CNT which has been part of the Fraunhofer IPMS business unit since 1.1.2013 is looking back over its ten-year history. Originally founded as a public-private partnership with the local semiconductor industry, the CNT customer base has widened in the last two years and new business models have been and continue to be developed. CNT capabilities, among them the use of new materials in microelectronics, also benefit other long-established fields of work at the Institute. Overall, the technological, economical and organizational integration of the CNT is almost fully complete. We will present the latest CNT results and key CNT customers will provide independent reports on their successful cooperations with us during Industry Partner Day on 11.6.2015. I look forward to personally welcoming you all in Dresden! Prior to Industry Partner Day, the Fraunhofer IPMS will host international experts in the field of Micromachined Ultrasonic Transducers (MUTs) in Dresden for the first time in 14 years. During the two-day conference scheduled for May 19-20, 2015, these experts will present the latest research results. We are excited to exchange knowledge with our guests on this, for us, still young topic. I wish you an informative reading of the current MEMS report.

Prof. Dr. Hubert Lakner

## QUICK NOTES

### Gateone: Boosting Smart System Innovation for SMEs



"Gateone" is a European project to equip SMEs with smart technologies and solutions to boost their innovation cycle. The official launch took place in Grenoble on January 23, 2015.

Smart systems, or the so called "More than Moore" applications, are expanding much faster than the semiconductor industry.

Their compound annual growth rate (CAGR) is already higher than 15%, with a total market in 2015 already expected to reach US\$60 billion (Source: Yole Développement).

In Gateone, Fraunhofer IPMS together with seven other European Research and Technology Organizations adopts a common process to reduce the risk associated with the adoption of new smart system technologies. Inspired from industry standards for product development, in partnership with SMEs, this process aims to reach the first gate of innovation.

The starting point is Gate zero, with a portfolio of more than 200 ideas or use cases. These use cases are supported by advanced state of the art technologies selected for their differentiation, IP and maturity. Fraunhofer IPMS will bring in the expertise regarding micro scanning mirrors, pressure sensors, Capacitive Micromachined Ultrasonic Transducers (CMUTs) and integrated capacitors. The offer is to work with SME to consolidate a business case and develop the necessary demonstration for a "hands-on" experience of the technology. This partnership is free of charge for the SMEs, no investment and no bind attached.

Gateone (Project ID: 644856) is supported by the European Commission and an Horizon 2020 innovation action led by company BluMorpho. The project started in January 2015 and will last for three years.

Further information can be found here:

[www.gateone-project.eu](http://www.gateone-project.eu)

# INDUSTRY PARTNER DAY 2015 – 10 YEARS APPLIED RESEARCH IN NANO ELECTRONICS

## Fraunhofer IPMS-CNT Celebrates 10th Anniversary with Industry Partner Day

Since its founding with strategic partners AMD and Infineon on May 31, 2005, the Fraunhofer Center Nanoelectronic Technologies CNT has evolved from a novel facility within the Fraunhofer-Gesellschaft into a fixture establishment in the Silicon Saxony semiconductor region. After ten years, the CNT symbolizes the typical Fraunhofer example for applied science in the area of 300 mm technology development.

With over 50 employees working in high-k devices, non-volatile memories, interconnects and nanopatterning, the CNT is a recognized research and development partner to major regional manufacturers such as Globalfoundries and Infineon. The expansion of the service portfolio to include a screening center for semiconductor-factory resources and the establishment of a test platform for semiconductor suppliers such as BASF have enabled the CNT to win numerous strategic customers and thus provide a sound basis for the coming years.

Integrated into the Fraunhofer Institute for Photonic Microsystems IPMS as one of five divisions at the beginning of 2013, the CNT still remains at the Infineon Technologies AG Königsbrücker Straße location with its own cleanroom and laboratory space. After many years under the direction of Prof. Peter Kücher, the CNT division has been led by Dr. Romy Liske since the integration.

The Center Nanoelectronic Technologies CNT researches and develops innovative materials and processes on silicon wafers with diameters of 200 and 300 mm for producers, suppliers and development partners. For this purpose, more than 40 industry-compatible process and analysis tools are available in the modern 800-square meter, Infineon-standard cleanroom.

The CNT invites you all to attend Industry Partner Day providing insight to the development cooperation in the fields of high-k devices and interconnects as well as industry technology trends on June 11, 2015, at the Königsbrücker Straße location. Among others, speakers and industry representatives from Globalfoundries, X-Fab, BASF and Entegris will be participating in the event.

Free registration online now at:

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



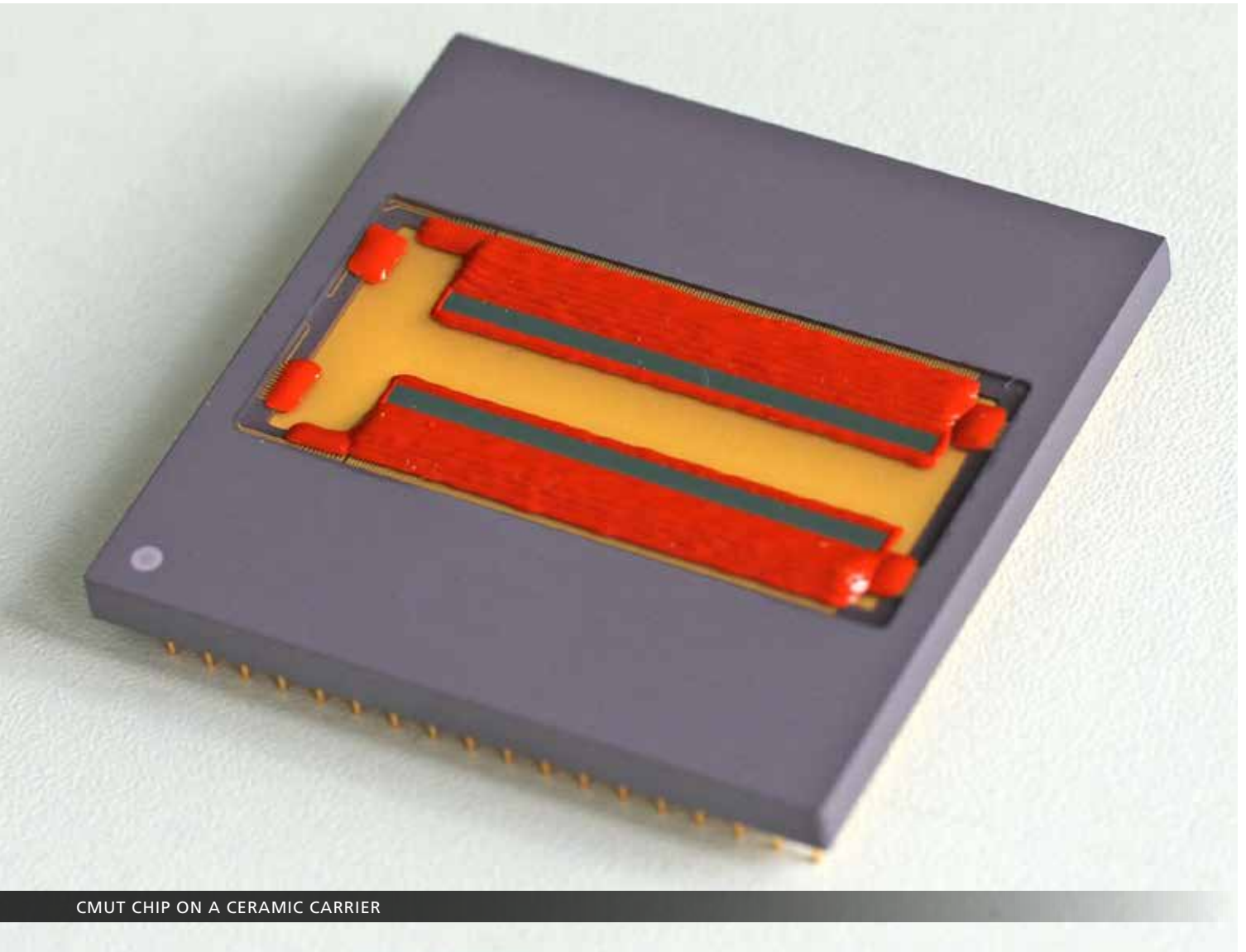
## Program

June 11, 2015, 9:00 - 14:30

Fraunhofer IPMS-CNT, Königsbrücker Str. 178, 01099 Dresden

- 09:00 Welcome and Opening**  
*Prof. Dr. Hubert Lakner, Director Fraunhofer IPMS, Dresden*
- 09:15 Globalfoundries in Dresden - Future Perspectives**  
*Dr. Rutger Wijburg, Globalfoundries*
- 09:35 Introduction CNT Highlights**  
*Dr. Romy Liske, Fraunhofer IPMS*
- 09:55 Technology Challenges at 28 nm and Beyond**  
*Dr. Maciej Wiatr, Globalfoundries*
- 10:45 Dresden Plating Lab - Industry Cooperation Model for Mutual Benefit**  
*Dr. Dieter Mayer, BASF*
- 11:10 Gentle Physical Photoresist Removal with Intelligent Fluids®**  
*Dr. Dirk Schumann, Bubbles & Beyond GmbH*
- 11:35 Real Time True Surface Monitoring for ALD Processes**  
*Dr. Hassan Gargouri, Sentech*
- 13:00 Semiconductor Memories: Current Status and Options for the Future**  
*Prof. Dr. Thomas Mikolajick, TU Dresden, NaMLab gGmbH*
- 13:25 Energy Efficient Non-volatile Memory Manufacturing (nv SRAM)**  
*Dr. Stephan Günther, Anvo Systems GmbH*
- 13:50 The EU ECSEL Project ADMONT – Status, Experiences and Prospects**  
*Dr. Karl-Heinz Stegemann, X-FAB Semiconductor Foundries*
- 14:15 Get Together / CNT Window Tour**

## MUT 2015 – 14TH INTERNATIONAL WORKSHOP ON MICROMACHINED ULTRASONIC TRANSDUCERS IN DRESDEN



CMUT CHIP ON A CERAMIC CARRIER

The development activities of Capacitive Micromachined Ultrasonic Transducers (CMUT) technology and applications at Fraunhofer IPMS are moving forward since the start at the end of 2012.

Several CMUT designs covering the frequency range between 1 MHz and 50 MHz were built and characterized at the facilities assembled at the Institute. The wide range of designs allows to address manifold applications with different requirements. Some of the applications in mind are focused on the development of CMUTs for the acoustic spectroscopy, imaging applications, e.g. medical, non-destructive testing (NDT), etc.

In order to understand the behavior of the CMUTs for the different applications, the researchers developed purposed-built test facilities and characterization programs. These include wafer level electrical impedance measurement systems as well as chip level immersed acoustic characterization methods. The homogeneity of

the resonances measured (in air) was within 5% compared to the center frequency, confirming that the CMUT fabrication process at Fraunhofer IPMS' clean room provides high quality CMUTs. The chips were also characterized in immersion (under water). For this, the wafers were diced, and the chips were mounted on a carrier, making sure all electrical signals were electrically insulated from the fluid. The acoustic performance (generated pressure, acoustic field shape, etc.) were measured for devices covering the frequency range 1 - 50 MHz.

The match between the simulated performance and measurement results from the fabricated CMUTs, in combination with the homogeneous results measured obtained in the wafer level measurements means that Fraunhofer IPMS masters the design and fabrication of CMUTs applicable in a wide range of possible applications.

# MUT 2015 – 14TH INTERNATIONAL WORKSHOP ON MICROMACHINED ULTRASONIC TRANSDUCERS IN DRESDEN

Initiated 2001 in Rome, the MUT (Micromachined Ultrasonic Transducers) workshop has taken place since then almost every year in various cities of Europe: Besançon (2002), Lausanne (2003), Florence (2004), Munich (2006), Antalya (2007), Trondheim (2008), Besançon (2009), Panevezys (2010), Salerno (2011), Tours (2012), Side (2013), Copenhagen (2014).

It gathers researchers and engineers from all over the world to exchange knowledge, ideas, results and perspectives on Micromachined Ultrasonic Transducers, that offer promising new applications in the medical, commercial, and consumer fields.

The 14th MUT conference will take place in Dresden, Germany, from May 19 - 20, 2015.

Tuesday, May 19	
08:00 h	Registration
09:00 h	Opening <i>Prof. Harald Schenk, Fraunhofer IPMS</i>
09:15 h	Development of Fabrication Process for Flexible Two-dimensional Piezoelectric MUT <i>Dr. Hongsoo Choi, Daegu Gyeongbuk Institute of Science &amp; Technology</i>
09:35 h	Fabrication of CMUTs with Through-Glass-Via Interconnects <i>Prof. Omar Oralkan, North Carolina State Univ.</i>
09:55 h	Stress Controlled CMUT Fabrication Based on a Sacrificial Release Process <i>Linus Elsaßer, Fraunhofer IPMS</i>
10:25 h	Coffee Break
10:55 h	Thermal Noise Analysis for CMUTs <i>Dr. Ayhan Bozkurt, Sabanci University</i>
11:15 h	Modal and Transient Dispersion Analysis of Acoustic Crosstalk Waves above CMUT Arrays <i>Shane Lani, Georgia Institute of Technology</i>
11:25 h	System Design Optimization for 1-D High Frequency CMUT Array <i>Evren Fatih Arkan, Georgia Institute of Technology</i>
11:55 h	Simulation of Two-Way Impulse Response of Annular CMUT Arrays <i>Prof. Abdullah Atalar, Bilkent University</i>
12:25 h	Lunch
13:40 h	3D Topography Time-sequence Immersed Measurements of MUT Response to Burst Excitation <i>Dr. Yves Emery, Lyncée Tec SA</i>
14:00 h	Acoustical Cross-Talk in Row-Column Addressed 2-D CMUT Arrays <i>Thomas Lehmann Christiansen, Technical University of Denmark</i>
14:20 h	Wafer Level Impedance Measurement and Data Analysis for CMUTs <i>Markus Klemm, Fraunhofer IPMS</i>
14:40 h	Fraunhofer IPMS Showroom and Cleanroom Tour
17:20 h	Tour and dinner at Radeberger brewery
22:30 h	End of day one



[www.mut2015.org](http://www.mut2015.org)

[mut2015@ipms.fraunhofer.de](mailto:mut2015@ipms.fraunhofer.de)

## Wednesday, May 20

09:00 h	Portable Low Cost Ultrasound Imaging System Using CMUTs <i>Rahim Mohammad Sobhani, Özyeğin University</i>	Session 4: Applications & Products Chair: Prof. Levent Degertekin
09:20 h	Row-Column Addressed 2-D CMUT Arrays Using LOCOS Fabrication: From Silicon Chip to Transducer Probe <i>Dr. Mathias Engholm, Technical University of Denmark</i>	
09:40 h	Real-time Sensing of the Liquid Density and Biochemical Species <i>Dovydas Barauskas, Kaunas University of Techn.</i>	
10:00 h	Dual Mode CMUT Arrays Optimized for Tissue Harmonic Imaging <i>Søren Elmin Diederichsen, Technical University of Denmark</i>	Session 5: Characterization 2 Chair: to be determined
10:30 h	Coffee Break	
11:00 h	Recent Progresses on an USgFUS cMUT Probe and its Driving Platform <i>Dominique Gross, University of Tours - GREMAN</i>	Session 6: Modeling 2 Chair: Prof. Abdullah Atalar
11:20 h	Output Pressure and Harmonic Characteristics for a CMUT as Function of Bias and Excitation Voltage <i>Dr. Anders Lei, Technical University of Denmark</i>	
11:40 h	Characterization of CMUTs for High Intensity Ultrasound applications <i>W. Apoutou N'Djin, Institut national de la santé et de la recherche médicale</i>	Session 3: Characterization 1 Chair: to be determined
12:00 h	High Quality Factor Resonant Mass Sensors Based on CMUT for Immersion in Liquid <i>Seyed Fakhreddin Nabavi, Ozyegin University</i>	
12:30 h	Lunch	Session 2: Modeling 1 Chair: Giosue Caliano
13:45 h	Modelling and Analysis of CMUTs in Cadence Spectre <i>Itir Koymen, Bilkent University</i>	
14:05 h	Linearization of Full-Scale Transmit Pressure in CMUTs <i>Dr. Alessandro Savoia, Università degli Studi Roma Tre</i>	Session 1: Fabrication Chair: Prof. Mario Kupnik
14:25 h	Reverberation Reduction in CMUT <i>Prof. Nicola Lamberti, Università degli Studi di Salerno</i>	
14:55 h	Coffee Break	Session 4: Applications & Products Chair: Prof. Levent Degertekin
15:25 h	Funding Options <i>Dr. Michael Scholles, Fraunhofer IPMS</i>	
15:45 h	MUT 2015 Best Paper Award	Session 3: Characterization 1 Chair: to be determined
15:50 h	Invitation to MUT 2016	
15:55 h	Closing Remarks	Session 2: Modeling 1 Chair: Giosue Caliano
16:00 h	End	

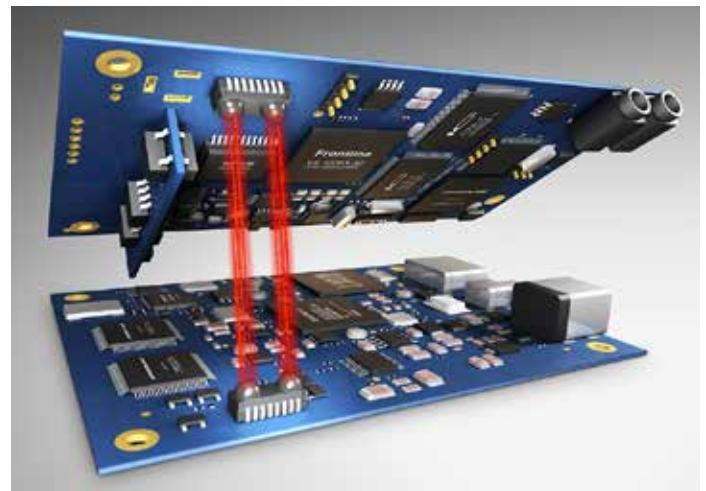
## WIRELESS 12.5 GBIT/S BOARD-TO-BOARD COMMUNICATION REPLACES HF CONNECTORS

The Fraunhofer IPMS has developed a transceiver based on Li-Fi technology which replaces HF connectors on printed circuit boards and uses infrared light to improve board-to-board communication.

High-frequency signals are commonly transmitted between two circuit boards via HF connectors. Higher data rates require more complex connector constructions in order to reliably send signals. Unfortunately, it is often the case that delicately-structured HF connectors are expensive and in practice, mechanically fragile. Contacts often become bent or loose and connectors can be replugged only a limited number of times.

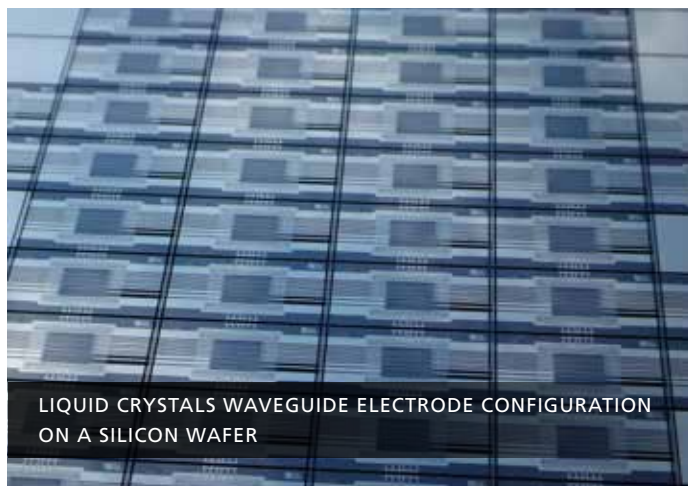
The Fraunhofer IPMS has designed a Li-Fi transceiver module to replace vulnerable HF connectors on printed circuit boards and thus ensure reliable board-to-board communication (see picture on the right). Infrared light is used as a wireless transmission medium for the exchange of high volumes of data, making it possible to transmit in excess of 12.5 GBit per second. Data can be transmitted in half and full duplex mode. The Fraunhofer IPMS transceiver provides the same functionality as wires or connectors and is up to ten times faster than current wireless solutions using radio frequencies.

Additional advantages provided by the transceiver include reduced negligible bit error rates ( $<10^{-11}$ ), low energy consumption and lowered cost. Fraunhofer IPMS has designed the transceiver to achieve the smallest possible dimensions of  $2 \times 2 \times 2$  mm. This new transceiver is especially suited for industrial applications in which large amounts of data need to be transmitted quickly and connectors no longer meet mechanical requirements or reliability demands.



## FAST OPTICAL POWER CONTROL WITH LIQUID CRYSTAL WAVEGUIDES

Variable optical attenuators (VOAs) and optical switches are employed for remote optical power control and the distribution of optical signals in fiber-optic networks. Scientists at the Fraunhofer IPMS have developed broadband, bi-directional, fast (sub-microsecond) and reliable VOAs and optical switches based on a unique, innovative concept of electro-optical waveguides



LIQUID CRYSTALS WAVEGUIDE ELECTRODE CONFIGURATION ON A SILICON WAFER

with a liquid crystal core integrated on a silicon backplane. These VOAs and switches can be conveniently programmed by directly applying voltages on individually addressable electrodes. In a novel device design concept, the electric field distribution – used to shape the waveguide – can be tuned to allow the propagation of either one or both linear polarization modes. The devices – developed for polarization maintaining and polarization insensitive applications – feature low insertion loss thanks to on-chip mode-matching couplers, low PDL and a continuously tunable wide optical attenuation range. Interrogation instruments for fiber optic sensors can greatly benefit from the Fraunhofer IPMS optical power control and switching solution in MHz range. Furthermore, these devices can be used in DWDM applications for channel selection, power manipulation and stabilization.

Part of the development has been carried out within the project Electro-Optical Waveguides based on Liquid Crystals for Integrated Optical Switching (EOF-IOS), contract No. 13N12442, funded by the German Federal Ministry of Education and Research in the program Photonic Research in Germany and the research initiative "Wissenschaftliche Vorprojekte" (WiVorPro).

## "ENERGY HARVESTER" IN ASPHALT

Almost everyone is familiar with RFID transmitter-receiver systems, which are used for the automatic and no-touch identification and localization of objects or living things using radio waves. Researchers from the Fraunhofer IPMS have developed a freely-programmable UHF transponder tag that is fitted with sensors and that can measure physical parameters such as temperature, humidity or pressure. Such tags can for example, be placed in the masonry or behind a drywall during the construction or renovation of buildings; once they are installed, they take regular moisture measurements to monitor possible building damages or hygiene-related issues. They can also be installed in asphalt during the construction of roads, in order to measure the sometimes significant change in temperature between the various road sections. This is particularly beneficial for winter service departments, as costs for sand/salt and service personnel can be minimized without compromising safety, while also preventing the type of asphalt damages that are normally associated with the excessive use of sand/salt.



The potential of UHF sensor transponders to improve quality along with cost and time savings and thus open the way for new applications is enormous in view of the advantages that this transponder technology offers: transponders are small, robust, easy to handle and cost-effective. In addition, they can be used not just to deliver data in real time and without contact with the assistance of a reading device for their entire service life, they can also be supplied with the required energy. A transponder integrated into the road surface could "harvest" its entire energy from a vehicle that spreads sand/salt, for example. Thanks to the flexibility of the transponder system, which consists of an antenna, transponder chip and sensor, and features an integrated I<sup>2</sup>C or SPI interface for connecting any external sensor, this Fraunhofer technology is an interesting option for a variety of possible uses.

## UPCOMING EVENTS

### MUT 2015

Dresden, Germany May 19 - 20, 2015  
ART'OTEL Dresden

### Sensor+Test

Nuremberg, Germany May 19 - 21, 2015  
Nuremberg Exhibition Center, Hall 12, Booth 12-537

### Sensors Expo & Conference

Long Beach, USA June 9 - 11, 2015  
Long Beach Convention Center, Booth 339

### CNT Industry Partner Day 2015

Dresden, Germany June 11, 2015  
Fraunhofer IPMS-CNT

### LASER

Munich, Germany June 22 - 25, 2015  
Munich Exhibition Center, Hall B3, Booth 341

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

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