

MEMS REPORT

3 / 2013



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Prof. Dr. Hubert Lakner
Director of Institute

Dear Customers, Partners and Friends
of Fraunhofer IPMS,

this present edition focuses on a presentation of the activities of the Fraunhofer IPMS-CNT, which has been part of our institute since January 1, 2013 and has established itself as an important developer of technology, particularly for the local semiconductor industry. Through the integration of the Fraunhofer IPMS-CNT as a department, the technological spectrum of the Fraunhofer IPMS has been expanded from "More-than-Moore" to "More-Moore". The competences of the Fraunhofer IPMS and Fraunhofer IPMS-CNT will also be merged in certain selected topics so that new customers can be addressed. This MEMS report offers a first insight into the new possibilities for the future.

Fraunhofer lives from developing new topics and competences so that it remains attractive for industry. Public sponsorship is particularly important here in view of the necessary funds, whereby the European contribution is increasing compared to national support. Fraunhofer IPMS is already well set up for the EU framework programme for research and innovation "Horizon 2020" that is now beginning, as the article on our activities within the EPoSS technology platform shows. I wish you all an informative read of this MEMS report.

A handwritten signature in black ink, appearing to read 'H. Lakner', written in a cursive style.

Prof. Dr. Hubert Lakner

QUICK NOTES

Extending the Institute's Executive Board at the Fraunhofer IPMS

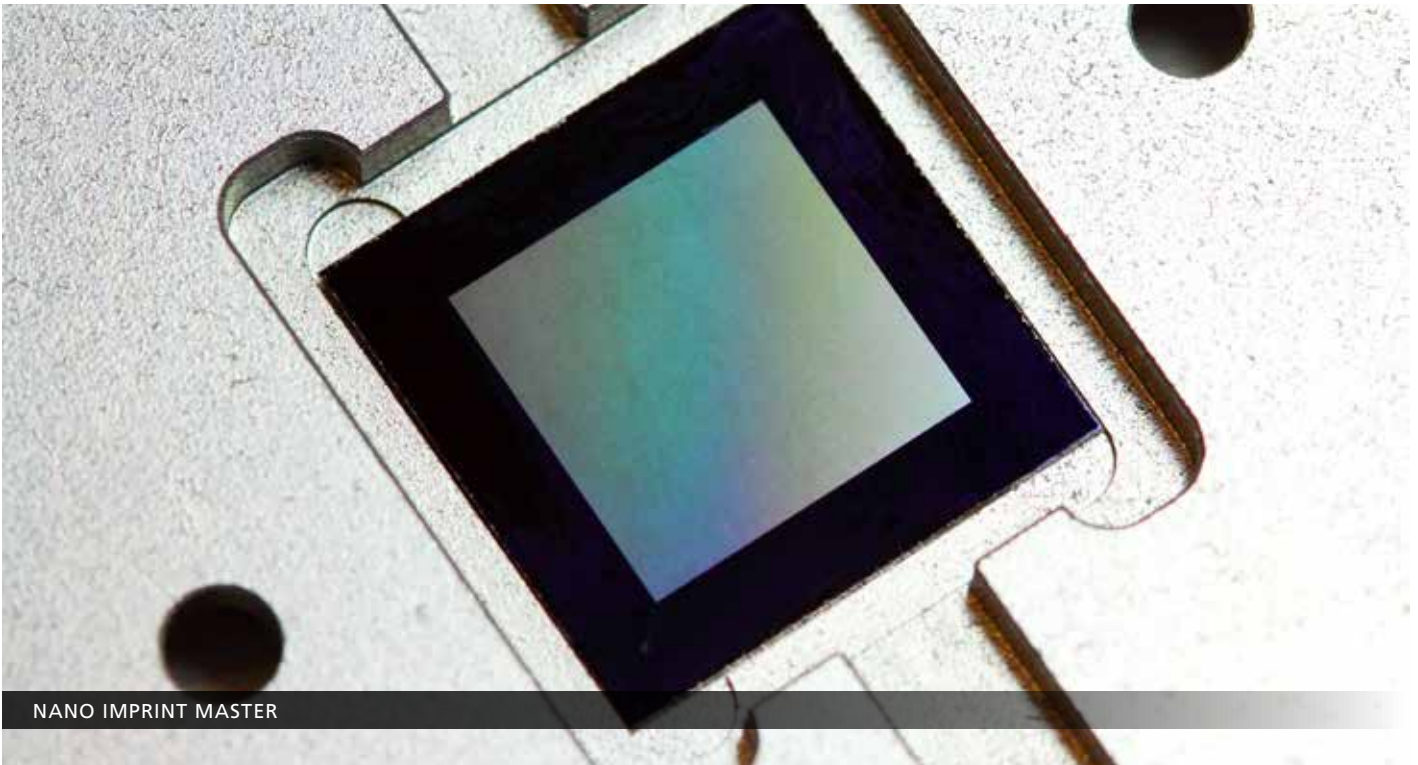
The management of the Fraunhofer Gesellschaft has appointed Prof. Dr. Harald Schenk as the second director of the Fraunhofer IPMS with effect from September 1, 2013. Prof. Schenk has been the deputy director of the institute since 2004 and was responsible for the business unit "Active Microoptical Components & Systems". The executive management of the Fraunhofer IPMS remains in the hands of Prof. Dr. Hubert Lakner, who is looking forward to the continued successful and constructive cooperation in the new constellation.



Fraunhofer IPMS at the EPoSS annual forum

All important protagonists from the field of "Smart Systems Integration" met between September 25 and 27, 2013 in Cork, Ireland, during the annual forum of the European Technology Platform EPoSS. The Fraunhofer IPMS, which realizes smart systems through the integration of MEMS and MOEMS as well as electronics with other, in particular photonic components, was also present. Dr. Michael Scholles, head of "Business Development & Strategy" at the Fraunhofer IPMS, chaired the regular meeting of the EPoSS working group "Key Technologies" as its elected chairman. The meeting focused on the role of key technologies in the EU's new framework programme for research and innovation "Horizon 2020". In the scientific part of the forum, Dr. Anartz Unamuno, group manager at the Fraunhofer IPMS, presented the most recent results of work related to CMUTs (capacitive micro-machined ultrasonic transducers). On the whole, the Fraunhofer IPMS is well positioned for public sponsorship in "Horizon 2020" through its intensive cooperation in EPoSS.

FRAUNHOFER IPMS-CNT: THE MOST ADVANCED FRAUNHOFER SEMICONDUCTOR RESEARCH ON 300 MM SILICON WAFER



The Fraunhofer-Center Nanoelectronic Technologies CNT was founded in 2005 as public private partnership with AMD and Infineon Technologies and has been integrated as business unit of Fraunhofer IPMS in 2013. The research topics of Fraunhofer IPMS-CNT include the development of processes and materials as well as the physical and electrical characterization of high performance logics, derivatives (e. g. embedded DRAM) and technologies for volatile and non-volatile memory devices. In close cooperation with industrial partners and other R&D organizations, the objective of the Fraunhofer IPMS-CNT is the development of innovative unit process solutions for nanoelectronic systems on 300 mm silicon wafers.

Fraunhofer IPMS-CNT uses 800 m² industrial-grade clean room space of ISO 6 (class 1000) standard which is equipped with 40 state-of-the-art clean room tools for silicon wafer processing, metrology and analytics. Process tools and environment are designed to operate under the conditions of semiconductor manufacturing. The results are directly transferable into production processes of the semiconductor industry to reduce time-to-market and costs for partners. Today, Fraunhofer IPMS-CNT experts work in three focus areas: Nanopatterning, High-k Devices and Interconnects – all related to silicon processing on 300/200 mm wafers. Additional

services provided are structuring of glass substrates, testing of consumables and evaluation of semiconductor processing equipment supported by nanoanalytic methods.

Nanopatterning

In the competence area nanopatterning, process capabilities were further enhanced for 28 nm node manufacturing support. The e-beam direct write litho cluster comprising a Vistec SB3050DW VSB writer as well as resist track, reactive ion etch and metrology tools was used for flexible patterning of multiple customer specific designs and layouts. Through collaborations with multiple partners and material suppliers, novel cleaning procedures for wafers, advanced hardmask and resist concepts were evaluated using Fraunhofer IPMS-CNT's most advanced 300 mm CMOS cleanroom and manufacturing environment. Significant efforts were spent in extending processes for patterning of large area nanoimprint (NIL) masters.

High-k Devices

Within the High-k Devices group there has been a growth in high-k ALD (Atomic Layer Deposition) being introduced for application on running 150 and 200 mm based IC applications. Therefore the Fraunhofer IPMS-CNT is now actively offering 300 mm leading

FRAUNHOFER IPMS-CNT: THE MOST ADVANCED FRAUNHOFER SEMICONDUCTOR RESEARCH ON 300 MM SILICON WAFER

edge high-k technologies for the IC industry running smaller wafer sizes. Also the non-IC market is addressed through the partnership with other research organizations in Saxony under the umbrella of ALD Lab Dresden, where the participating institutes have brought together their expertise and infrastructure in ALD and beyond. The Fraunhofer IPMS-CNT offers a unique competence center in ALD – bridging the need for initial high investment for entering the field of ALD for small to large sized companies.

Interconnects

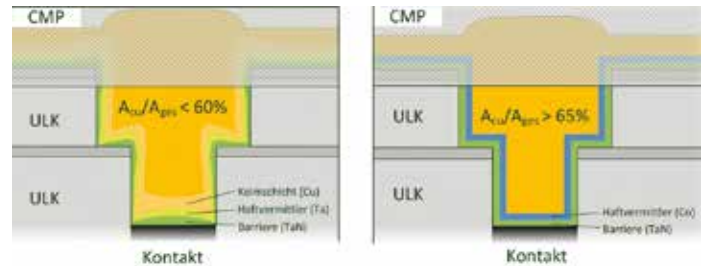
Within the scope of device manufacturing, interconnect downscaling is deemed a technology driver. While it is clear that transistor performance intrinsically improves with geometrical scaling, interconnect performance does not. Therefore, tremendous efforts are being made to develop new interconnect materials and processes. Besides downscaling, new technologies currently arise that comprise on-chip functionalization by integrating passives or analog devices in interconnect levels.

Integration of cobalt as a “Seed Replacement Liner” for future copper metallizing nodes

The SAB project NOLIMIT was launched at the end of 2010 at Fraunhofer IPMS-CNT and deals with the development of a wiring technology for nano-structures taking into account the growing demands on electrical reliability. NOLIMIT is being coordinated by GLOBALFOUNDRIES. Apart from the Fraunhofer IPMS-CNT, the Fraunhofer Institutes ENAS and IZFP, the TU Dresden, TU Ilmenau as well as Infineon AG are involved in the research activities.

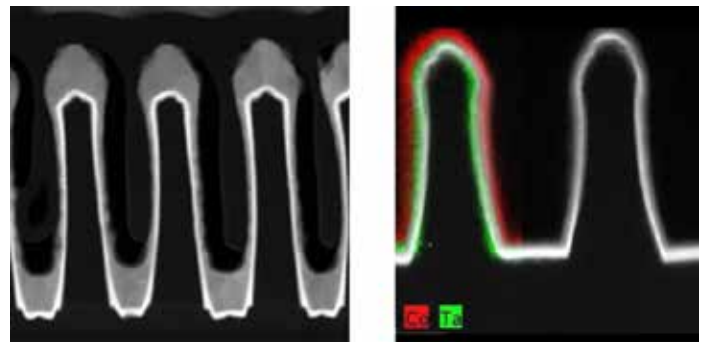
Scientists and engineers at the Fraunhofer IPMS-CNT are working on the production of thin cobalt layers within the scope of NOLIMIT. These serve to isolate copper and the surrounding dielectric from each other. Each square centimeter of chip surface has around 3.5 km of copper conductors that are responsible for triggering and controlling the active components (transistors, capacitors). The smallest of these copper conductors are less than 50 nm wide and place very high demands on the manufacturing processes. Conventionally, a triple layer stack consisting of tantalum nitride, tantalum and a copper seed layer is applied between the dielectric and copper, whereby physical plasma vapor deposition (PVD) is the method of choice. The advantage of PVD is the high layer purity, which is reflected in the electrical reliability of the conductors. One disadvantage of anisotropic coating technology is

the low edge coverage and the formation of overhangs in narrow structures.



Schematic diagram of the metallizing process using conventional coating methods (left) and using cobalt (right).

Cobalt could replace tantalum and the copper seed layer as a “Seed Replacement Liner”, therefore cutting the three-layer down to a two-layer system. This space saving would benefit the electrochemical copper deposition that follows and have a positive effect on the conductor resistance. What's more, the Fraunhofer IPMS-CNT has succeeded in producing cobalt layers with a low oxygen and carbon share by means of chemical vapor deposition CVD. These layers have a high degree of conformity, even in very narrow structures, which is why the technology is promising even smaller technology nodes in the future.



STEM image of very distinctive overhangs of the PVD copper seed layer (left) and Overlapping STEM and TEM-EDX images of the highly compliant CVD cobalt layer stack (right).

Apart from the single process development to 300 mm, the integration of cobalt into the process flow is also of great importance. Thus, the subsequent process steps of electrochemical copper deposition and chemico-mechanical planarizing have been adapted in the Fraunhofer IPMS-CNT and successfully evaluated for the 28 nm technology node together with GLOBALFOUNDRIES.

INTERVIEW WITH DR. ROMY LISKE

Fraunhofer IPMS: “Where is the current focus of your team's work?”

Romy Liske: “We started developing individual processes for the semiconductor industry at the Fraunhofer IPMS-CNT in 2006. Our interconnects team is hereby involved in metallizing in the broadest sense of the word and with the Cu/low-k-processes in particular. The emphasis is not just on the individual processes but on process integration, i. e. what effect does the introduction of a new material or process have on the subsequent processes and how do preceding processes have to be adapted in order to achieve optimum results. Analysis and process characterization, which we perform ourselves as far as possible, plays an important role here.”

Fraunhofer IPMS: “What is the biggest challenge facing the integration of cobalt?”

Romy Liske: “Cobalt has the advantage that electrochemical copper deposition can be carried out directly without a seed layer. The space saving this entails is an important argument for the introduction of cobalt in future technology nodes. The deposition of cobalt by means of chemical vapor deposition has to be optimized so that as few foreign atoms as possible, such as oxygen or carbon, are integrated, since these degrade the electrical properties of the metallizing layers. What's more, a high conformity has to be achieved in sub-50 nm structures. The process hereby has to take place at temperatures below 400 °C so that existing structures are not damaged.”

Fraunhofer IPMS: “What are the next steps?”

Romy Liske: “Following the integration of cobalt in the existing process flow and the adaptation of the copper deposition and chemico-mechanical planarizing, we now have to evaluate the overall metallizing layer with respect to electrical properties and reliability. We also have a number of other ideas we would like to investigate.”

Fraunhofer IPMS: “What possibilities for cooperation exist in the field of interconnects?”

Romy Liske: “Apart from the development of processes and materials for semiconductor firms, we also offer our process know-how to chemical companies who are established, or wish to



Dr. Romy Liske has been working at the Fraunhofer IPMS-CNT since 2006, and since 2010 she has been the group manager for the interconnects division. She completed her doctorate in 2011 at the TU Dresden on electrochemical copper deposition in sub-100 nm structures.

establish themselves on the semiconductor market (e. g. screening of plating, cleaning and CMP consumables). Another important part of our customer work also involves the constant adaptation of process plants together with manufacturers.”

Fraunhofer IPMS: “How does this work?”

Romy Liske: “There are some new development opportunities for our interconnects team in the field of More-than-Moore. The metallizing layer will be used in future to provide even more functions on the chip. This ranges from the integration of individual components such as capacitors through to complex assemblies, e. g. analog circuits.”

Fraunhofer IPMS: “Let us close by looking ahead: what are the next developments that will be pursued by your group?”

Romy Liske: “Our goal is to cover further stages of the development chain alongside the process development of 300 mm wafers. We are therefore planning to intensify our research work with respect to material development and applications and to integrate this more strongly in the Fraunhofer IPMS-CNT field of work.”

MEMS-SCANNER: ZEISS TRUSTS IN THE TECHNOLOGY OF FRAUNHOFER IPMS FOR LIGHT SHEET MICROSCOPE LIGHTSHEET Z.1



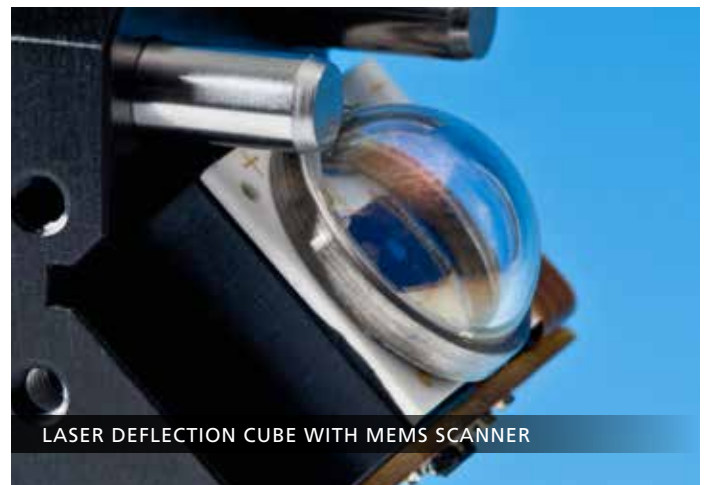
ZEISS has developed a light sheet microscope that permits the three-dimensional observation of biological samples over very long periods of time. The MEMS scanner developed by the Fraunhofer Institute for Photonic Microsystems IPMS is used in this microscope.

The light sheet fluorescence microscope system Lightsheet Z.1 (Figure above) for the first time gives researchers the opportunity to observe dynamic processes in large living organisms. Compared to former methods of fluorescence microscopy such as confocal microscopy, this system is characterized by a much lower light load on the specimens, opening up whole new possibilities for gentle, long-term examinations of living organisms in 3D. Light sheet fluorescence microscopy (LSFM) allows only the relevant volume and not the entire specimen to be illuminated for a section of the fluorescence-marked tissue by a very thin, expanded laser beam, the so-called light sheet. This means that the fluorescent dye is only locally excited to emit light. A projection lens that points vertically on the light sheet with a downstream camera efficiently records the emitted light. For the first time, specimens can now be recorded under natural, physiological conditions and the development of entire organisms tracked three-dimensionally for many days.

Fraunhofer IPMS develops MEMS scanner for Lightsheet Z.1

A resonant microscanner developed by the Fraunhofer IPMS is used to perfect the imaging quality and eliminate unwanted artefacts such as shadowing caused by opaque components of the specimen in the light sheet. The pivot scanner (or MEMS scanner) has a reflecting plate with a diameter of 1.2 mm and a mechanical

scanning amplitude that can be dynamically adapted to the desired lens magnification in the range from 0.9 - 6°, and will be operated near its mechanical resonance at 23 kHz. The angle of the light sheet changes relative to the specimen within the illumination plane depending on the position of the reflecting plate, and accordingly the direction of the shadow. Thanks to the high scanning frequency of the MEMS scanner, no additional averaging effort is needed, the camera is integrated automatically through its exposure time.



Compared to conventional resonant galvanometer scanners, the MEMS scanner from the Fraunhofer IPMS convinces through not only its small size but also a much more stable oscillation mode and an absolute freedom from noise. The scanning module and the control electronics are adapted to the requirements of the microscopy system starting from the modular LDC (Laser Deflection Cube) platform of the Fraunhofer IPMS.

INC9: OPPORTUNITIES AND CHALLENGES IN NANOTECHNOLOGY

Within the scope of the International Nanotechnology Conference on Communication and Cooperation INC9, that was initiated by the Fraunhofer Group for Microelectronics, 150 scientists as well as decision-makers from industry and politics from more than 15 countries discussed the opportunities and challenges of nanotechnology in Berlin.

The focus was on an exchange of experience in nanoelectronics and their fields of use. The experts from Europe, Japan and the USA also reported on research cooperations in nanoelectronics and related fields of nanotechnologies. Other topics that came in for intensive discussion included the potential contribution of nanoelectronics to energy-efficient and environment-friendly products as well as the question of nanophotonics as a possible key technology in the field of optical communication. Prof. Dr. Hubert Lakner, executive director of the Fraunhofer IPMS and chairman of the Fraunhofer Group for Microelectronics, was on the steering committee of the INC9 and ranked the standing of nanotechnology as follows: "Nanotechnology supports the entire value-creation chain, from the conceptual design through to the product. It forms the basis for an endless number of new products and applications."



Young scientists presented the results of their research in the field of nanotechnology during a poster session. The jury chose three winners from the regions Europe, Japan and the USA from a total of 63 posters. Prof. Dr. Lakner (on the left) presented Sascha Hermann from the Fraunhofer ENAS with the winner's certificate.

INC10 will be held from May 13 to 16, 2014 in Gaithersburg, Maryland.

UPCOMING EVENTS

SEMICON Europa

Dresden, Germany
Hall 2, Booth 2100

Oct 8 -10, 2013

Microsystems Technology Congress

Aachen, Germany

Oct 14 -16, 2013

Fraunhofer Talent School

Dresden, Germany

Nov 15 -17, 2013

MEDICA

Düsseldorf, Germany
Hall 3, Booth E74

Nov 20 - 23, 2013



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