Fraunhofer IPMS

FRAUNHOFER INSTITUTE FOR PHOTONIC MICROSYSTEMS IPMS

MEMS REPORT

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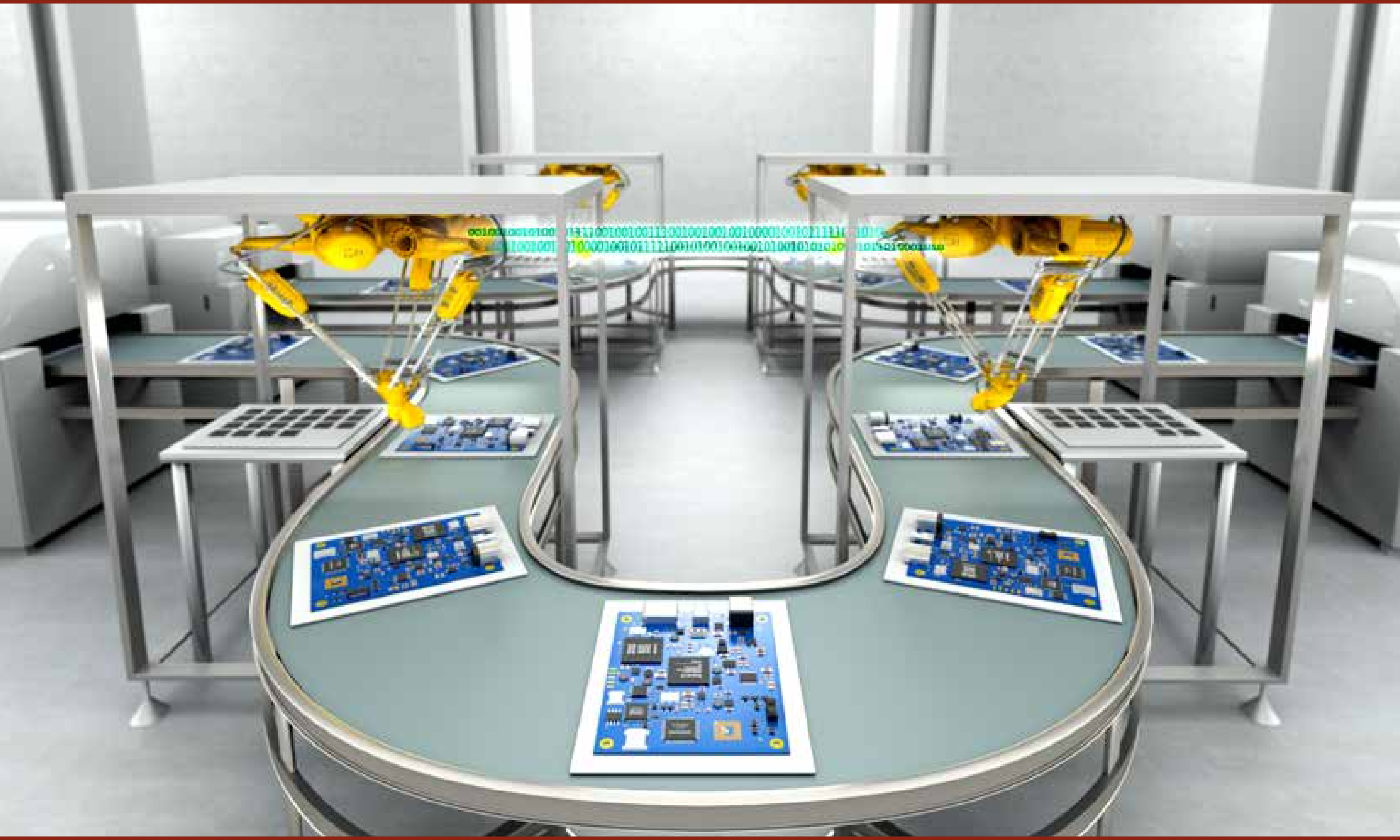

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Dear Customers, Partners and Friends
of Fraunhofer IPMS,

Summarized under the keyword ”Industrie 4.0“, changes to transform the currently established production processes into a maximally self-organized manufacturing require mutually-tuned hardware and software components as a technical foundation. In this MEMS Report, we introduce more Fraunhofer IPMS development results and related topics in this area.

For example, maintenance-free RFID sensor nodes developed at the Institute collect data necessary for automatic production control. Requiring no batteries, these sensor nodes obtain energy from the reader. In addition to other components, sensory elements further developed at the Institute such as capacitive micromachined ultrasonic transducers could be put into operation. In order to facilitate the use of sensory information in any automation system regardless of its manufacturer, universal software interfaces are required. Fraunhofer IPMS now offers software solutions for RFID components based on the OPC UA standards and will describe these products in more detail in this MEMS Report. Therefore, we are a well-prepared partner for customers looking to strengthen ”Industrie 4.0“ production.

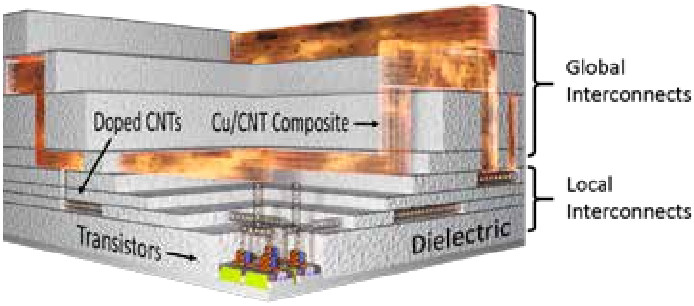
We wish you an enjoyable and informative reading of this current MEMS Report.

Prof. Dr. Harald Schenk   Prof. Dr. Hubert Lakner

CARBON NANOTUBES FOR ADVANCED INTERCONNECTS

Fraunhofer IPMS, CEA-Leti, IBM, Aixtron, CNRS, GSS and University of Glasgow have started the joint project ”CONNECT“ on fabrication techniques and processes to enable reliable Carbon NanoTubes (CNT) for on-chip interconnects in ultra large scale integration (ULSI) microchip production.

As the chip size goes down, interconnects become major bottlenecks irrespective of the application domain due to electromigration issues and an ever increasing power consumption. The CONNECT project investigates ultra-fine CNT lines and metal-CNT composite material for addressing the issues of current state-of-the-art copper interconnects. Novel CNT interconnect architectures for the exploration of circuit- and architecture-level performance and energy efficiency will be developed. CMOS compatibility as well as challenges of transferring new processes into industrial mass production will be addressed.



Novel interconnect architecture.

With significantly improved electrical resistivity, ampacity, thermal and electromigration properties of CNT interconnects compared to state-of-the-art approaches for conventional copper interconnects, an increased power and scaling density of CMOS or CMOS extension will be available and applicable to alternative computing schemes such as neuromorphic computing.

The technologies developed in this project are key for both performance and manufacturability of scaled microelectronics to manifest miniaturized microelectronic products with enhanced functionality at ever decreasing cost. The procurement of CONNECT will foster the recovery of market shares of the European electronic sector and prepare the industry for future developments of the electronic landscape.

RFID OPC UA AUTOID SERVER FACILITATES THE IMPLEMENTATION OF TRANSPONDER TECHNOLOGY IN INDUSTRIE 4.0 ENVIRONMENTS

Fraunhofer IPMS has developed a hardware-independent RFID OPC UA AutoID Server for Industrie 4.0 that can be easily integrated into any application. This enables RFID components being used in automation technology and coming from various manufacturers to communicate with each other.

As the key characteristic of Industrie 4.0, production is interlinked with modern information and communication technologies: Processes are fully automated and manufacturing as well as logistics are computerized. Man, machine and process control are digitally connected with one another to form an autonomous, intelligent system.

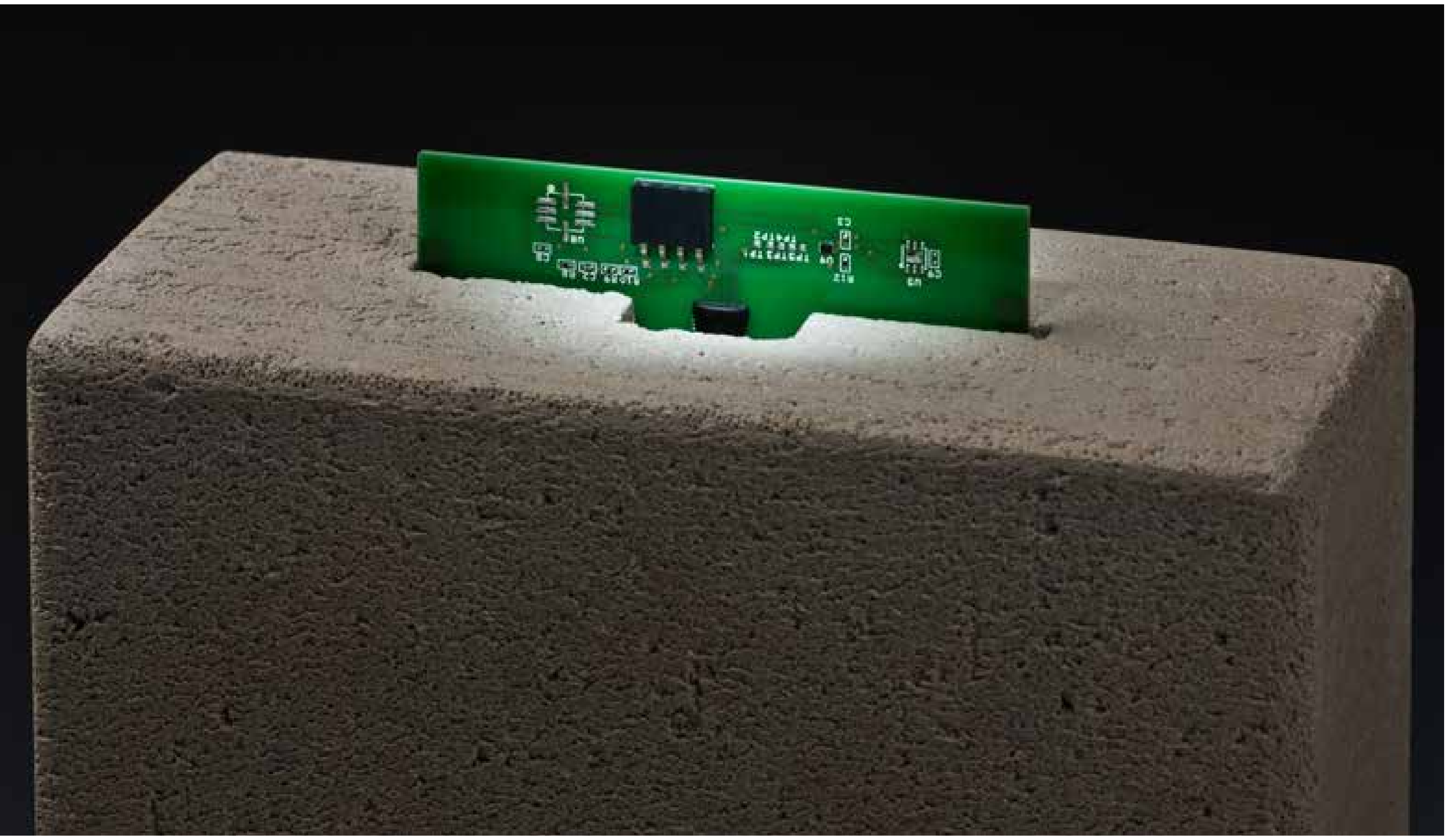
As production becomes more digitalized and connected, increasing amounts of sensors, machines and control units must communicate with each other resulting in a large number of required interfaces. In order for two devices to exchange data in modern networks, both must be precisely aware of the counterpart's communication and functional capabilities – accordingly, extensions and replacement have proven to be relatively difficult so far. OPC UA (Open Platform Communication Unified Architecture) now offers a solution. When using OPC UA, exactly one compliant interface is developed for each device which can then be integrated into scalable control and monitoring systems without much effort.

As the standard for manufacturer independent communication in automation technology, OPC UA enables the universal interconnection of industrial bus systems and protocols. Machine-relevant and context-related information can be encapsulated and provided at any time.

Fraunhofer IPMS has developed a new software that implements the OPC UA AutoID companion specifications for RFID components. Various RFID readers from any supplier with different frequency ranges and diverse transponders can be directly controlled via this OPC UA AutoID server. This makes manufacturer- or frequency-specific integration efforts unnecessary. In the future, applications and services must establish only a connection to the server – time and effort spent on manually adapting individual control and security infrastructures to numerous manufacturer standards is thus eliminated. As the RFID OPC UA AutoID server developed by Fraunhofer IPMS is platform independent, it is able to utilize the RFID reader and RFID tags regardless of which frequency band is being used. In addition, it can be easily integrated into any OPC UA infrastructure.

Fraunhofer IPMS offers tailored RFID OPC UA AutoID server packages and services for reader manufacturers, RFID technology suppliers and system integrators.

MAINTENANCE-FREE SENSOR NODES FOR THE INTERNET OF THINGS



Experts at the Fraunhofer IPMS have been developing compact, customer-customized sensor transponders for diverse industrial applications for years. Because wireless sensors of the Institute are maintenance-free and battery independent, powered with energy provided solely by the antenna of the reader in the network, RFID-Tags are predestined to replace the bulky sensor nodes of conventional battery-powered systems in industrial sensor networks.

The "Internet of Things" makes it possible to automatically feed huge amounts of industrial logistics and manufacturing data into the web where it can be analyzed and processed with virtually unlimited computational resources. This enables complex production processes to be organized or the allocation of resources to be optimized via remote control in real time. Intelligent sensor networks made up of a multitude of sensor nodes are prerequisite, as they connect the real and digital worlds making smart applications such as comprehensive monitoring and the remote control of industrial plants profitable. In optimal cases, sensor systems are wireless because fixed cabling increases installation time and cost, particularly in cases with a high sensor density, and can influence measurement results. In addition, due to limited battery lifetime and the changing of batteries increasing maintenance needs and distorting measurement results, battery-powered systems used today are unsuitable, as sensor nodes rely on a dependable power supply to carry out continuous large-scale industrial measurements over several years.

Both issues – wiring and necessary battery replacement – can be eliminated by implementing radio frequency identification (RFID) sensor nodes developed at the Fraunhofer IPMS. Dr. Frank Deicke, Fraunhofer IPMS business unit manager explains: "Our sensor transponders reach performance levels necessary for operation from the radiated electromagnetic field of the reader. They are small, robust and can be deployed flexibly. Therefore, our sensor nodes are modularly built and can be arbitrarily equipped with sensors according to individual customer needs."

The transponder system consists of an antenna, a transponder chip and a sensor, connects external sensors over an integrated I²C or SPI interface and covers a wide range of temperature. Its flexibility allows the Fraunhofer technology to be eligible for a variety of possible industrial applications. Samples for measuring temperature, barometric pressure and humidity are available.

POWERING "WEARABLE ELECTRONICS" VIA ENERGY HARVESTER

Harvesting kinetic energy from human motion and converting it into usable electrical energy has become in recent years an attractive approach to powering wireless portable devices. Scientists at the Fraunhofer IPMS have developed a new energy harvesting device based on emergent electroactive polymers, which is small enough to be embedded in the sole of a shoe and can be used to power such devices.

Vibration energy harvesters can be connected to electronics in garments and footwear that are able to track physical parameters such as speed, movement and temperature. It is yet really challenging to generate in this way enough energy to power today's applications. Fraunhofer IPMS developed an energy harvester device able to power electronic devices with improved efficiency. "The device able to convert mechanical to electrical energy is based on thin films of dielectric polymers of large relative permittivity. As compared with traditional piezoelectric configurations, this concept works non-resonantly and can be optimized for capturing energy from mechanical power sources in the low frequency range. Additionally, the developed device is small, flexible and easily embeddable into, for instance, the sole of a shoe," says Dr. Florenta Costache, project manager at Fraunhofer IPMS.

A first device demonstrator of a polymer energy harvester embedded in a shoe is now available. This is able to generate several µW of power in a second when subjected to mechanical deformation of pressure and frequency range specific to human walking. The harvester circuit has been adjusted to power a transmitter module. Thus the system is able to generate mechanical power and, using that, to transmit telegrams at intervals of seconds. The harvester device and circuit can be adapted for other applications such as for powering wireless sensors (temperature, acceleration, pressure), for powering portable devices and monitoring various bio-data.

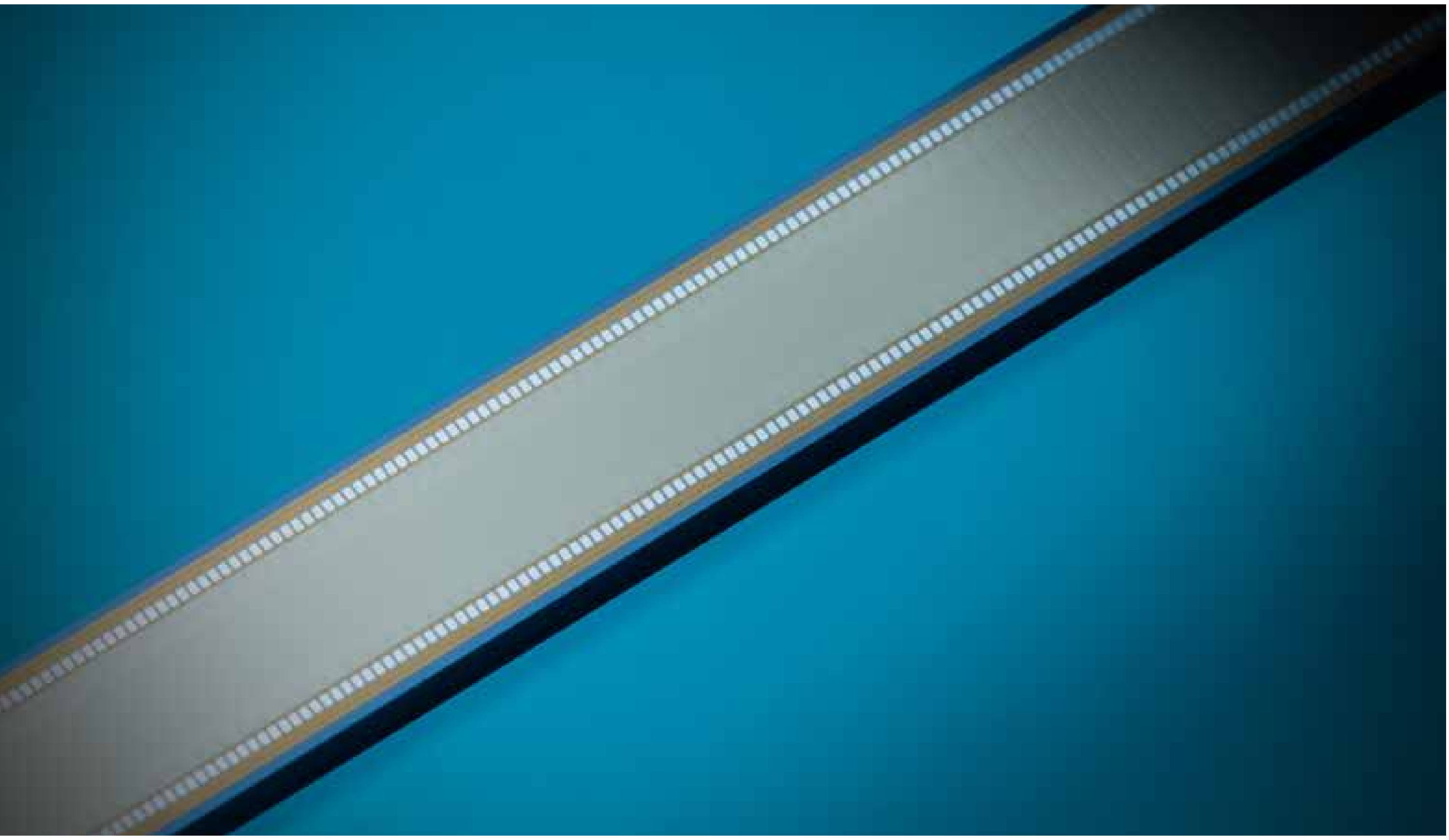
CAN FD PLUG FEST SHOWS ROBUST OPERATION OF CONTROLLER IP CORE

The CAN Bus Controller IP Core by CAST and Fraunhofer IPMS has successfully undergone a second round of real-world-like testing at the CAN Plug Fest run by the CAN in Automation (CiA) association.

The CAN FD Plug Fest gathered firms to evaluate how well their respective CAN Flexible Data Bus Protocol products work together in network topologies that emulate actual automobile environments. Sourced from Fraunhofer IPMS, the CAN-CTRL CAN 2.0 & FD Controller Core is one of the few ASIC RTL and FPGA netlist IP cores to support all current and proposed specifications (CAN 2.0, CAN FD ISO and Bosch, and Time-Triggered TTCAN). It is also the first soft IP core to undergo a second year of Plug Fest testing.

The CAN FD Controller IP Core is available now through CAST worldwide, with a reference design board and other development aids plus Verification IP.

ACOUSTIC SPECTROSCOPY VIA CMUTS FOR THE QUALITY CONTROL OF LIQUIDS



Continuous monitoring of the properties of fluids and lubricants is an important task in sensor technology. For lubricants in particular, the characterization of solid and water shares is an important quality parameter. When making these characterizations, sensors for the mobile miniaturized monitoring are preferable over laboratory measurements. Here, a miniaturized ultrasonic spectroscopy based on capacitive micromachined ultrasonic transducers (CMUT) allow new opportunities.

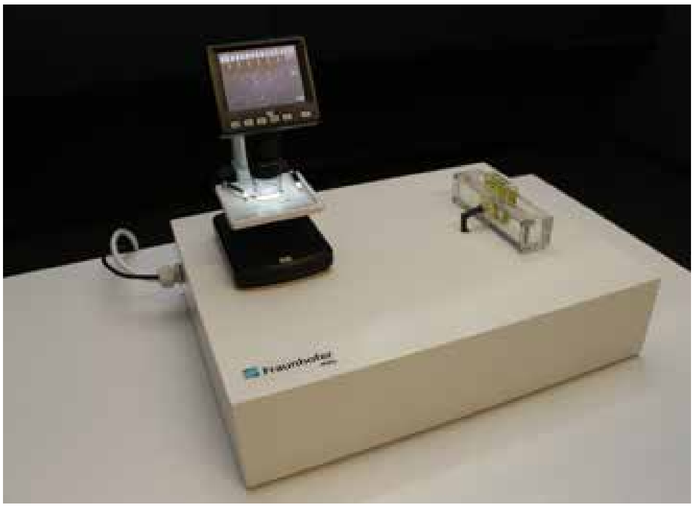
Spectroscopic examination by means of ultrasound provides information about the physical characteristics of materials in particular as well as the chemical analysis of dispersions. By analyzing the frequency-dependent attenuation and speed of sound, quality conclusions and the composition of oils, alcohol-water mixtures or other liquids can be determined, providing an ideal complement to optical spectroscopy.

In this area of application, the use of capacitive micromachined ultrasonic transducers can lead to new highly-compact environment measurement systems. In contrast to conventional ultrasonic piezoelectric elements, CMUTs are realized through a micromechanical manufacturing process and allow for an extremely compact structure.

CMUTs are basically MEMS structures which consist of two opposite electrodes. One of the electrodes is fixed, the other is movable. The two electrodes are separated by an insulating layer and a gap scaled in vacuum. CMUTs can both send and receive by converting electric energy to acoustic energy or vice versa through the displacement of the movable electrode. When a CMUT is sending sound, an electronic potential is established between the electrodes in order to deflect the electrostatic force from the movable electrode to its fixed counterpart. This movement generates a sound wave. Using the opposite procedure, the CMUT is also able to act as a receiver.

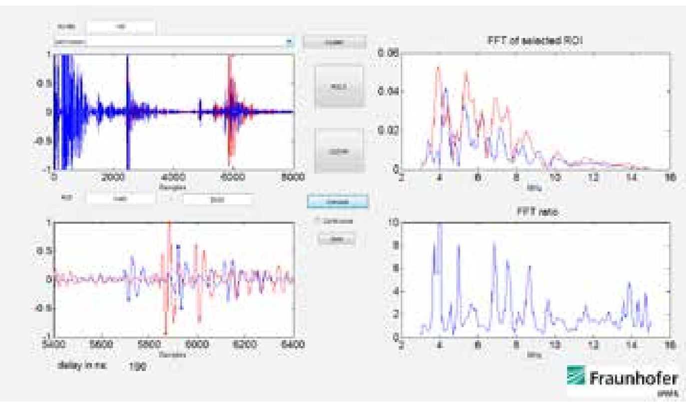
CMUTs are ideal for acoustic spectroscopy because they can radiate sound in liquid media with extreme efficiency, detection is highly sensitive and a wide frequency bandwidth can be used. In liquids, CMUTs offer a frequency bandwidth of >100% of the medium frequency which is particularly advantageous for broad band reception of frequency-dependent attenuation.

At Fraunhofer IPMS, CMUT production implements a unique method that allows for CMUTs to be produced as so-called Back-end-of-Line (BeoL) process modules which facilitates integration in a CMOS process. This integration allows for the realization of highly compact analysis systems, a prerequisite to the mobile usage of CMUTs as continuous sensors.



Novel demonstrator for CMUTs.

Fraunhofer IPMS has set up a demonstration test site with CMUTs for the acoustic spectroscopy of liquids. At this testing station, liquids are radiated in cuvettes via a CMUT and frequency-dependent attenuation is determined by means of a Fourier analysis. Obtained data can then be subsequently evaluated. This test site provides a demonstration intended to qualitatively present the concept of acoustic spectroscopy. Results indicate a good potential for CMUTs to make new miniaturized mobile analysis systems for the quality control of liquid mixes possible. Fraunhofer IPMS would like to advance the further development of such systems, into practical application together with our partners.



Program interface.

UPCOMING EVENTS

Sensor+Test
Nuremberg, Germany — May 10 - 12, 2016
Nuremberg Exhibition Center, Hall 5, Booth 248

Optatec
Frankfurt/Main, Germany — June 7 - 9, 2016
Frankfurt Exhibition Center, Hall 3, Booth D50

Sensors Expo & Conference
San Jose, CA, USA — June 22 - 23, 2016
McEnery Convention Center, Booth 535

SEMICON West
San Francisco, CA, USA — July 12 - 14, 2016
Moscone Center

ECOC
Düsseldorf, Germany — September 19 - 21, 2016
CCD Congress Center Düsseldorf, Booth 327

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Further Information:

Dr. Michael Scholles, Head of Business Development & Strategy
Phone: +49 351 88 23 201
E-Mail: info@ipms.fraunhofer.de

PUBLISHING NOTES

Publisher: Fraunhofer Institute for Photonic Microsystems IPMS, Maria-Reiche-Str. 2, 01109 Dresden
Phone: +49 351 88 23-0, Fax: +49 351 88 23-266, www.ipms.fraunhofer.de
Editor: Romy Zschiedrich, Moritz Fleischer, info@ipms.fraunhofer.de

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