Press release

**Starting signal for the next generation of nanosystem technology**

**The aim is clearly defined: In the project “FunALD“ a new class of ultra-thin functional materials, on the basis of ALD-technology, should be developed. The top-class partner consortium thereby enables the micro and nano sensors to open up a wide, sustainable field of development for a variety of innovative and intelligent sensors.**

In the automotive industry they detect diesel and gasoline exhaust in the outside air and prevent the vehicle interior from penetration of these harmful substances. In the food production they monitor the ammonia concentration in cooling systems and in factory halls they control for example the leakage of methane from the mains system: air quality sensors as well as sensors in measuring systems capture toxic and explosive gases and warn of the leakage of dangerous harmful substances.

But for many applications sensors of today exhibit a comparatively low sensitivity and a high cross-sensitivity at simultaneous high power consumption and high costs. Within the framework of the leading market competition “NeueWerkstoffe NRW“ of the government of North Rhine-Westphalia the project “functional ultra-thin materials by atomic layer disposition for the next generation of nanosystem technology” (short: “FunALD”) now started under the leadership of Fraunhofer-Institute for Microelectronic Circuits and Systems IMS. During the three year project duration a new class of ultra-thin functional materials on the basis of ALD-technology for mechanical sensors and gas sensors should be developed. The top-class partner consortium consists besides of Fraunhofer IMS of the Institute for Energy and Environmental Technology (IUTA), the Ruhr-University Bochum (RUB) as well as the Heinrich Heine University Düsseldorf and the ExTox Gasmess Systeme GmbH. As associated partners the automotive supplier Paragon AG and Aixtron SE, a leading manufacturer of separation systems for the semiconductor industry, contribute additionally. The project is financed by the European Regional Development Fund (EFRE) and supervised by promoter Jülich.

**Key technology of the 21st century**

In the modern microsystem technology CMOS-wafer serve as “intelligent” substrates that are equipped with analog and digital control, read-out or interface circuits. Through post-integration layers, structures and components can be directly integrated onto the CMOS, if very small systems are requested or small signals need to be read out on ways as short as possible. This is how compact, clever single-chip-microsystems occur, that in times of industry 4.0 and the internet of things (IoT) are diversely applicable. Therefore the microsystem technology is a key technology of the 21st century. Products with microsystem technology components capture more and more fields of application of everyday life and in their potentials regarding functionality and economic efficiency it has become impossible to imagine everyday life without them. New application fields are currently intensified developed in nanometer range. Up to now researcher at Fraunhofer IMS developed, within the framework of nano and microsystem technology, for example metallic electrodes for cell-contacting and signal deduction of nerve cells with a novel templat-procedure that uses well-defined methods of CMOS-procedure technology. Established nano technologies in contrast use nanoparticles or nanowires, which are processed at high temperatures separately from the substrate. After that, these particles are suspended in liquids and applied to the electrodes – the electrodes are arranged on the CMOS-surface. But the established nano-technologies only provide disordered structures; furthermore there are problems in reproducibility in the production.

 **New ALD-Procedure convinces threefold**
“FunALD“ therefore moves an essential step further: the nano-electrodes are not manufactured through the application of nanoparticles, but on the basis of the ALD-procedure (Atomic Layer Deposition). In doing so, ultrathin single and multiple-layers with a layer thickness of less than 50 nanometers are separated atomic layer by atomic layer. In the project, functional ALD-layer stacks are developed, which can be integrated in an intelligent circuit with an especially easy post-CMOS-procedure and thereby generate self-supporting 3D-components on CMOS-circuits. With only three additional lithographic masks, complex sensor or actuator-structures can already be realized. In the future, these ALD-materials allow a very wide application field, so that e.g. ultrasensitive self-supporting nanowires of a metal oxide can be used for gas or bio sensors. The self-supporting 3D-micro or nanostructures are produced through highly compliant, ultrathin ALD-layers with the help of an easy sacrifice technology. Thereby on a CMOS-substrate the sacrificial layer – a kind of protective layer and spacer for the underlying material – is removed. The out of it resulting amorphous silicon is especially good structurable: this is the great advantage of this new process!

In the production, the new ALD-layer is separated in the minute wholes of the substrate, the self-supporting nanowires are applied onto the metal-oxide-semiconductor-circuits, and the desired gas sensors result. The new ALD-process convinces immediately in a threefold way: Firstly, due to the huge material diversity a variety of novel sensors or actuatoric components on the CMOS-surfaces can be realized. Secondly the procedure is unproblematic compatible with the already existing instrumental possibilities of a typical CMOS or microsystem-clean room. Beyond that, even costs can be significantly saved, due to the extremely simplified manufacturing-process. To test the new material classes before entering the industrial utilization sufficiently, the project wants to provide the development of two demonstrators. The first demonstrator is a self-supporting metal-oxide-structure that serves in a gas-sensor-application as a conductometric sensor element. The second demonstrator that is going to be developed in the project afterwards, consists of self-supporting metallic ALD-membranes that are used for a mechanical resonator.
“The in the project “FunALD” examined self-supporting ALD-nanostructures promise a high sensitivity and a short response time of the new gas-sensors. Because of the possibility to directly integrate them onto the CMOS-circuit, a new generation of intelligent, cost-effective sensors can be realized. Due to the regional cooperation with universities, research facilities and companies a strong consortium has developed that effectively brings forward the material development”, summarizes Dr. Andreas Goehlich, project leader and head of department at Fraunhofer IMS, the advantages of “FunALD”. In the project, the Duisburger research institute is responsible for the microsystem technology and the provision of the necessary hardware.

The also in Duisburg located IUTA plays part in the project because of its competence in the field of reference analysis in the trace-concentration-sector and application-oriented testing of gas and particle sensors, while the Heinrich-Heine-University Düsseldorf researches the basics of gas sensors in material analysis and surface analysis, based on their expertise.

**Winner of the EFRE-regional competition**
During the project term, the Ruhr-University Bochum stays in constant contact with the Fraunhofer IMS, because they provide the raw materials by the development of the precursor.

“With our precursor-research we lay the foundation for all ALD-separations in the work group “chemistry of inorganic materials“ at the Ruhr-University Bochum. Our year of experience in the development of new organometallic complexes helps us to manufacture purposive and highly specialized precursors for the application in ALD-procedures in cooperation with our partners of the project”, says Prof. Dr. Anjana Devi of the Ruhr-University Bochum. “At Fraunhofer IMS our precursors for the separation of three-dimensional test structures are used, which are then tested as industrial gas-sensors. It is great to be part of the chain from precursor to the final sensor.“ “Linked sensors and detectors are one of the basic prerequisite for new innovative IT-based analyses of the processes and controlling concepts as well as customized services, which we develop together with our FuE-partners. The new generation of miniaturized sensors enables for example an online trace analysis of gaseous substances in the pph-area and is the basis of applications in the field of gas detectors or detectors of filter breakthroughs as a signal generator for needs-based filter change”, says Dipl. Chemist Hartmut Finger, project leader in the field air pollution control and filtration at IUTA. “With “FunALD” IUTA is able to expand their competences beyond state of the art in the field gas and aerosol measuring technology, an important momentum to support the in the IUTA-network engaged companies with new impulses for innovative applications.”

The specialist for gas detectors, the ExTox Gasmess-Systeme GmbH from Unna, applies these sensors in devices. After this phase the new sensors are tested in the field test: The automobile manufacturer Paragon AG checks the practical feasibility of air quality sensors directly in the vehicle.

As manufacturer of MOCVD equipment, the AIXTRONSE from Herzogenrath supervises the equipment during the project. Prof. Dr. Heuken from AIXTRON clearly sees the potential of the new classes of ultrathin materials and explains the motivation for the participation in “FunALD”: “New materials and innovative separation methods in the microelectronic and sensor technology are gaining more and more importance. For us as equipment manufacturer the understanding of these topics gains more and more importance, so that we can sell our machines on the global market. The participation in projects like “FunALD” makes an important contribution and strengthens our market position.”

That the project is seen as a basis for the establishment of a new generation of efficient, compact and intelligent sensor technology is verified by winning the EFRE-regional competition “New materials”. Due to the later application of ALD-materials for intelligent micro and nano sensors a variety of new applications is possible. This is why for example new topics can be anchored at institutes and universities. Because of the application-driven predevelopment and provision of all relevant materials it is possible to immediately start the industrial development subsequent to the project. Miniaturized, clever sensors as a basis of future nano and microsystem technology therefore do not only strengthen the industry and science, but also the technology base NRW.

**Fraunhofer IMS**

Since 30 years scientists at Fraunhofer IMS in Duisburg deal with the development of microelectronic circuits, electronic systems, microsystems and sensors. Because of its comprehensive know-how, the access to technology and the high-quality development work the Institute is a worldwide recognized partner for the industry. In eight business units Fraunhofer IMS is dedicated to applied research, advance development for products and their applications. Stable, efficient and marketable technologies and procedures that are used in extremely many branches take center stage in contract work.

[*www.ims.fraunhofer.de*](http://www.ims.fraunhofer.de)





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Dieses Feld, sowie die Tabelle auf der letzten Seite nicht löschen!