ims chips IMS Newsletter 1/21

June 2021

DEUTSCHER ZUKUNFTSPREIS
Preis des Bundespräsidenten
für Technik und Innovation

Deutscher Zukunftspreis 2020

The project "EUV lithography - new light for the digital age" is awarded Deutscher Zukunftspreis 2020. A key element for the production of the EUV optics are highly accurate "Computer Generated Holograms", which are developed and produced in a unique technology at Institut für Mikroelektronik Stuttgart.

Deutscher Zukunftspreis page 2

Microelectronics in AI – neuromorphic hardware

In this joint project funded by the state of Baden-Württemberg, the requirements for adaptive as well as secure and energy-efficient AI chips are being developed. These are now considered central building blocks for an increasing amount of applications in the Industry 4.0 and Internet of Things field.

NeMoH page 3

MOCVD 4.2 – Metal Organic Chemical Vapour Deposition technology

The MOCVD 4.2 project is a joint publicly-funded project to increase the production capability of the MOCVD (Metal Organic Chemical Vapour Deposition) technology for applications in power electronics, in photo voltaic as well as in nano photonics and sensor technology. As part of the project GaN-on-Si, wafers provided by the project partners will be characterized at IMS CHIPS.

GaN/MOCVD 4.2 page 3

MULTI-3D – focus modulating multimodal 3D sensor system

IMS CHIPS has worked on the investigation of a CMOS image sensor, which can acquire a very high dynamic range with a linear characteristic and a large signal-to-noise ratio within the "MULTI-3D" project. The project consortium included IMS CHIPS, two industrial partners, Fraunhofer IOF as well as Friedrich Schiller University Jena.

Multi 3D page 4

Deutscher Zukunftspreis 2020

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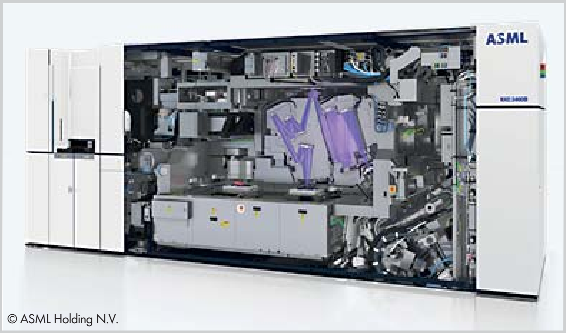

EUV stepper system with sketched beam path of the EUV light

The German Federal President, Frank-Walter Steinmeier awarded this year´s Deutschen Zukunftspreis 2020 on November 25th, 2020, for the project "EUV lithography - new light for the digital age". The team surrounding Carl Zeiss SMT is making a significant contribution to the development of a technology that can be used to manufacture microelectronic components with extremely fine structures. By using extreme ultraviolet light (EUV), this optical lithography method established in chip manufacturing has been taken to a new level. Unlike traditional optical lithography, Zeiss' EUV imaging system is not based on lenses but on mirrors. These high-precision mirrors developed in Oberkochen can have a diameter of up to one meter and require curvature accuracies in the nanometer range. In order to measure these mirrors, individually manufactured high-precision "Computer Generated Holograms" (CGH) are required, which are produced at Institut für Mikroelektronik Stuttgart (IMS CHIPS) using a unique technology. With state-of-the-art equipment and dedicated experts, it is possible at the IMS to provide even very large quartz substrates with structures that are able to measure even a thousandth of the thickness of a human hair. Probably unique to the world, a pilot line with machines specially designed for this purpose are available at IMS CHIPS. In addition to the installation and commissioning of the machinery in IMS's own clean room, the challenge in recent years has been in particular to optimize and coordinate the individual production steps. The reciprocal coordination of the CGH design with the manufacturing processes, ambitious schedules and numerous interfaces have led to an unprecedentedly intensive collaboration between the IMS and Zeiss. As a result of this long-standing partnership, Zeiss is now able to measure mirrors of a wide variety of geometries with the required precision using high-precision CGHs.

IMS clean room

Compared to the optical lithography previously established in chip fabrication, EUV lithography can produce much smaller structures, along the range of a few nanometers (millionths of a millimeter). To achieve this, the prize winners and their partners had to drastically push the limits of what was previously thought technically feasible.

The result is an optical system consisting of mirrors (Zeiss SMT) with a special coating (Fraunhofer Institute for Applied Optics and Precision Engineering IOF) and a powerful EUV radiation source (Trumpf Lasersystems for Semiconductor Manufacturing). This way, microchips can be produced that are particularly powerful, energy-efficient and cost-effective. The microchips of this new generation are already being used by major manufacturers of smartphones and semiconductor products.

The German Federal President honors outstanding research and development projects with Deutscher Forschungspreis. The jury's decision is based on the degree of scientific and technical innovation as well as the potential to translate this achievement into sustainable jobs.

The German Federal President Frank-Walter Steinmeier and the team including Dr. M. Kösters, Dr. P. Kürz und Dr. S. Yulin

The IMS will continue its successful collaboration with Zeiss in the field of CGHs for EUV lithography in the future.

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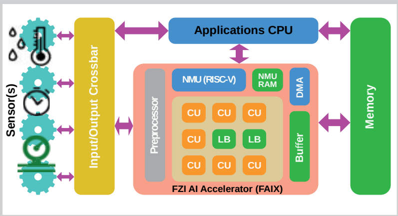
Microelectronics in AI – neuromorphic hardware

Lean AI solutions directly at the sensor



Schematic illustration of the AI concept NeMoH

The Internet of Things is hardly conceivable without the multitude of embedded systems that measure, control and regulate. Real-time capability in automated applications now goes without saying. Huge amounts of data, created by a wide variety of applications, are processed using machine learning approaches to derive the system state or generate important parameters. Big Data requires powerful systems, often entire computing clusters. Whereas applications in the field of Industry 4.0 and the Internet of Things require intelligent data acquisition, signal processing and data reduction on site - at best directly at the sensor.

The project combines AI and sensor technology. IMS CHIPS, FZI and Hahn-Schickard are supported by Staiger GmbH & Co. KG, Pilz GmbH & Co. KG, Balluff GmbH, PSIORI GmbH as well as Robert Bosch GmbH.

Take the solenoid valves from Staiger for example, it shows how a trained neural network can detect operating states and malfunctions with very high accuracy by simply monitoring the switching current of the valve.

Source: Staiger GmbH

The research project aims at developing safe, energy-efficient and practical AI-assisted microelectronics for resource-efficient on-site processing of data.

Neuromorphic hardware describes highly networked and parallel computing units that are modeled on the biological model, the brain, in their interaction. Artificial neural networks (KNN) can be used successfully wherever a problem cannot be described sufficiently mathematically or if there is too much input data with too many variables. Large amounts of data with many influencing factors can be structured by KNN. Typical applications of neural networks are therefore pattern recognition and classification of input data. A trained network is able to make a decision for new and unknown input signals based on previously learned data.

The two-year project is funded by the state of Baden-Württemberg with just under 2 million euros.

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MOCVD 4.2 project

Metal Organic Chemical Vapour Deposition technology

As part of the project GaN-on-Si, wafers provided by the project partners will be characterized at IMS CHIPS. Parallel to this, power HEMTs (High Electron Mobility Transistors) are also developed, produced and characterized.

Fig. 1: Batch process in the furnace

An essential step in the development of power HEMTs is the reproducible production of low-resistance contact resistors in the drain and source regions. Low contact resistances are necessary to guarantee a small drain-source forward resistance (Ron) of the power HEMT. Since production must be designed to be CMOS compatible, Au-based ohmic contacts, which are now most commonly used, cannot be applied. In addition, we do not use epitaxial steps to grow GaN layers locally; instead, an ALE (atomic layer etching) process is used. The optimized process uses batch-compatible furnace annealing (Fig. 1) at low temperatures (450 °C) of Ti/Al-based contact metals at low temperatures (450 °C) in order to produce low-resistance contact resistors that are homogeneous across the wafer.

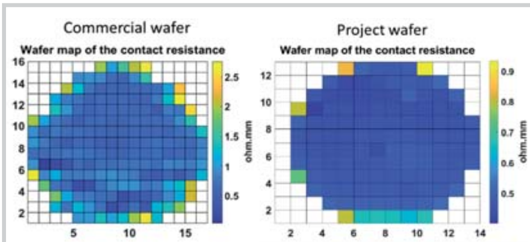

Fig. 2: Homogeneity of contact resistance on a project wafer compared to a commercial wafer.

The CMOS-compatible GaN process developed at IMS CHIPS allows the fabrication of low-resistance contact resistors with high homogeneity (Fig. 2). Comparing commercial wafers and wafers fabricated within the project shows an average contact resistance of 0.6 Ω mm with the comparable homogeneity. Both wafers have the same epitaxial design and are representative of state-of-the-art power wafers. The wafer maps (Fig. 2) illustrate the homogeneous production capacity for power elements at IMS CHIPS.

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High-dynamic linear CMOS image sensor

Manufacture of image sensor with a 640 x 480 pixel VGA resolution and 120 dB

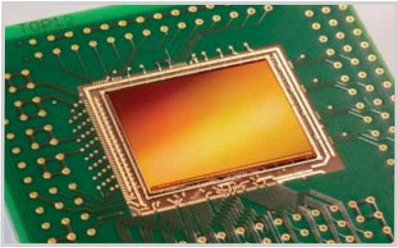

Fig. 1: Linear High Dynamic Range (HDR) MULTI-3D Imager

In industrial image processing, image-based robotic controls and autonomous driving, high dynamic range image sensors are required that enable robust image acquisition and processing. The desired linear high dynamic range of the image sensor with simultaneously high signal-to-noise ratio is achieved by a two-stage conversion process: As a first stage, the photodiode voltage is reset several times asynchronously during a fixed period of 10 ms, for example. Following this, in a second stage the residual value remaining at the end of the integration time is converted from analog to digital.
Following a test sensor with a reduced resolution (128 x 100 pixels), in the recently completed project "MULTI-3D" an image sensor with VGA resolution (640 x 480 pixels) has also been realized successfully in a 0.18 μm technology for CMOS image sensors (see Fig. 1). In addition to the pinned photo diode and other analog circuit elements, each pixel contains a 10 bit counter and requires an area of 34.4 x 34.4 μm^2, resulting in a total die size of 22.9 x 18.0 mm^2.
For the opto-electronic characterization of the image sensors, an evaluation board with serialized differential high speed data transmission was developed.
The "MULTI-3D" project was funded by the German Federal Ministry of Education and Research (BMBF) under the Photonics Research Germany funding program (FKZ 13N14227) and was successfully completed in December 2020.

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News Flash

Future Cluster QSens The future cluster QSens "Quantum Sensors of the Future" from the Stuttgart/Ulm region, in which IMS CHIPS is significantly involved, is one of the winners of the "Clusters4Future" competition. QSens researches innovative quantum sensors that can realize unprecedented sensitivity and spatial resolution.

MikroSystemTechnik Kongress 2021 The next MST Kongress will be held in Ludwigsburg from November 8th thru November 10th, 2021. For further information, please visit https://www.mikrosystemtechnik-kongress.de.

ZIM project Nano-HySiF launched The project entails technologies developed by NanoWired to contact chips with nano structures, which can be electrically connected similar to Velcro, combined with the Chip-Film Patch (CFP) technology from IMS CHIPS. This creates hybrid systems in foils (HySiF).

Research Association
of the Institut für Mikroelektronik Stuttgart e.V.

The non-profit Research Association of the Institut für Mikroelektronik Stuttgart was established in 1983 and supports the contacts between industry and research. It is a contact point for talents from Germany as well as from abroad that will be supported by the IMS with a scholarship. It opens doors to member companies that sponsor them.
An annual member meeting takes place every year. Members receive a discount on trainings and events.
For further information, please refer to www.ims-forschungsverein.de.

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