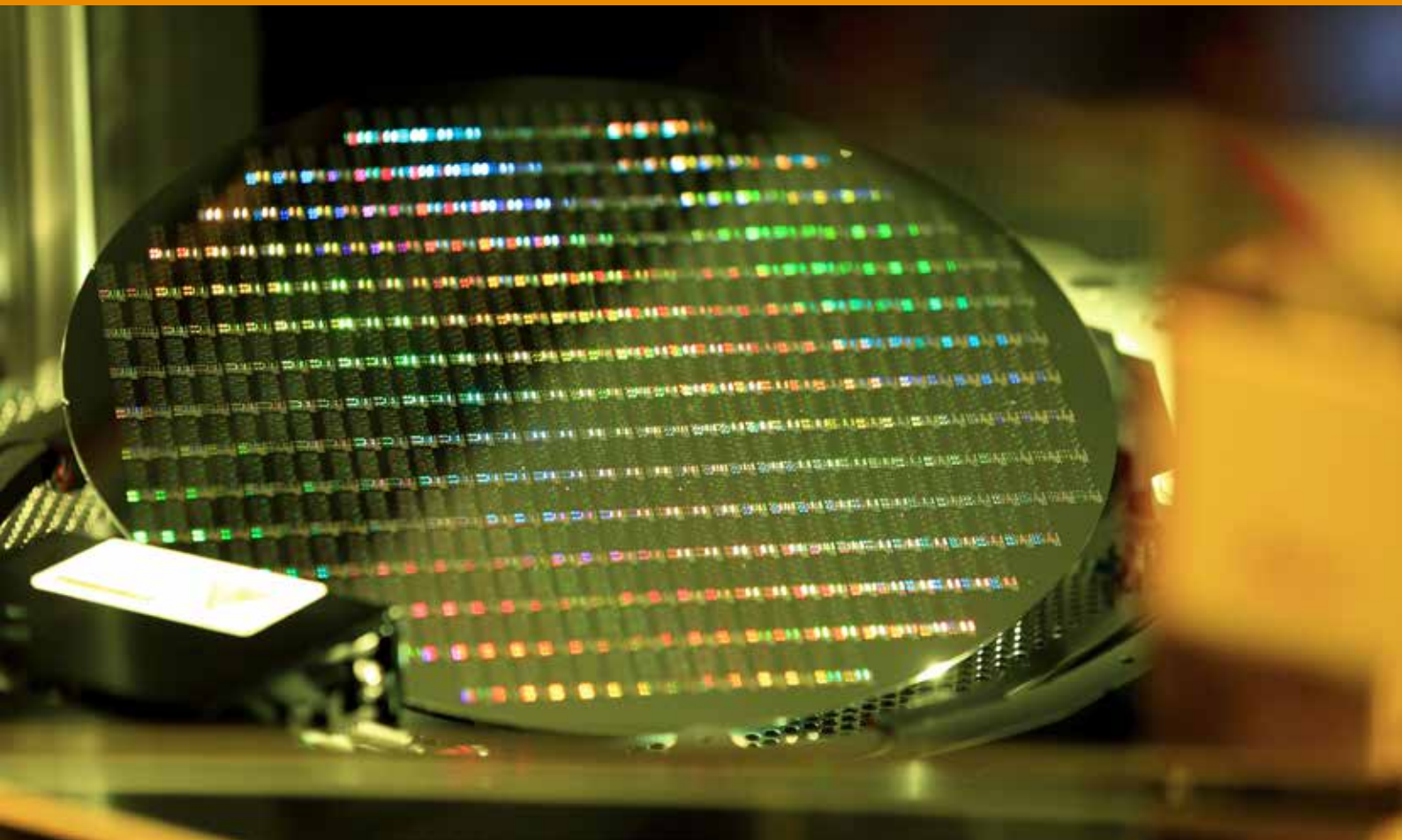


MEMS REPORT

4 / 2014



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Prof. Dr. Hubert Lakner
Director of Institute

Dear Customers, Partners and Friends
of Fraunhofer IPMS,

You have known our Institute as a competent partner for research, development and pilot fabrication of MEMS components, in particular for photonic applications. We have attracted new customers and opened up new fields of application by extending our portfolio and integrating the "Center Nanoelectronic Technologies" (CNT). One key technology here is "Atomic Layer Deposition" (ALD), which allows the use of new materials in microelectronics and thus innovative assemblies. Our CNT business unit is leading the way here, as we will explain in more detail in this edition of the MEMS Report. You are also warmly invited to talk to our experts personally about this and other topics during the SEMICON Europe.

Technical and scientific successes can only be achieved with dedicated employees. We invest in continuous further education and qualification and are an attractive employer, not least for university graduates. We are hereby anxious to increase the share of female scientists in the long-term. This is why the Fraunhofer IPMS helped to organize the "Science Campus" that was held for the first time in Dresden, where women in MINT courses were to be attracted to work at Fraunhofer. You will also find a review of this very successful event in this edition. I wish you an informative read of the latest MEMS Report.

Prof. Dr. Hubert Lakner

QUICK NOTES

Fraunhofer IPMS exhibited for the first time at the "ECOC" in Cannes

The Fraunhofer IPMS exhibited for the first time at the "ECOC 2014" Exhibition in Cannes, France, between 22 and 24 September 2014. The ECOC is Europe's largest and most established optical communication event and a key meeting place for the fiber optic communication technology industry. The Fraunhofer IPMS used this event successfully as a platform to showcase its latest developments, services and solutions in the fields of smart micro-optics and optical wireless communication to a broad audience of expert suppliers and industry leaders.

Fraunhofer IPMS hosted Indian Delegation

The Fraunhofer IPMS supports exchange of experience and knowledge transfer in scientific and competence networks. On September 16, 2014 the Institute had the honor to host a Roadshow on opportunities and innovation in electronics and IT organized by the Embassy of India in Berlin. The high level delegation was led by Mr. Ravi Shankar Prasad, Minister for Communications & Information Technology. The other members of the delegation include senior officials from the Department of Electronics including the State Secretary, representatives from Indian State Governments, representatives from the electronics industry and industry associations as well as representatives from electronic cluster developers.



The event was organized with the help of the microelectronics cluster Silicon Saxony, the Chamber of Commerce and Industry of Dresden, the Saxony Economic Development Corporation, the German Electrical and Electronic Manufacturers' Association as well as the Saxon State Ministry for Economic Affairs, Labor and Transport represented by the State Minister Mr. Sven Morlok.

SEMICON EUROPE CNT SPECIAL: ATOMIC LAYER DEPOSITION (ALD)



Between October 7 - 9, 2014, the Fraunhofer IPMS will be exhibiting at the SEMICON Europe trade fair for the semiconductor industry, which will be held this year for the first time in the French city of Grenoble. The institute will be demonstrating not only developments in the field of MEMS and capacitive micromachined ultrasonic transducers (CMUT) but above all the range of work and services of the business unit "Center Nanoelectronic Technologies" (CNT).

The CNT is involved in the qualification of processes and materials on 200 and 300 mm wafers with close links to the production lines of local industry. Our own industry-compliant clean room environment and the extensive know-how of the scientists make it an ideal link between basic research and direct industrial application. IDMs (Integrated Device Manufacturer) and manufacturers of equipment, consumer materials and chemicals find an optimum development platform for their applications at the CNT.

Apart from nanopatterning by means of electron beam lithography and the development of new chip-wiring technologies with highest reliability, the CNT also deals with the integration of materials with high dielectric constants (high-k materials) in microchips. The latter are used in particular in the embedding and scaling of passive components for buffering energy or the isolation of signals on a microchip level ("system on chip") or package level ("system in package"). The complete value chain is offered, from material and

precursor screening, process development and reliability tests, right through to pilot production. The team has more than ten years of experience in the introduction of new materials in manufacturing, from a laboratory to an industrial scale ("lab-to-fab").

The core competence is hereby atomic layer deposition (ALD), a thin-film deposition method based on alternating, saturated surface reactions. This limits the film growth itself and enables properties such as a precise layer thickness control, excellent homogeneity and conformity as well as lower deposition temperatures compared to conventional methods. ALD is used, for example, in memories and functional capacitors or in transistor technology as a gate oxide where new materials with higher capacities are used.

The high-k team also uses thermal ALD and plasma enhanced ALD, various furnace processes (single wafer and batch), as well as epitaxy and cleaning processes for the process development. One key aspect of the research work is the development of ferroelectric hafnium oxide as a storage medium in NVMs (non volatile memories). Together with GLOBALFOUNDRIES and NaMLab, the ferroelectricity was proven in fully CMOS-compatible HfO_2 dielectrics and the scaling gap in a 28 nm technology node has been closed for the first time since the introduction of the FeFET concept. The implementation on 300 mm wafers for industrial applications is imminent.

ALD LAB DRESDEN – CENTRE OF EXCELLENCE

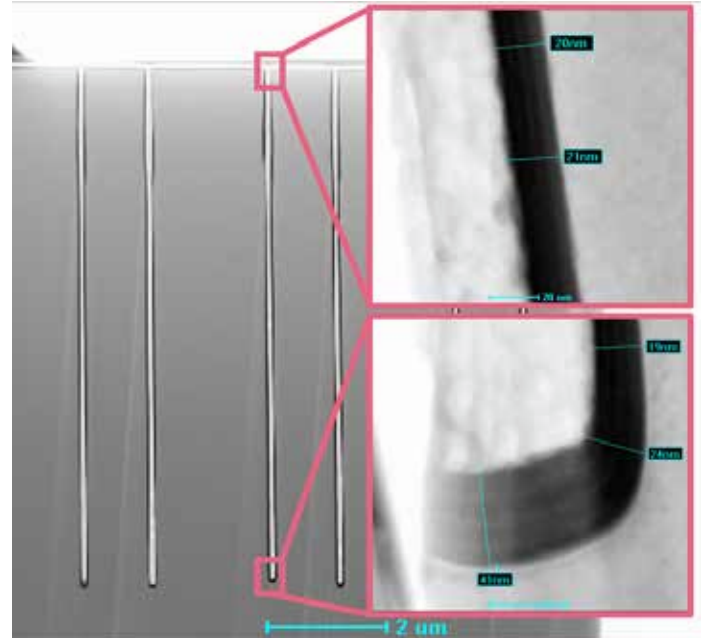
The endurance characteristics are matching the demands of current NVMs utilizing wear leveling already.

A further focus in the field of high-k materials is the development of super capacitors. The CNT together with CEA Leti and three companies in a joint European project carries out research for innovative materials and equipment for the industrialization of 3D integrated capacitors with world-record density. The main fields of application include intelligent miniature sensors for aerospace, medical technology and automation, which require an increasingly higher integrability so as to combine functionality and complexity in a microsystem. One example is the use of integrated capacitors with a very high capacity, small size and maximum reliability in a capsule, whose properties can only be achieved through the optimization of materials using ALD technologies at the CNT. An example is the prototype of a medical pill with integrated temperature sensor and RF transceiver (see picture below).



On the one hand these cooperations are exemplary for the opportunity given to partners of optimizing materials, processes and concepts before integrating these into production at no risk and without any interruption of their own production lines. On the other hand, the CNT also offers smaller companies access to ALD technologies and their applications since this avoids the huge initial investments and allows direct access to the comprehensive know-how and existing systems.

(S)TEM image of a highly compliant high-k oxide layer through ALD for MIM capacitor applications in aspect ratio structures (> 50: 1):

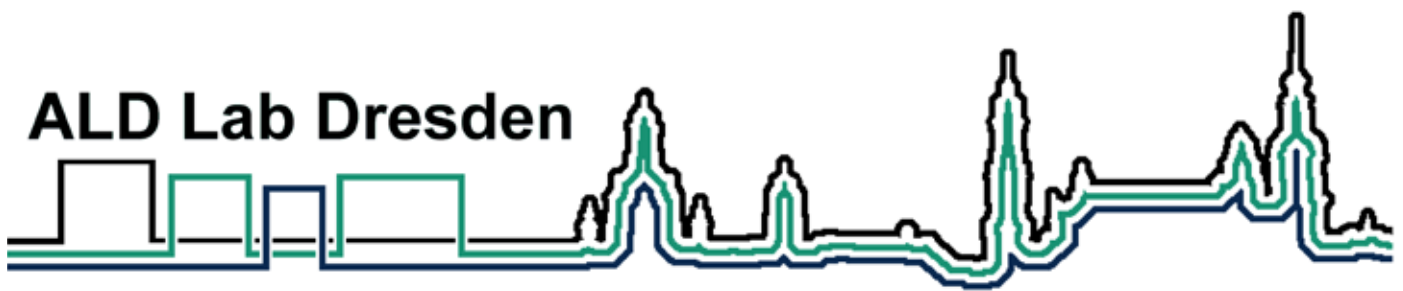


The Center Nanoelectronic Technologies is a co-founder of the Saxon competence center for atomic layer deposition – the ALD Lab Dresden – a coalition of eight institutes from Dresden, Cottbus and Chemnitz for the research, development and production of industry-related ALD applications. The ALD Lab offers not only extensive expertise and a number of technologies, but also a unique range of services for substrate sizes up to 300 mm. Numerous atomic layer deposition processes for isolating and conductive materials and combinations are available for substrates of silicon, compound semiconductors, glass, ceramic materials, metals, polymers as well as moisture-sensitive structures and components. Further fields of use for ALD include diffusion barriers for organic electronics, energy storage, industrial coatings for wear and corrosion protection, spintronic devices or micromechanical systems (MEMS/MOEMS).

ALD Equipment at the CNT

- A412 large batch furnace – ASM (ALD, CVD)
- Polygon 8300 w. Pulsar 3000 – ASM (Single Wafer ALD)
- Eureka 3000 – Jusung (Advanced High-k ALD)
- ALD 300 – FHR (Single Wafer ALD)

ALD-WORKSHOP AT SEMICON EUROPE 2014



The current challenges facing ALD technology lie in the deposition of dielectrics that are only a few atomic layers thick and metal layers in high-k/metal-gate structures. The advantage of the precise control over the layer thickness on large substrate sizes offered by ALD becomes very clear here. Progress in atomic layer deposition is very closely connected to the systems used. Apart from the chemical "design" of the ALD precursors, the successful implementation of ALD processes depends on optimum conditions for gas supply, the process chamber and the substrates.

In order to present the competences and discuss new developments, ALD Lab is organizing a yearly workshop at the SEMICON Europe to bring together system manufacturers, producers of consumables and ALD users. The SEMICON is the biggest European trade fair for semiconductor products, materials and services and is held alternately in Grenoble and Dresden. "The SEMICON Europe is the ideal platform for our workshop and we are looking forward to a direct exchange, interesting talks by international guests and partners as well as new stimuli for the future development of the ALD technology," says Dr. Jonas Sundqvist, co-organizer and team leader of the high-k team at CNT.

The event is open to anyone who is interested and can be accessed with no additional ticket. The program can be found on the right.

Contact ALD Lab Dresden

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E-Mail: jonas.sundqvist@cnt.fraunhofer.de

ALD Workshop: www.semiconeuropa.org/node/2171
SEMICON Booth Number: 1473

ALD Lab Dresden Symposium at SEMICON Europe

Date: October 7, 2014, 9:00 to 13:00

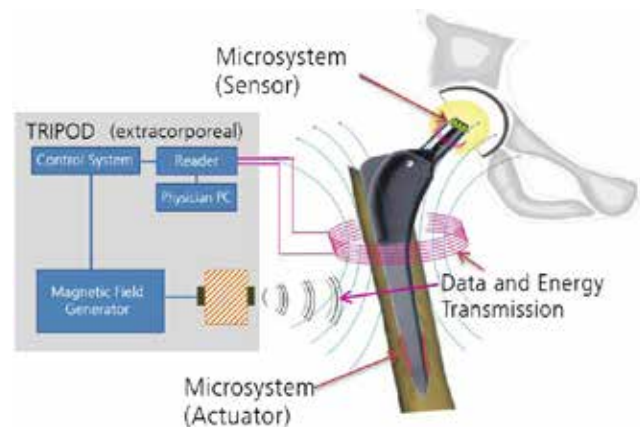
Location: Le Bans, ALPEXPO

- 09:00 **Fundamental insight into ALD processing by in-situ observation**
Prof. Johan W. Bartha, Institute of Semiconductors and Microsystems, TU Dresden
- 09:30 **Development of innovative ALD materials and tools for high density 3D integrated capacitors with CEA/Leti, Ipdia, Picosun and Sentech**
Dr. Malte Czernohorsky, Fraunhofer IPMS-CNT
- 10:00 **Recent developments in heteroleptic chemistries for next generation thin films PEALD/ALD**
Jean Marc Girard & Nicolas Blasco, Air Liquide Electronics
- 10:30 **High permittivity dielectrics for CMOS FDSOI gate first technologies**
Mickael Gros-Jean, ST Microelectronics
- 11:00 **ALD deposited ferroelectric HfO₂**
Uwe Schröder, NaMLab gGmbH
- 11:30 **ALD of metals and metal oxides for advanced interconnect and sensor technology: in-situ investigations for the ALD of copper**
Prof. Stefan E. Schulz, Fraunhofer ENASITU Chemnitz
- 12:00 **Real Time True Surface Monitoring for ALD Processes**
Dr. Hassan Gargouri, Sentech
- 12:30 **Conversation & Networking**

THERANOSTIC IMPLANTS – DEVELOPMENT OF KEY TECHNOLOGIES FOR MEDICINE THAT ARE RELEVANT FOR APPROVAL

Theranostic implants are complex, multifunctional medical products that can be implanted and combine diagnosis and therapy in one medical-technical system. The recording of specific vital parameters forms the diagnostic basis for the relevant therapeutic measures to be initiated, the efficacy of which is optimized in a closed control loop. On account of their numerous possible uses, the constantly growing demands on the quality of highly-specialized medical care as well as demographic developments, the significance of theranostic implants is greatly increasing at present. They have therefore achieved a relevance for the whole of society that will lead to a major leap in innovations in medical technology within the context of future technological possibilities.

This kind of major leap in innovations is largely the result of the interaction of several technologies at a high level. This is why the key project "THERANOS" was launched by the Fraunhofer Gesellschaft on July 1, 2014 that is aimed at bundling the technological possibilities to develop theranostic platforms. Alongside the Fraunhofer IPMS, a total of 12 further Fraunhofer Institutes will be contributing their know-how and expertise. The goal is to assume a leading position in the key technologies that are important for theranostic implants. Within the scope of this key project, three demonstrators with a high relevance for the market are to be set up and tested as examples. One of these – the skeletal demonstrator – is being



realized by the researchers at Fraunhofer IPMS. In this context a "smart hip joint prosthesis" (see picture above) is being developed that detects a possible loosening of hip joint implants and counteracts this both through suitable actuators as well as through the selective stimulus of bone growth. Furthermore, a cardio-vascular and a neuro-muscular demonstrator are also being developed. This means that almost the entire field of currently relevant theranostic implants can be covered. The technology platform that will be created by this offers the preconditions needed to develop and produce modular medical technology components, systems and implants quickly in future.

REVIEW: FRAUNHOFER SCIENCE CAMPUS 2014 IN DRESDEN

The Fraunhofer "Science Campus" was held in Dresden between August 18 to 21, 2014 and was attended by 45 female students studying MINT – mathematics, information sciences, natural sciences and technology. For the first time the Fraunhofer IPMS was also involved in this event.



The goal of this four-day event was to give women in MINT courses a deeper insight into our research work and to capture their imagination for scientific work at the Fraunhofer IPMS. On one of the specialist days the participants could take a glance behind the scenes at our institute and could experience our work live. The participants were given an idea of a scientist's daily work at first hand, were told how solutions can be found for complex problems or how the careers of the presenting female researchers had developed. They were also given exclusive insights into the clean room and the laboratories of the Fraunhofer IPMS.

In various seminars, workshops and lectures, the students were also able to strengthen their professional competences and learn more about how they can use and expand these in application-oriented research.

The science campus is an initiative of the Fraunhofer Gesellschaft. Apart from the Fraunhofer IPMS, the Fraunhofer institutes IVI, IWS and IWU as well as the TU Dresden were also involved.

PROJECT AD-WISE: ON-LINE MONITORING SYSTEM FOR BIOGAS PLANTS

Biogas generated from organic waste is a valuable renewable energy source. It is generated by a biological process where the organic matter is degraded to form biogas and a digestate by means of anaerobic digestion. One of the main research topics within this matter is the development of advanced methods for the optimization and control of biogas plants. Typically, the parameters controlled on-line are the methane concentration in biogas as well as the temperature and pH value of the digestate. However, this information does not suffice to control the process, since these parameters do not predict but merely diagnose a process malfunction. Among all proposed parameters, the most reliable one is the volatile fatty acids profile (VFAP), because it allows checking not only the state of the process but also predicting and avoiding an acidification of the fermenting substrate.

Within the project "AD-WISE" researchers worked on the development of an on-line system for biogas plants to optimize the anaerobic digestion process and maximize biogas production while maintaining process stability. Fraunhofer IPMS developed an optical demonstrator system to measure the VFAP directly in the fermenting substrate. With this information on VFAP, plant operators can now optimize the feeding of the plant, increase biogas production and avoid process stops.



The project consortium consists of five partners – next to Fraunhofer IPMS, the technological center AINIA (Spain), the milking cow farm San Ramón (Spain), the National Microelectronics Research Centre (Ireland) and the company INTERSPECTRUM (Estonia) are involved. "AD-WISE" has received funding from the European Union's Seventh Framework Programme (FP7/2007-2013) under Grant Agreement N.315115.

UPCOMING EVENTS

VISION

Stuttgart, Germany Nov 4 - 6, 2014
Exhibition Center Stuttgart, Booth 1-H 73

Electronica

Munich, Germany Nov 11 - 14, 2014
Exhibition Center Munich, Booth A4-113

MEDICA

Düsseldorf, Germany Nov 12 - 15, 2014
Exhibition Center Düsseldorf, Booth 3-E74

BiOS Expo

San Francisco, USA Feb 7 - 8, 2015
Moscone Center, South Hall, Booth 8707

SPIE Photonics West

San Francisco, USA Feb 10 - 12, 2015
Moscone Center, North Hall, Booth 4409

www.ipms.fraunhofer.de/en/events.html

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