Institut für Mikroelektronik Stuttgart

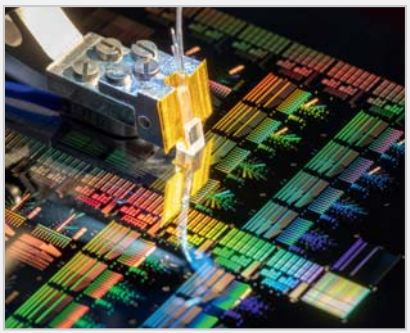
IMS Newsletter I/23

IMS CHIPS develops novel approaches for biomedical technology

IMS CHIPS researches and develops solutions and new approaches for electronic and photonic microsystem applications in the field of biomedical engineering. As part of the SpektroChip project funded by the Vector Foundation, a new type of micro-spectrometer system is being developed for analytical and biomedical applications.

Biomedical projects page 2

Automated optical throughput tester for integrated photonics



To qualifiy waveguides and components in integrated photonics, the throughput of hundreds to thousands of circuits often has to be measured. The automated tester at IMS CHIPS now records 800 to 1000 such throughput spectra per hour with a reproducibility of ±0.25 dB. For this purpose, a fiber optic array is precisely positioned above each grating coupler with a precision of a few hundred nanometers.

Automated tester page 3

Q.ANT and IMS CHIPS establish quantum chip fabrication on

The Stuttgart-based start-up Q.ANT and Institut für Mikroelektronik Stuttgart have signed an agreement for the joint production of quantum chips. Quantum chips are considered to be the central building blocks for quantum processors, which in the future will provide a speed advantage in the future. Additional fields of application range from medical technology, sensor technology, telecommunications, cryptography, logistics and the financial sector.

Quantum chip manufacturing page 3

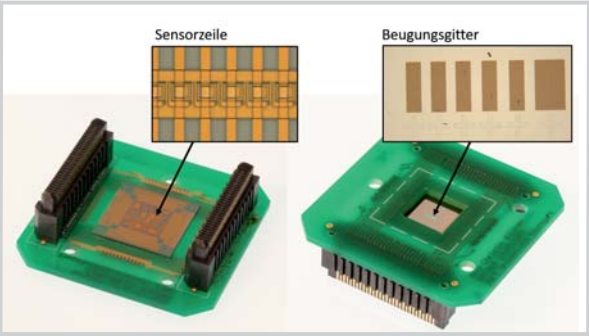
ASIC from a single source

IMS CHIPS offers low-threshold access to your own microchip. Both for research and development and for use in products. A company´s individual ASIC offers several advantages compared to microchips freely available on the market: one is much more independent from the general supply situation and products with ASICs are excellently protected against unwanted replicas.

ASIC from a single source page 4

Microsystems for Biomedical Technology

Innovative system solutions - from integrated circuits via sensors to data processing



The SpektroChip project

Today, many analytical procedures in biomedicine and medical technology rely on highly expensive and inflexible spectroscopy solutions. The miniaturization of such systems (lab-on-a-chip) would enable cost-effective real-time on-site sensing in biomedical research and medical technology.

This motivates the development and demonstration of a new type of micro-spectrometer system for the near-infrared (NIR) range aimed at in SpektroChip.

The origin of the idea behind the project was a collaboration with the Institute of Semiconductor Technology (IHT) at the University of Stuttgart. There, a sensor chip with a germanium-on-silicon (Ge-on-Si) sensor line and a diffraction grating was developed (see figure above). In the project, the chip, which is sensitive in the NIR range, will now be integrated into a highly miniaturized spectrometer system setup for

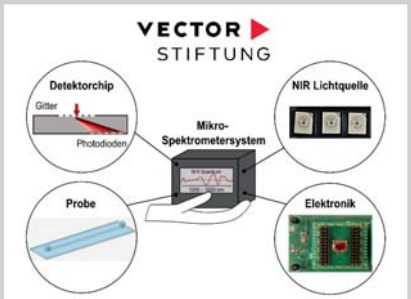


Figure 1: System integration of a miniaturized NIR spectrometer

the quantitative analysis of a biomedical sample as indicated in figure 1. The technology of NIR spectroscopy is to be used as an analytical tool. The project particularly focuses on the realization of a simple, low-cost system that stands out from the high-priced, inflexible solutions currently available on the market and allows for direct automated analysis of a sample. In particular, current sensor applications, such as „on-site" detection, lab-on-a-chip systems and in-line process monitoring are to be addressed.

The optical sensor chip is based on Ge-on-Si photodiodes, which are much more cost-effective than the compound semiconductor detectors (e. g., made of indium gallium arsenide) that dominate the market in the NIR range, since they are compatible with CMOS technology and thus bring much greater miniaturization and scaling potential.

General Future Topic „Biomedical Engineering at the IMS"

Looking back on various research projects it is evident that the promising field of biomedical engineering can benefit enormously from the know-how and possibilities of microelectronics and nano structuring. In this context, microelectronics research can address various requirements of medicine: an increasing need for digitized and smart systems leads to increasing amounts of tasks that can be solved with the help of sensors. Biological activities generate very small electrical signals that need to be measured and evaluated. At the same time, the systems required for this should be as small and least invasive as possible. Both requirements can be well met with highly integrated microchips that can measure, amplify and evaluate signals within a very small space. Here, AI solutions can help to directly evaluate the enormous volumes of data from the sensors used and reduce them to a necessary level. Electronic micro systems with intelligent sensors also enable on-site diagnoses and analyses. To meet these requirements, a high degree of interdisciplinarity is needed: in addition to the development of integrated circuits, an in-depth understanding of suitable materials and sensors that can be used in the biological-medical environment is required. New types of approaches from a combination of optical systems and electronics enables silicon photonics, which makes it possible to equip microchips with enhanced sensory functions up to spectroscopy at chip level. IMS CHIPS researches and develops solutions and new approaches for applications of electronic micro systems in the field

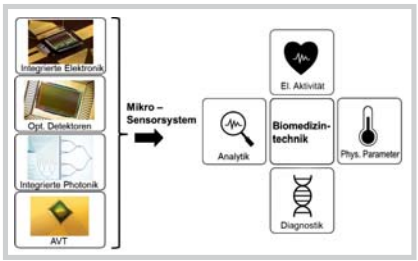


Figure 2: Microsystems for biomedical technology - From components to application-specific sensor system solutions

of biomedical engineering, for example in the projects BWimplant and PanaMEA (electronics for implants to stimulate the body's own insulin production), TENECOR (measurement of brain waves in premature infants), POSITION2 (ASIC for MRI-proof heart catheters for ECG measurement and electroablation). In the past, sensor chips for the blind (retina implant) and for video endoscopes and a „video pill" were also realized. In doing so, IMS CHIPS has the ambition, as indicated in Figure 2, to develop holistic innovative system solutions from individual components via ASICs and sensors, data processing and system control, with which research and product development in biomedical technology can be advanced.

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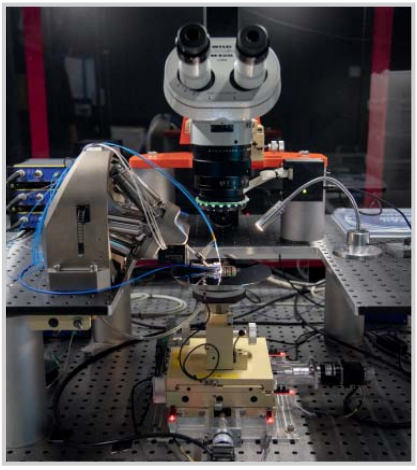
Automated optical throughput tester

800 to 1000 measurements per hour with high reproducibility



A new optical measurement setup for the characterization of integrated optical circuits has been commissioned at IMS. Its main purposes are the final inspection of photonic chips, characterization of new processes in the silicon photonics line, and qualification of the design of new or improved photonic devices. Fast and reliable optical measurement technology is essential for this. Extensive design parameter variations as well as the reliable extraction of various performance quantities often require characterizing hundreds or thousands of test circuits. For this reason, a new partially automated optical prober was developed from a manually operated semiconductor prober equipped with a hexapod and a piezo positioner. A new software framework was implemented, a capacitive distance sensor was integrated, and the optical signal paths were optimized. Above all, it is the high mechanical precision that now enables throughput spectra to be recorded with a reproducibility of ±0.25 dB.

The setup can be used to measure integrated photonic circuits on single chips up to 150 mm wafers in the wavelength range of 1510 - 1610 nm. Grating couplers within an area of about 10 x 10 mm² are automatically addressed one after the other at a speed of 800 to 1000 throughput spectra per hour. Areas of a wafer beyond this can be reached by simply moving the wafer stage, which currently still requires a new manual alignment. A quadruple fiber array is used to couple and decouple the light, of which one fiber is used to inject light into a coupler, and three fibers are used to simultaneously measure output powers.

Currently, the optical measurement setup is being further upgraded so that a real-time adjustment of the polarization as well as a wavelength range of 1450 - 1650 nm will be available in the future. Other upgrades planned for this year include the integration of current and voltage sources to measure active electro-optical components, as well as an automated wafer stage to achieve full automation.

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Q.ANT and IMS CHIPS set up production facility

Chips for quantum processors to be produced in small batches as early as two years from now

Prof. Dr. Joachim Burghartz, Director and Chairman of the Board of and Michael Förtsch, Managing Director of Q.AN

On June 21st, the Stuttgart-based start-up Q.ANT and Institut für Mikroelektronik Stuttgart signed an agreement for the joint production of quantum chips. Chips for quantum processors to be produced in small batches as early as two years from now. As a leading quantum technology company, Q.ANT will be contributing its expertise in quantum computer chip production to this cooperation. In addition, the start-up will be contributing machinery and process technology in an initial investment worth 14 million euros. IMS CHIPS is joining using its existing machine park. Quantum chips are considered to be the central building blocks for quantum processors, which in the future will provide a speed advantage in the future.

In addition to clean room production with the appropriate equipment, IMS CHIPS also introduces experts with experience in industrial-scale manufacturing to the cooperation. In return, the start-up invests in manufacturing capacities and equipment geared to quantum technologies. For the IMS, which is a foundation of the state of Baden-Württemberg, this cooperation advances its research and development activities.

In addition to quantum processors, the chips, which operate on the basis of light, will be used in a wide variety of industries in the future: The fields of application range from medical technology, sensor technology, telecommunications, cryptography, logistics and the financial sector.

Opposed to many other quantum computing solutions, which operate at cryogenic temperatures as low as -273 °C, Q.ANT's photonic chips operate at room temperature. This significantly simplifies an integration into existing computing architectures. For its chips, Q.ANT relies on a specially developed technology platform with the material lithium niobate, which is perfectly suited for the photonic approach to quantum computing due to its good electro-optical properties.

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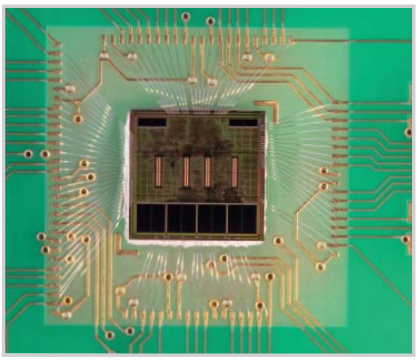
ASIC from a single source

The in-house chip is back in fashion



The „DoRiE" AI chip derived from the state-level project of the same name: two AI accelerators and a RISC-V processor integrated on one chip enable energy-efficient sensor-based AI solutions - without cloud or expensive high-performance computers.

Unlike integrated circuits (ICs) freely available on the market, ASICs are manufactured only for specific applications and, more importantly, only for one particular customer. Although this exclusivity has its price (one-off costs in design and production preparation), it offers invaluable advantages today: once the wafers with ASICs have been manufactured, you are largely independent of supply chains and allocations on the chip market. Another increasingly important advantage is the protection against piracy and plagiarism. Since an ASIC is only available to the client, a plagiarist would have to understand the chip through reverse engineering, recreate the circuit and have it manufactured. Therefore, the threshold to replicate an ASIC is very high. MS CHIPS accompanies customers all the way to series ASIC through a preliminary feasibility check, a jointly created specification, cost-effective sample production via multi-project wafers, comprehensive transparent documentation of the design process up to design release. The production of the ASICs as well as the assembly into the desired IC package is carried out by partners with whom IMS CHIPS closely cooperates. With our own laboratories for quality, lifetime tests and our in-house qualified assembly line, we can meet all desired standards. ASICs from IMS CHIPS can be found in virtually all areas of technology: in industrial control systems, in vehicle construction, in aerospace and in medical technology research. ASICs also play an indispensable role in current innovation topics, such as AI, quantum systems and energy technology.

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News Flash

All2GaN project launched - Gallium nitride chips boost energy efficiency and reduce CO2 emissions. The „ALL2GaN" project (Affordable smart GaN IC solutions for greener applications) will focus on easily integrated energy-saving chips based on gallium nitride (GaN). They have the potential to improve energy efficiency by 30 percent compared to existing semiconductor solutions in a wide range of applications, saving an extrapolated 218 million tons of CO2 worldwide. https://www.all2gan.eu/home.

"REACT-EU" program – Equipment purchased through REACT-EU funding has been put into operation. The Ministry of Economy, Labor and Tourism has funded the acquisition of an electron beam direct writer (e-beam writer) and additional equipment in the clean rooms of Institut für Mikroelektronik Stuttgart (IMS CHIPS) with a total of 8.38 million euros.

„Beams & More" - This title defines the 20th lithography workshop be held at the IMS. The workshop will take place as webinar on November 16th, 2023. For further information and registration, please go to https://beams-and-more.ims-chips.de.

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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