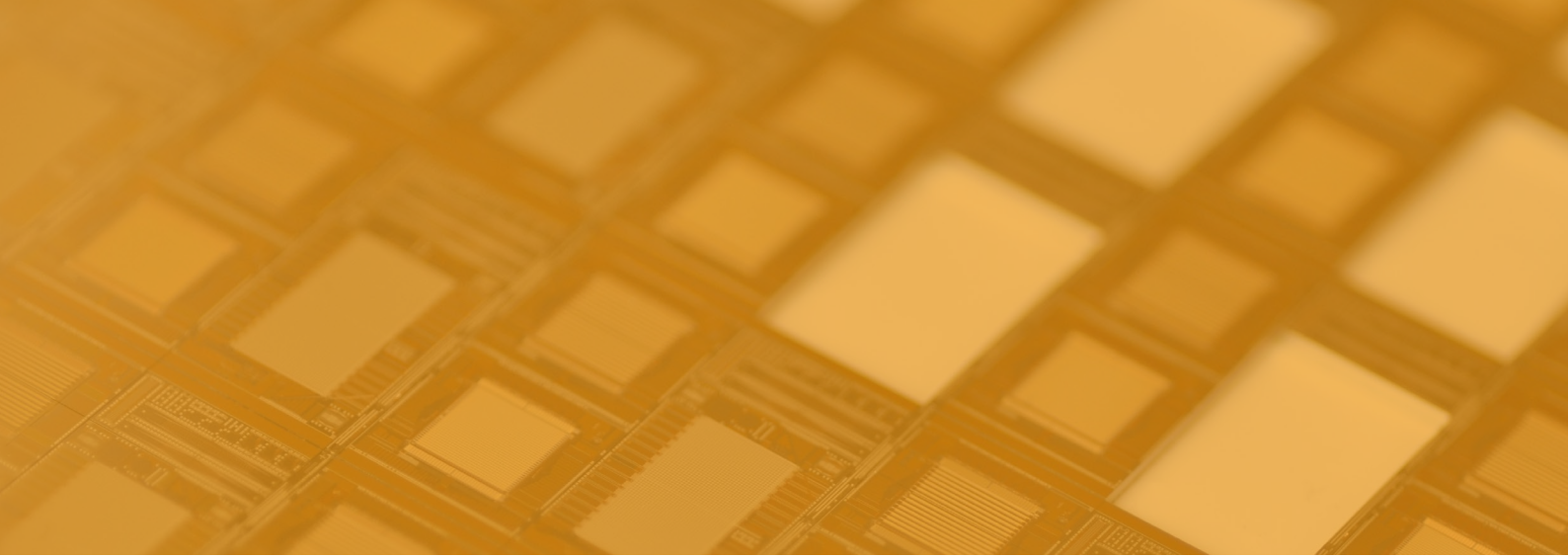
Fraunhofer
IMS

FRAUNHOFER INSTITUTE FOR MICROELECTRONIC CIRCUITS AND SYSTEMS IMS

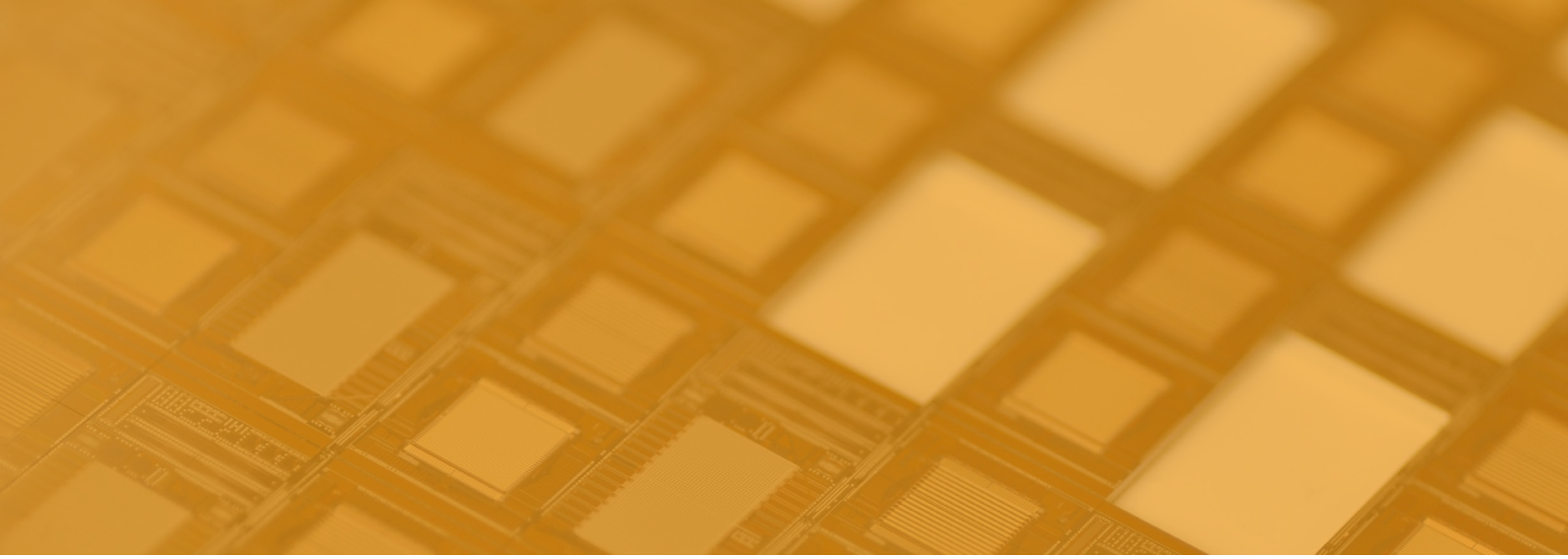
2019
2020
ACTIVITY REPORT



2019
2020
ACTIVITY REPORT

This file contains interactive elements. Click to jump to pages, websites or write an email.

TITLE PAGE:
Uncooled infrared imagers manufactured by Fraunhofer IMS support the early detection of wild fires.



CONTENT

DEAR FRIENDS AND PARTNERS OF FRAUNHOFER IMS, DEAR COLLEAGUES,

We welcome you to our activity report of 2019 and 2020. These times have been turbulent for all of us but by the help of our great colleagues and partners we have continued going forward!
This probably is illustrated best by our work around Embedded AI. Years ago we have quickly embraced the new and emerging topic of AI. Through our strategic advantages of a large partner network, years of experience in microelectronics and our modern infrastructure we have since improved existing sensors and developed completely new systems with the benefits of Embedded AI. To celebrate, we have dedicated one chapter of this report to sharing our advances in the field.

In order to keep our innovative edge we have redefined our institute's structure. We have identified our areas of expertise and the direction we want to grow in our updated core competencies. How and where these will be applied is defined by our new business units. As such we have achieved to align the institute's focus with our mission statement: Developing smart sensors for a safe and sustainable future for all of us.
We now gladly invite you to a tour of our institute and its engagement of the past years through this publication. It is our hope that in the end you will share our enthusiasm - and optimism - for the years that lie ahead.

1 Prof. Dr. Axel Müller-Groeling

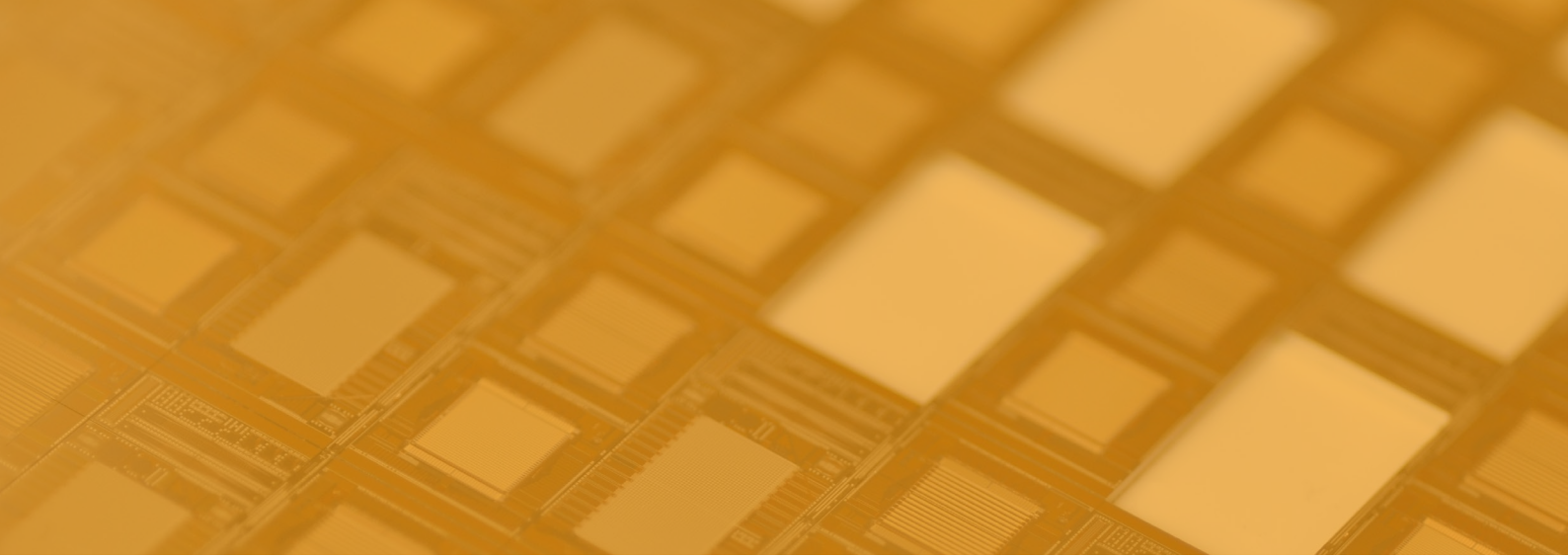
2 Prof. Dr. Anton Grabmaier

THE INSTITUTE

Fraunhofer IMS develops solutions from concept to pilot production

Discover services, organizational structure and key facts

move back up
to content overview

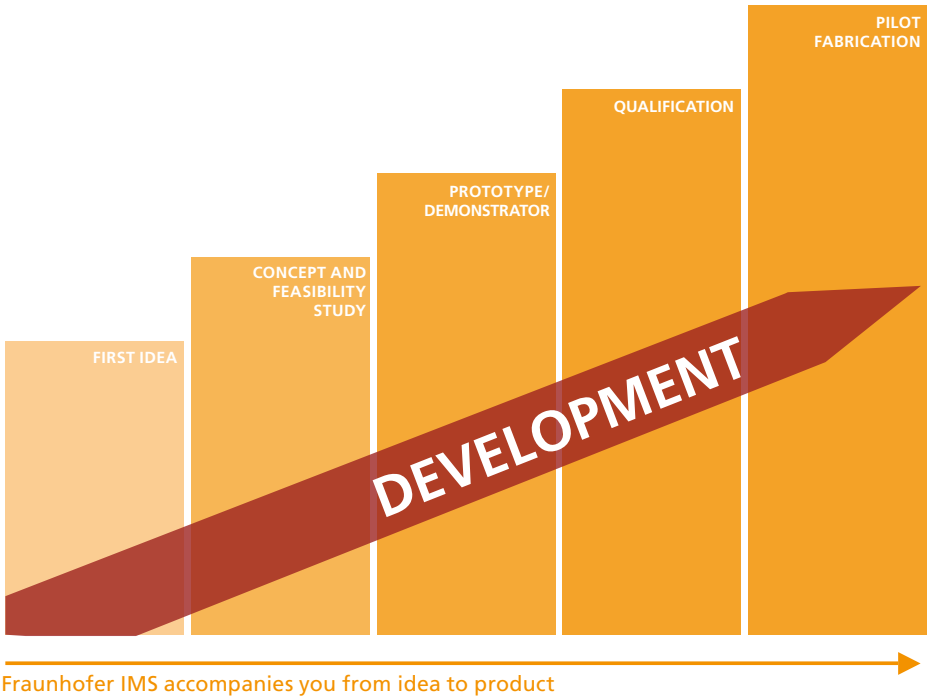


YOUR IDEA — IMPLEMENTED BY FRAUNHOFER IMS

Find your competent research partner for the development and pilot production of innovative microelectronic systems.

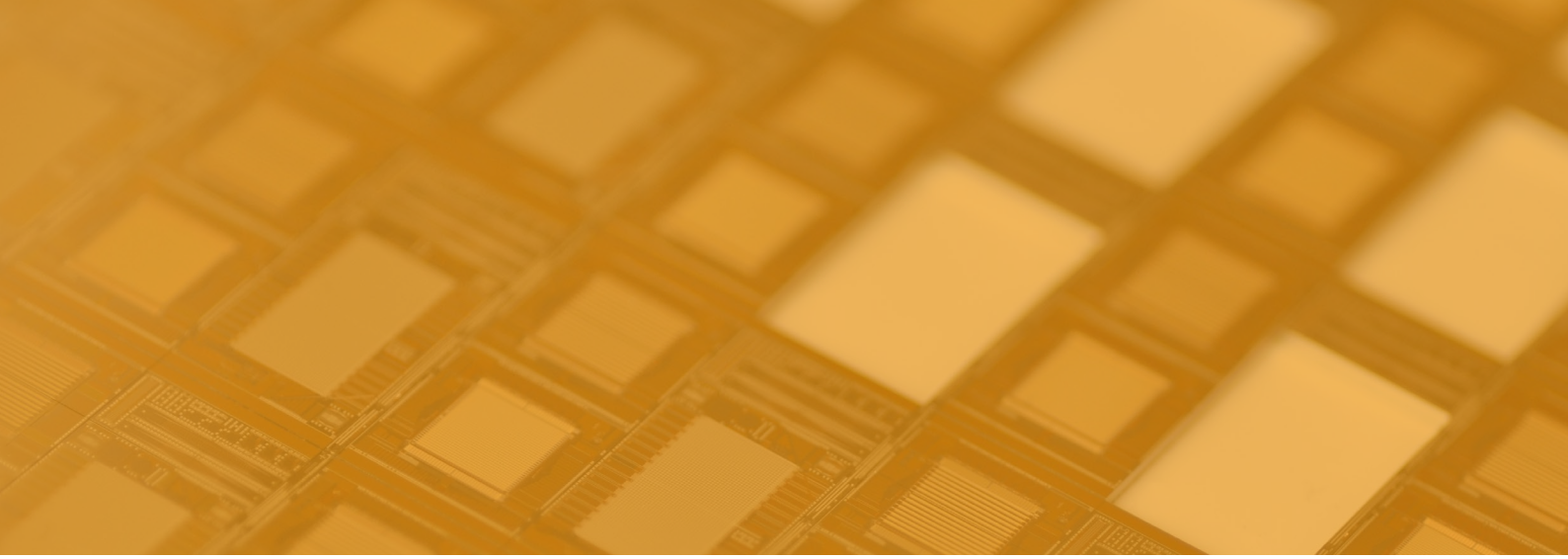
The scientists in our business units and our core competencies focus on offering solutions and developing marketable technologies and processes in the field of microelectronic circuits and systems that can be used in virtually all industries. We accompany your development from the very start until successful finalization, adding unique selling points and competitive advantages to your product along the way.

Get concept and feasibility studies, comprehensive development, prototyping and product qualification through to pilot fabrication, all from one source. Our institute is a globally recognized research and development partner for its extensive know-how, access to technology and outstanding technical infrastructure. As an independent institute, we have been working together with private and public partners, providing a direct benefit to the economy and society for more than 35 years.



Fraunhofer IMS accompanies you from idea to product

Fraunhofer IMS test lab, partner network and experience are established tools to implement incremental improvements to products and services with each developmental step.



COOPERATION AND PARTNERSHIPS

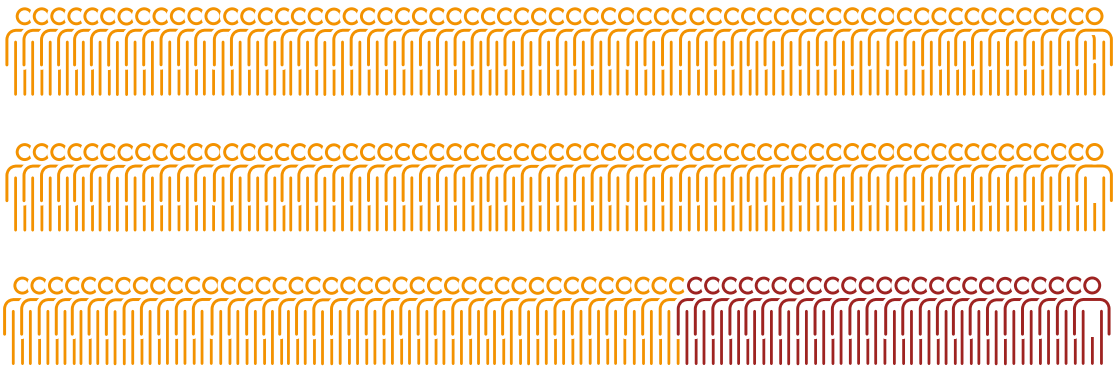
The pandemic has been challenging, also for us. Yet, as the saying goes: "It's in a storm that you find out what your crew is made of". Knowing this, Fraunhofer IMS long ago said: "Thank you, crew and: Ahoy Partners!".

Cooperation in publicly funded projects creates opportunities to develop new products and solutions by combining knowledge, resources and technology from various partners of excellence. Fraunhofer IMS has been cooperating in such publicly funded projects from the very first beginning of the institute in 1985 and has since then developed a well established network of partners from industry and research. Fraunhofer IMS is also part of the Forschungsfabrik Mikroelektronik Deutschland (FMD) - a global innovation driver consisting of eleven Fraunhofer institutes and two Leibniz institutes. Another great example of cooperation is the Fraunhofer-inHaus-Zentrum in Duisburg. Within the ecosystem, the Fraunhofer Gesellschaft pools the potential of the Fraunhofer IMS and many hundreds of business partners to exchange ideas, develop products and test them for real-life usability.

Find new application fields, develop innovative technologies and combine national and international excellence in science and industry.

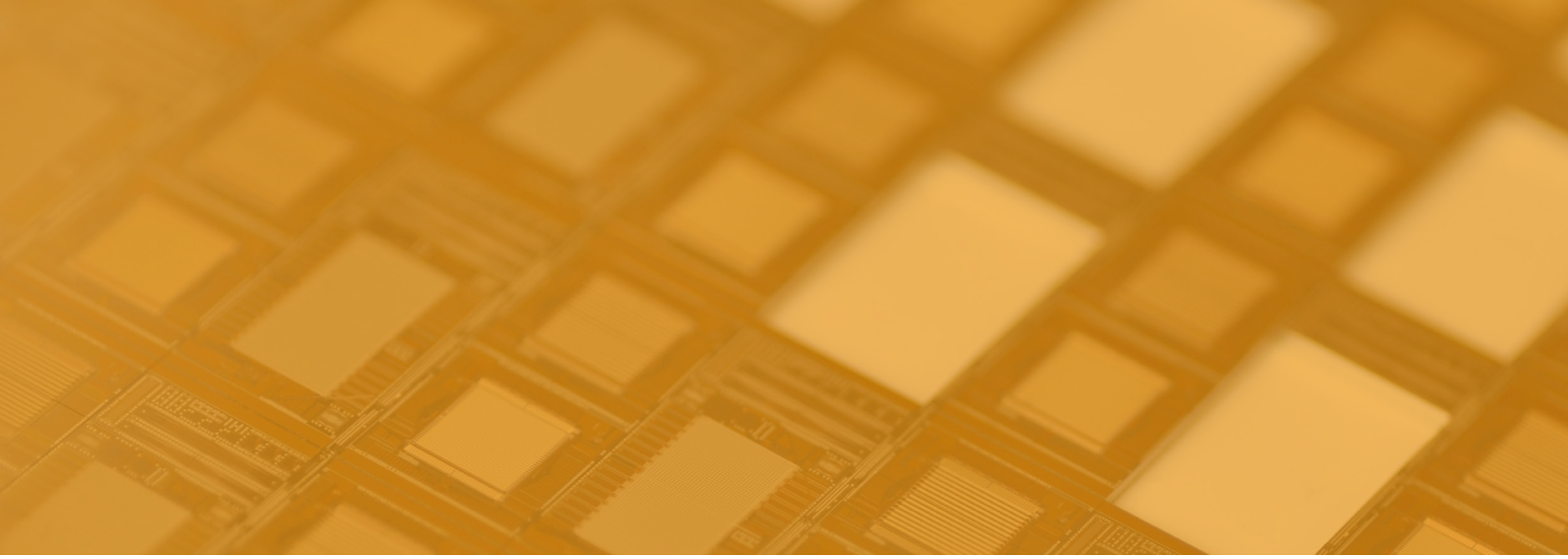
Please click on the icon and discover more information.

STAFF MEMBERS

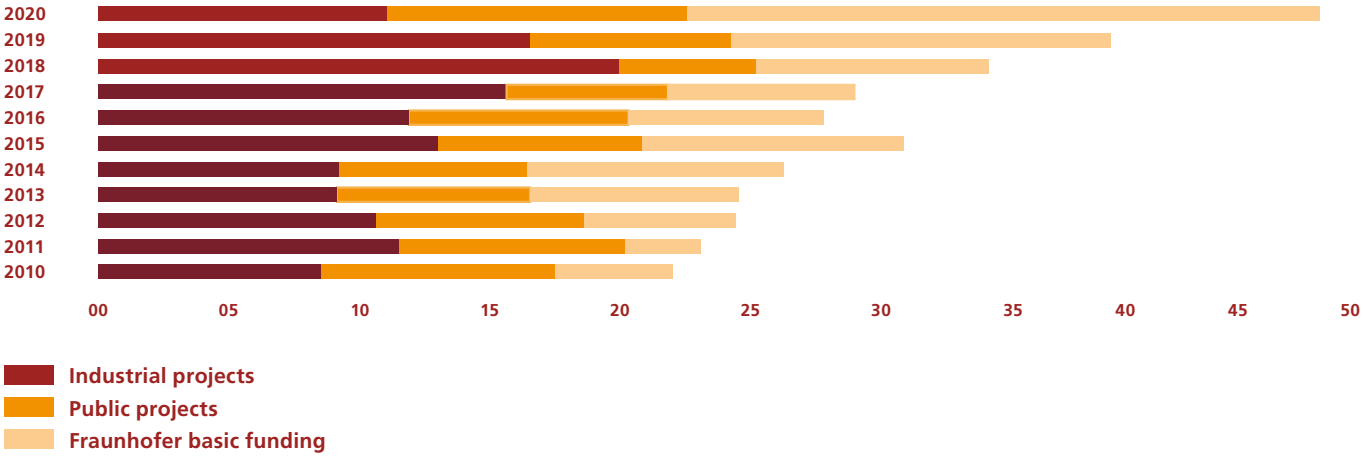


191
Employees

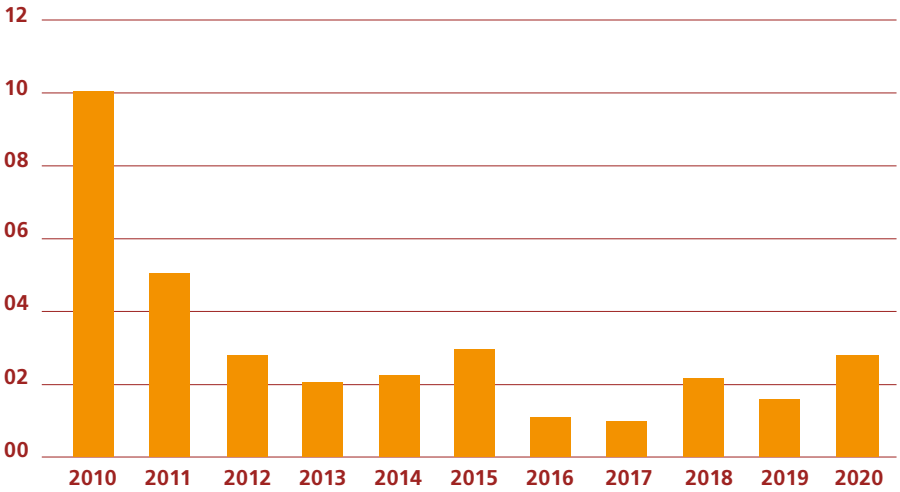
40
Scientific
Assistants



BUDGET (IN MILLION EUROS)



CAPITAL INVESTMENTS (IN MILLION EUROS)



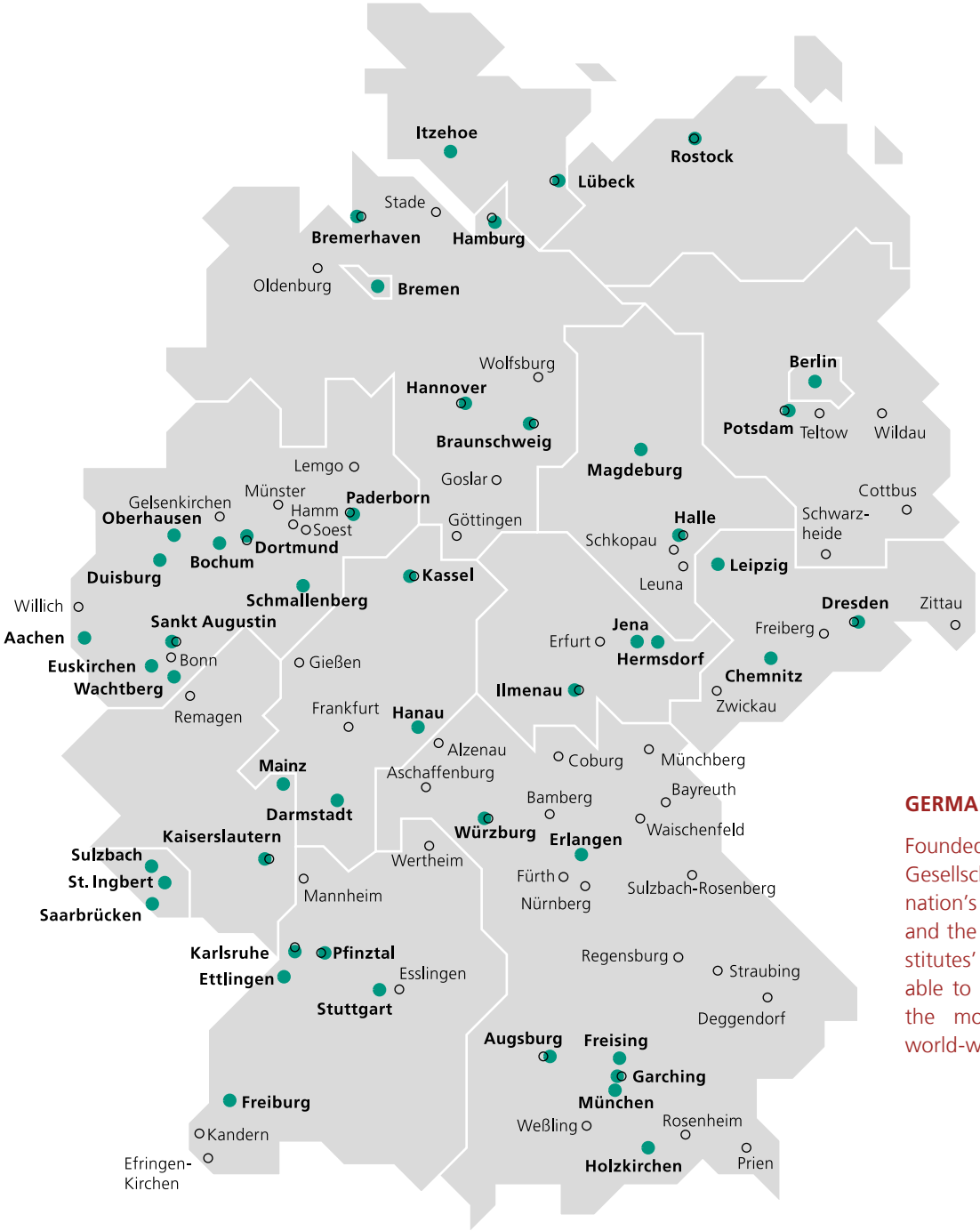
MEASUREMENT LABORATORIES

During development, numerous investigations are required to characterize sensors, circuits and systems. Fraunhofer IMS therefore has a number of specialized laboratories available:

- **Test lab for Application Specific Integrated Circuits (ASICs)**
- **Pressure Sensor Lab**
- **High Frequency Lab**
- **Biosensor Lab**
- **CMOS Imager Lab**

WORLD-WIDE COMMITMENT

As the world's leading applied research organization, the Fraunhofer-Gesellschaft has cooperations all around the world. Foreign independent Fraunhofer Institutes, Fraunhofer Representative Offices and Fraunhofer Senior Advisors on virtually every continent provide a bridge into the local markets and a foundation for fruitful international collaboration.



GERMANY

Founded in 1949, the Fraunhofer-Gesellschaft has grown into the nation's link between research and the industry. Through the institutes' work, Germany has been able to keep its status as one of the most innovative industries world-wide.

Executive Director Prof. Dr. Müller-Groeling
Director Prof. Dr. Grabmaier

BUSINESS UNITS

Space and Security	Health	Industry	Mobility
Brockherde	Prof. Dr. Seidl	Dr. vom Bögel	Dr. Ruskowski

CORE COMPETENCIES

- **Embedded Software and AI** – Heidemann
- **Smart Sensor Systems** – Kappert
- **Technology** – Dr. Weyers
- **Center for Sensor Technology** – Dr. Kolnsberg

Administration – Benninghoff

Innovation Centre / Sales
Gröting

Research Coordination
Prof. Dr. Kokozinski

Quality Mangement
Kelter

BUSINESS UNITS

Fraunhofer IMS applies cutting-edge research to various industries

Discover value creation, knowledge transfer and experts

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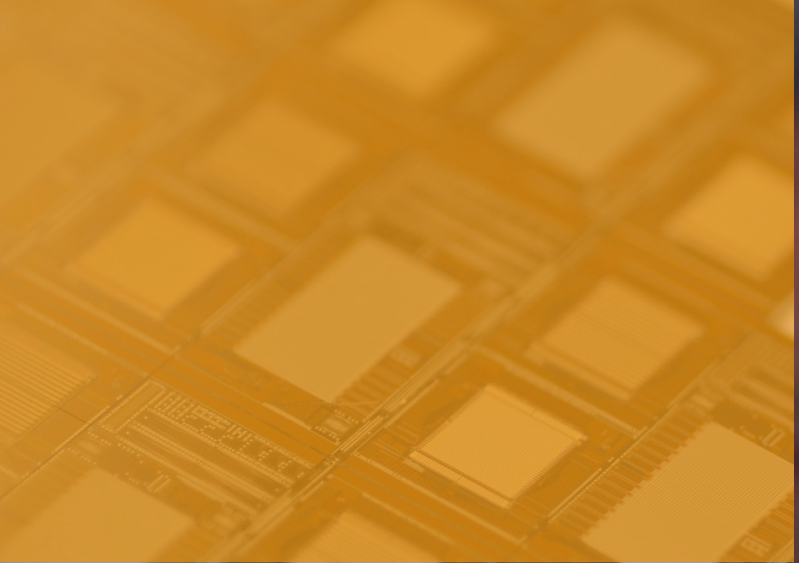

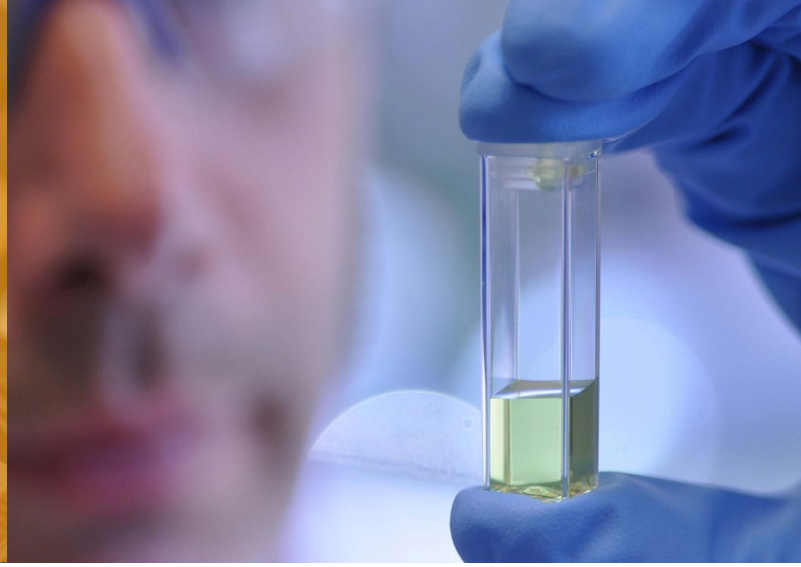

HEALTH

Smart sensor systems for health applications

We develop smart next-generation biomedical sensor systems for medical implants, in-situ diagnostics and noninvasive healthcare applications.

These are specifically adapted to the requirements of the target application in the fields of medicine, life science, biotechnology, food, pharmaceutical and environmental technology.

Together with our customers, we bring these systems through to approval.

- *Non-invasive healthcare*
- *In-situ diagnostics*
- *Medical implants*

Head of Business Unit
Prof. Dr. Karsten Seidl

More information:
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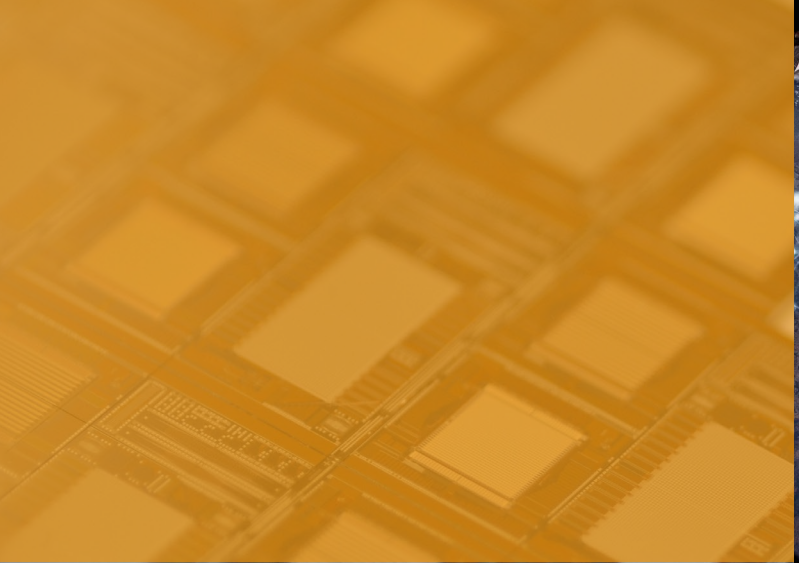

SPACE AND SECURITY

Innovative technology aiding 3D-detection and observation

From development to pilot production, we develop customer-specific and helping to vision innovative MEMS sensors and optical sensors for Space and Security Applications.

State-of-the-art-technologies deployed include BSI SPAD (backside illuminated single photon avalanche diode) arrays and uncooled IRFPA (infrared focal plane array).

Fraunhofer IMS is thus able to provide flexible, future-proof and reliable customer applications for observation and surveillance of critical infrastructures on earth as well as in and from space.

- *Space*
- *Security*

Head of Business Unit
Werner Brockherde

More information:
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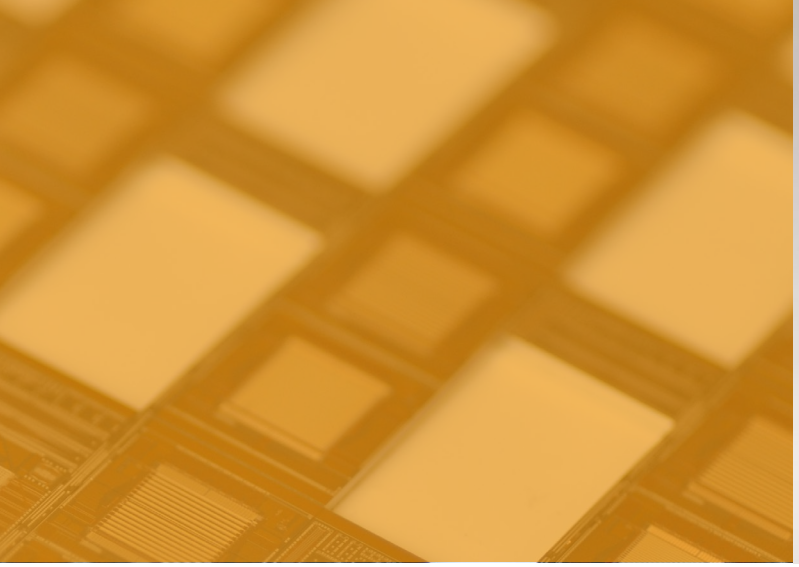

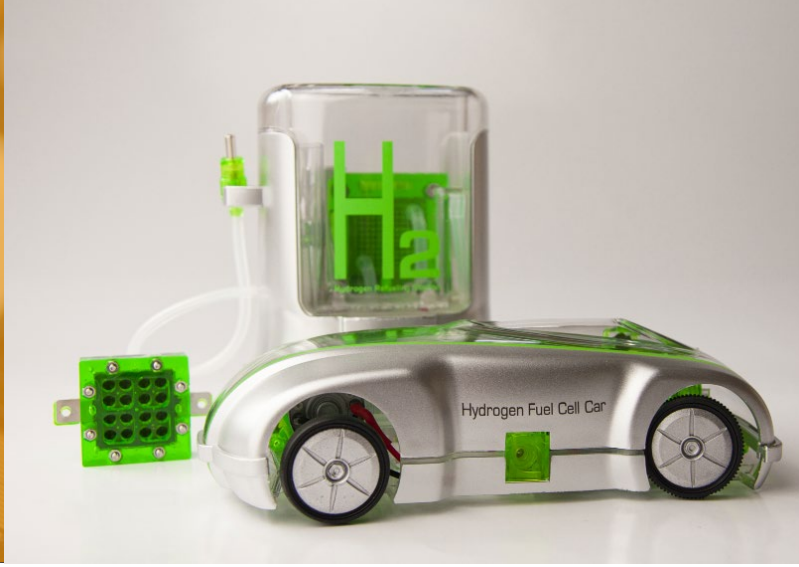

MOBILITY

Realizing emission-free and autonomous mobility

Together with manufacturers, suppliers and research and development institutions we develop solutions for the mobility industry in a maritime, urban, aerial or railroad and road context.

Application-specific sensors and systems are developed to be used with algorithms and artificial intelligence. In addition, our clean room and the "Microsystem Lab&Fab" enable individual manufacturing of MEMS and CMOS technology. The resulting solutions are used to enable safe and sustainable mobility.

- *Autonomous mobility*
- *Emission-free mobility*

Head of Business Unit
Dr. Jennifer Ruskowski

More information:
CLICK THE ICON

INDUSTRY

Enabling clean and sustainable production

We aim to reduce the use of resources and make production more sustainable and efficient.

To this end, research in the field of robotics and intra-logistics, predictive analytics and digitalization is conducted. The safe use of AI is investigated and risk of data theft and sabotage is managed.

Smart sensor systems and embedded computing platforms are enabling innovative, reliable solutions for clean and safe production.

- *Sustainable production*
- *Mobile autonomous manufacturing*
- *Industrial AI*
- *Trusted electronics*

Head of Business Unit
Dr. Gerd vom Bögel

More information:
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CORE COMPETENCIES

Fraunhofer IMS greatest strength: Expertise founded in decades of cross-topic research

Discover experience, theoretical knowledge and practical know-how

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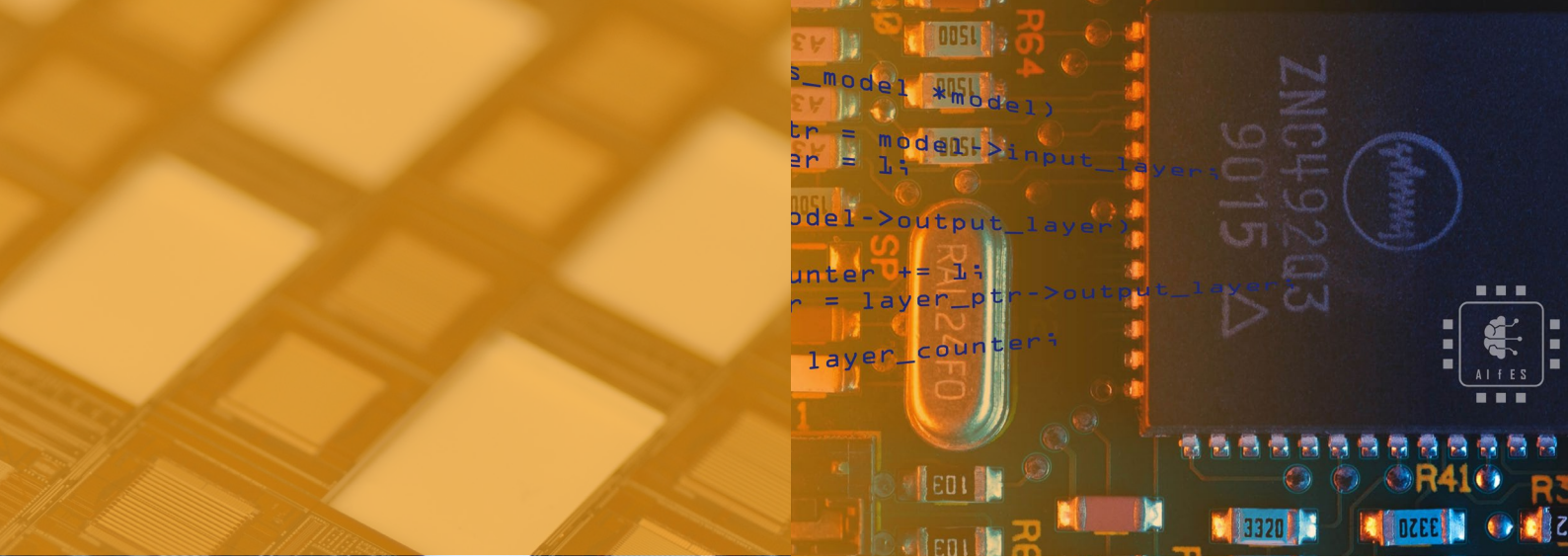

EMBEDDED SOFTWARE AND AI

Building intelligent components for complex systems

We create the future by contributing to a user-friendly, time and resource-efficient handling of complex tasks, made possible by the integration of embedded AI.

Fraunhofer IMS uses embedded software and AI to create down-sized smart sensor systems. These excel in terms of energy consumption, data traffic, speed and safety and enhance existing workflows through their implementation in industry settings, user interfaces or computer vision.

- *Embedded systems*
- *Integrated smart sensors*
- *Distributed sensor systems*

Head of Core Competence
Burkhard Heidemann

More information:
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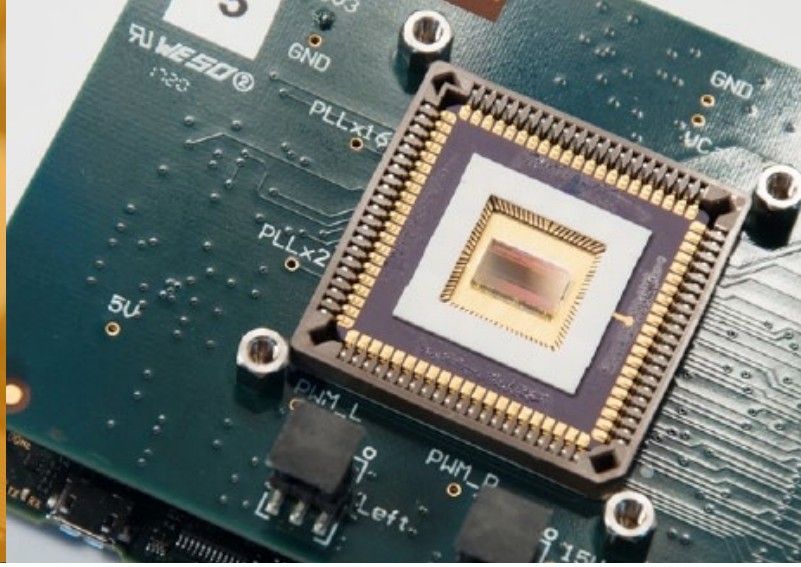

SMART SENSOR SYSTEMS

Developing future oriented intelligent sensor solutions

We realize smart sensor systems based on our strong expertise in mixed signal integrated circuit including integrated sensors and system design. These capabilities are complemented by wireless sensors and optical systems. Special focus is on high precision sensor signal conditioning, RISC-V based embedded microcontrollers, sensor transponders (LF to SHF), LiDAR and low light imaging.

Various laboratories exist for characterization and testing.

- *Integrated sensors*
- *Application Specific Integrated Circuits (ASIC)*
- *Embedded systems*
- *Wireless system solutions*
- *Optical systems*

Head of Core Competence
Holger Kappert

More information:
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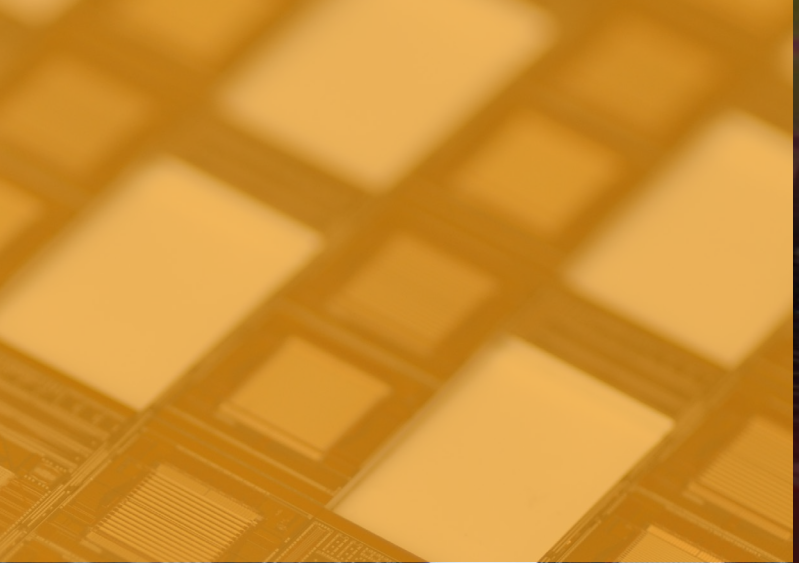

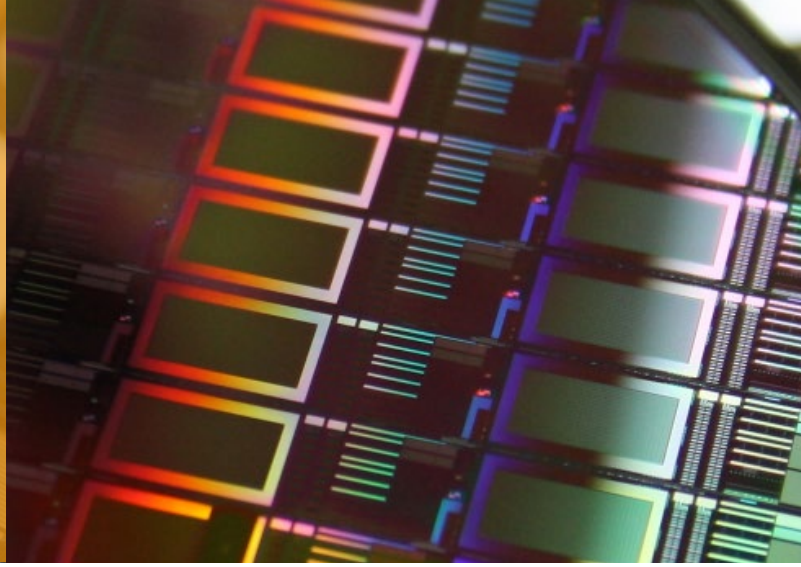

TECHNOLOGY

Perfecting CMOS and MEMS device production

We realize beyond state-of-the-art sensor systems by relying on our in-house CMOS production line, the Microsystems Technology Lab&Fab as well as modern measurement laboratories.

We also offer process optimization to our partners, especially in the field of complementary metal-oxide-semiconductors (CMOS) and micro-electro-mechanical systems (MEMS). Other technologies include customized CMOS that are able to withstand harsh conditions up to 300°C.

Our portfolio includes:

- *Optical sensors from X-Ray to infrared*
- *Pressure sensors*
- *Bio sensors*
- *Gas sensors*

Head of Core Competence
Dr. Sascha Weyers

More information:
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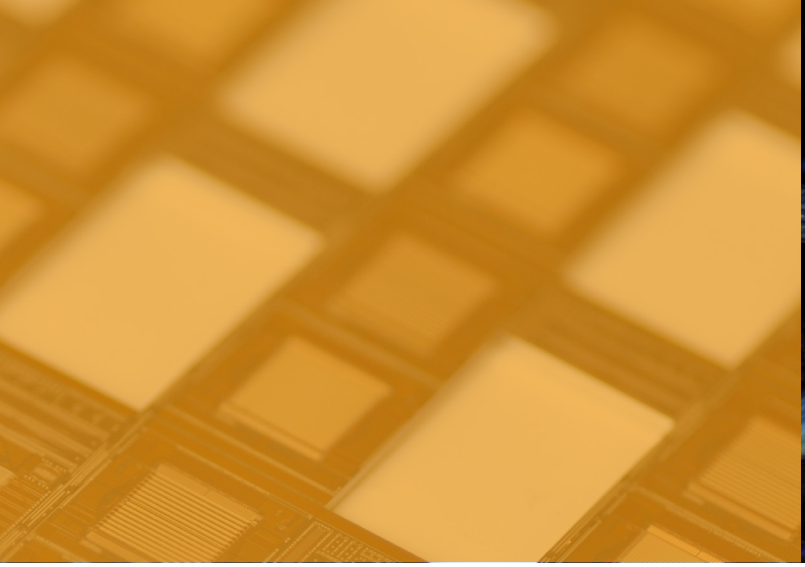

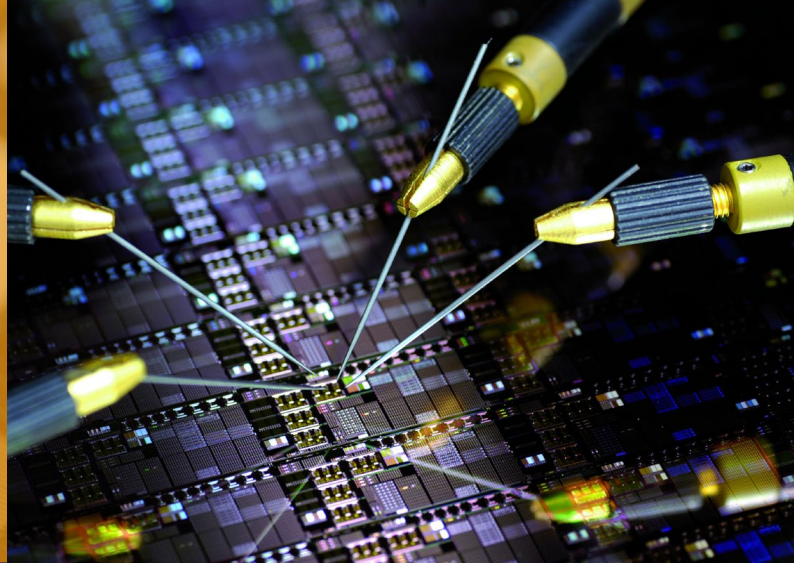

CENTER FOR SENSOR TECHNOLOGY

Providing complete semiconductor fabrication

In our clean room of 2000 m² - the Center of Sensor Technology - we fabricate innovative sensors with state-of-the-art equipment and technologies. Uniform 200 mm silicon cassette handling enables us to implement the complete process chain from bare silicon wafer to complete sensor system.

Our team of experienced scientists, developers, design experts and technologists work hand in hand with you – starting with the fabrication of demonstrators and prototypes up to pilot production.

Our portfolio consits of:

- *Automated fabrication line for 200 mm wafers*
- *Silicon and SOI-based CMOS and OPTO processes*
- *MEMS line for post-processing on CMOS*
- *Wafer and device level test*
- *Semi automated assembly and packaging*

Head of Core Competence
Dr. Stephan Kolnsberg

More information:
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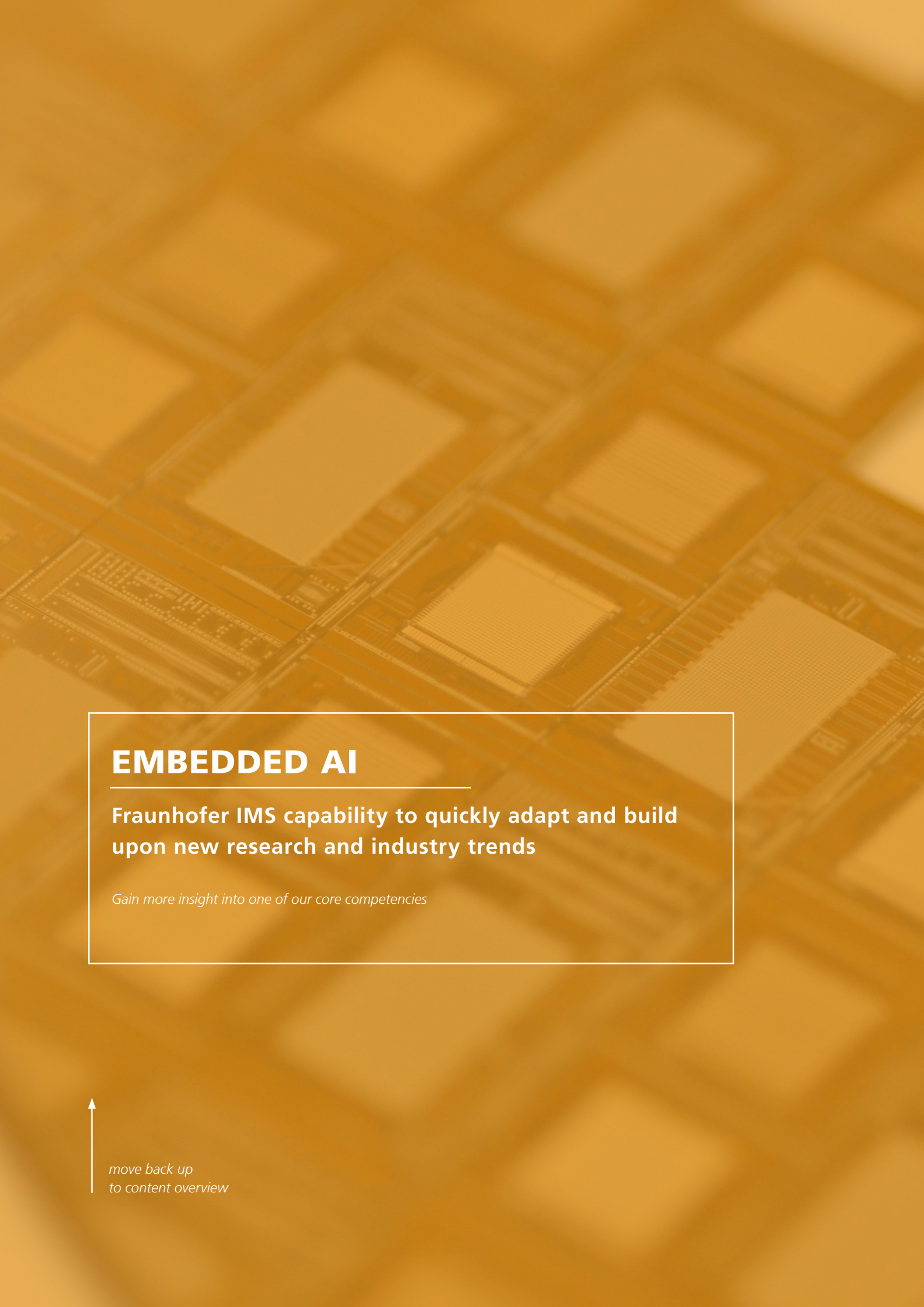

EMBEDDED AI

Fraunhofer IMS capability to quickly adapt and build upon new research and industry trends

Gain more insight into one of our core competencies

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WHY IS EVERYONE TALKING ABOUT AI, ANYWAY?

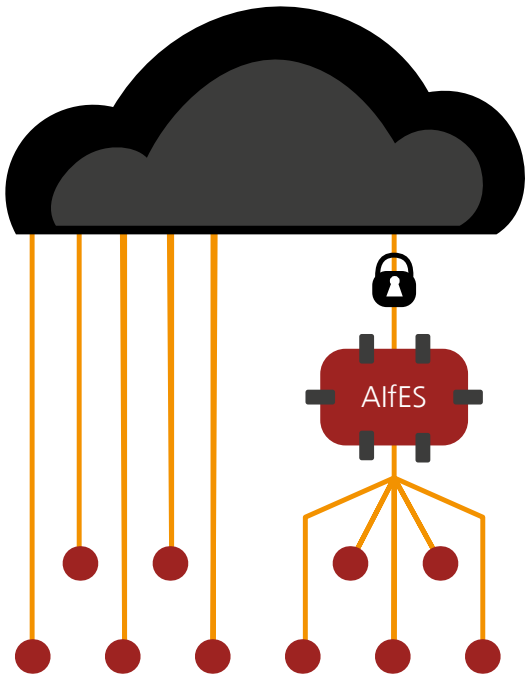
Today, in almost any device from blood pressure meters to washing machines, microcontrollers are installed. Researchers at Fraunhofer IMS are striving to make them smart, too.

Work processes in our society have become very complex and demanding while both time and staff are scarce and expensive. One example of this is nursing care, where demographic change and the shortage of nursing staff means that real human interaction often has to be sacrificed for efficiency and speed. Assistance to caregivers based on electronic systems with embedded software and artificial intelligence, however, is seen as a silver lining. In addition to offering more technical functionality, these systems excel in user operability and acceptance. Smart sensor systems make it possible to build user interfaces that react to gestures or handwriting. These intuitive inputs do not have to be learned or taught. Instead, patients and staff immediately benefit from the technology, leaving time for human interaction in an ever more technical, complex world.

ADVANTAGES OF EMBEDDED AI

Most artificially intelligent systems today rely on "big data" and its centralized analysis. Embedded AI on microchips, however, extracts only the data it needs to analyze it immediately at the place of extraction, producing downsized streams of valuable information.

- *Data protection*
- *Cost and complexity of hardware reduced*
- *Decreased data transfer*
- *Energy efficient operation*



COMMUNICATION AND NETWORKING

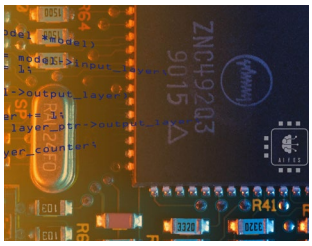
The right communication interfaces allow data to be exchanged freely and securely
Familiar with a variety of industry standards and able to design new and custom interfaces, Fraunhofer IMS can competently support its partners in establishing the right connection.

USER INTERFACES

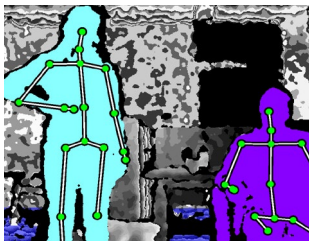
Crucial for customer acceptance, market success and ease of operation of the system
Through extensive research, Fraunhofer IMS implements ever more intuitive user interfaces. Highly efficient, AI-based gesture and handwriting recognition is available; brain-machine interfaces are under development.

MACHINE LEARNING FOR EMBEDDED SYSTEMS

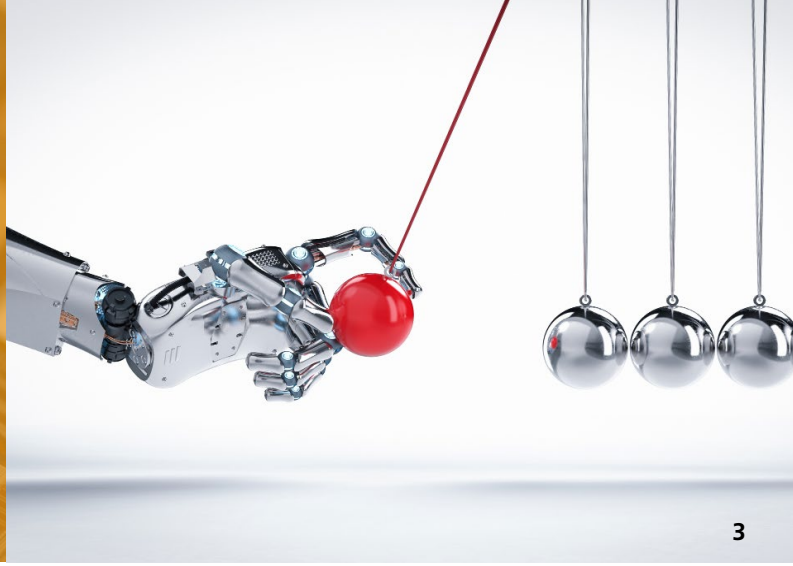
Bigger is not always better: enabling resource-saving data processing on-chip
Reversing the trend of bigger and more consuming neural networks, Fraunhofer IMS builds smaller clusters of microcontrollers, achieving high accuracy and efficiency through new learning processes.



COMPUTER VISION



Images and videos contain multidimensional information to be read out automatically
At Fraunhofer IMS, developing both the optical sensors and their output's analysis yields highly efficient systems. Motion analysis, person detection, automated driving: the applications are countless.



AI TEACHING, UPDATED

IMPROVED MACHINE LEARNING FOR EMBEDDED SYSTEMS

In building ever deeper neural networks, more training data is required, too. Instead of relying on collecting huge amounts of data and cloud computing, Fraunhofer IMS is finding new ways.

In many applications, especially in healthcare, data protection is very important. Embedded AI has the innate advantage of computing sensitive data right where it was created and then only transmitting processed information. For example, a device capable of recognizing gestures will analyze motion on the same chip on which the motion was captured and measured through accelerometers. It will then transform the analysis into condensed output information like a number or text string. All raw data stays on the chip and is not transmitted. Yet, this takes away a great learning advantage of centralized computing. Here, all raw data is transmitted to one neural network and can be used to train the entire system. The isolated - and protected - Embedded AI devices only have the raw data available created by "their own" sensors.

DISTRIBUTED LEARNING

In distributed learning, however, this drawback is also overcome. Individual learning progresses are merged into a common model and then distributed again. This way, even more data can be recorded and processed within a shorter period of time as in real-time applications bandwidths and latency limit the use of cloud solutions. Fraunhofer IMS is working on reducing the communication effort even further without reducing the quality of the common model and also increasing resilience. All this enables the use of distributed learning in a data-sensitive environment. Other application fields such as intelligent condition monitoring in the Industry 4.0 also show potential for processing complex signals. Here too, large amounts of data are needed for training that represent different scenarios in sufficient quality and quantity. However, comprehensive real-world data acquisition is often too resource-intensive to be economical.

HYBRID LEARNING WITH PHYSICS-GUIDED NEURAL NETWORKS

This is where simulation-based hybrid learning methods can provide a remedy. In this context, Fraunhofer IMS is researching methods for combining physics- and AI-based models in order to generate realistic training data. For example, there already exists a wide range of methods for the efficient analysis of sensor signals in classical digital signal processing. Fraunhofer IMS is using this expert knowledge in signal processing to ensure faster training of neural networks while reducing the amount of data required, e.g. for pattern recognition or signal classification. In hybrid learning, expert knowledge of the underlying physics of a system can thus be applied at various points in the machine learning pipeline. From training data generation to the final model it is used to design intelligent sensor systems that are efficient, robust and safe.

3 One learning event is shared with the other devices

CONTACTLESS MEASUREMENT OF VITAL PARAMETERS

COMPUTER VISION APPLIED

One of the most effective measures to contain the current COVID-19 pandemic is to practice social distancing. Still, medical staff need to be able to assess a person's state of health. Researchers at the Fraunhofer IMS have found a way to achieve both objectives, using AI.

Vital signs such as heart rate and blood pressure are important indicators of a person's state of health. In the case of COVID-19, they can also be used to assess whether a person is infected or not by analysing for fever and shortness of breath. While fever can be measured easily and contactless with an infrared camera, such a practicable measurement system for analysing the respiratory rate had not existed yet.

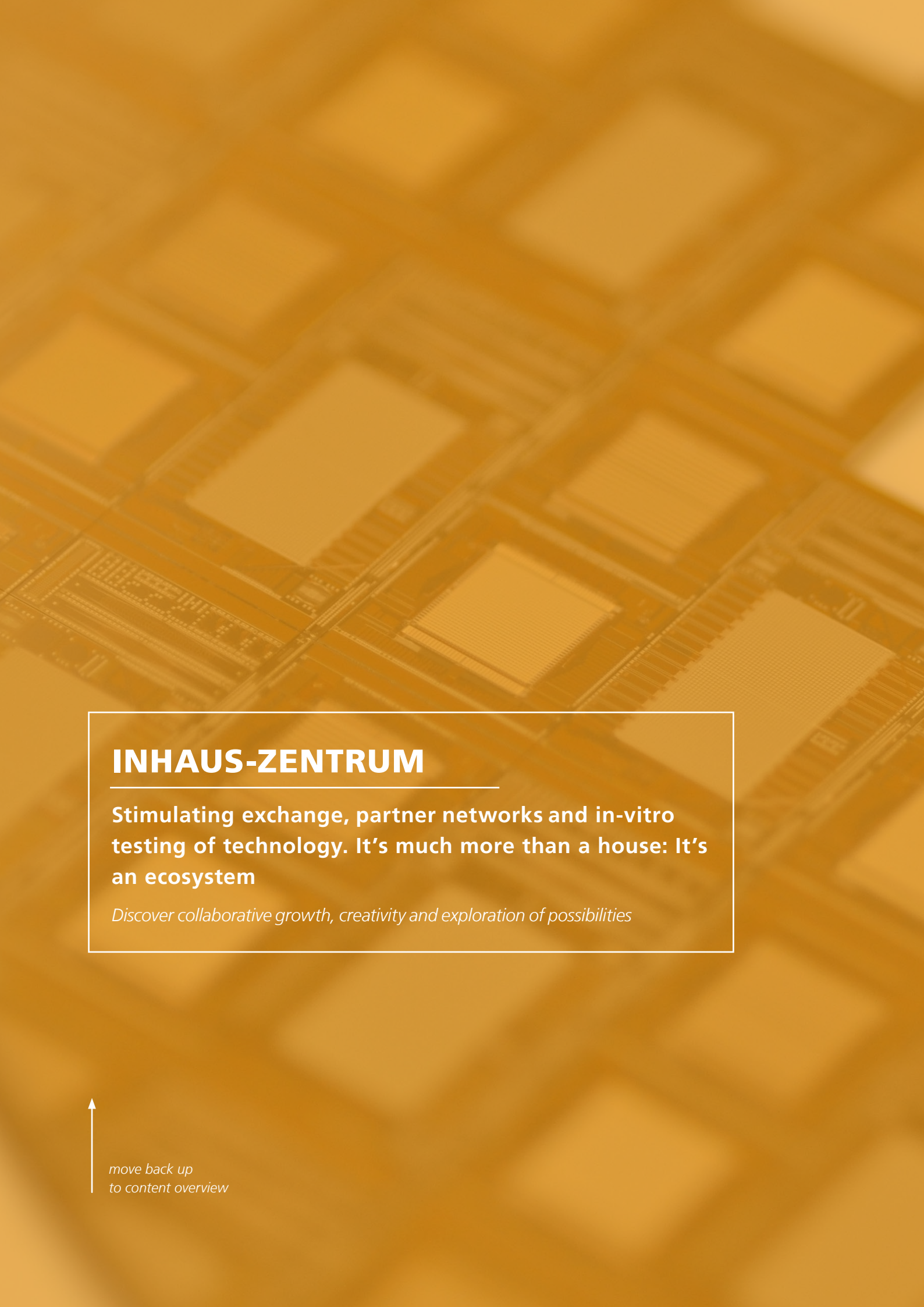
In order to fill this gap, a system was developed that can accurately determine the respiratory rate via a commercially available RGB camera. Intelligent image processing analyses the movement of the chest and filters out the signal of respiratory movement. Potentially infected people stand in front of the camera for 30 seconds and the attending hospital staff can then make an assessment of the patient based on the displayed frequency value and body temperature. During the measurement a safe distance of at least two meters can be maintained without any problems. The measurement is completely contactless, so that contamination of equipment is eliminated and the risk of infection for personnel is significantly reduced. In addition, wearing a mask is possible and does not restrict the measurement. Video and personal data are not transmitted, as the system operates locally and without connection to the hospital infrastructure or the Internet, and recorded images are deleted immediately after evaluation.

The described system for respiratory rate measurement is already being evaluated in clinical studies and there is a wide range of further possible applications for contactless vital sign measurement:

- *Screening in hospitals*
- *Health monitoring in the field of Ambient Assisted Living (AAL)*
- *Monitoring training in rehabilitation*
- *Driver monitoring in autonomous driving*
- *Market research*
- *Sleep laboratories*

For further reading on the topic of non-invasive healthcare,
CLICK THE ICON

4 Remote measurement of vital signs



INHAUS-ZENTRUM

Stimulating exchange, partner networks and in-vitro testing of technology. It's much more than a house: It's an ecosystem

Discover collaborative growth, creativity and exploration of possibilities

move back up
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INHAUS-ZENTRUM

Creating cutting-edge products and fruitful partnerships

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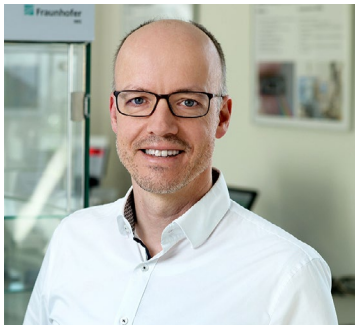

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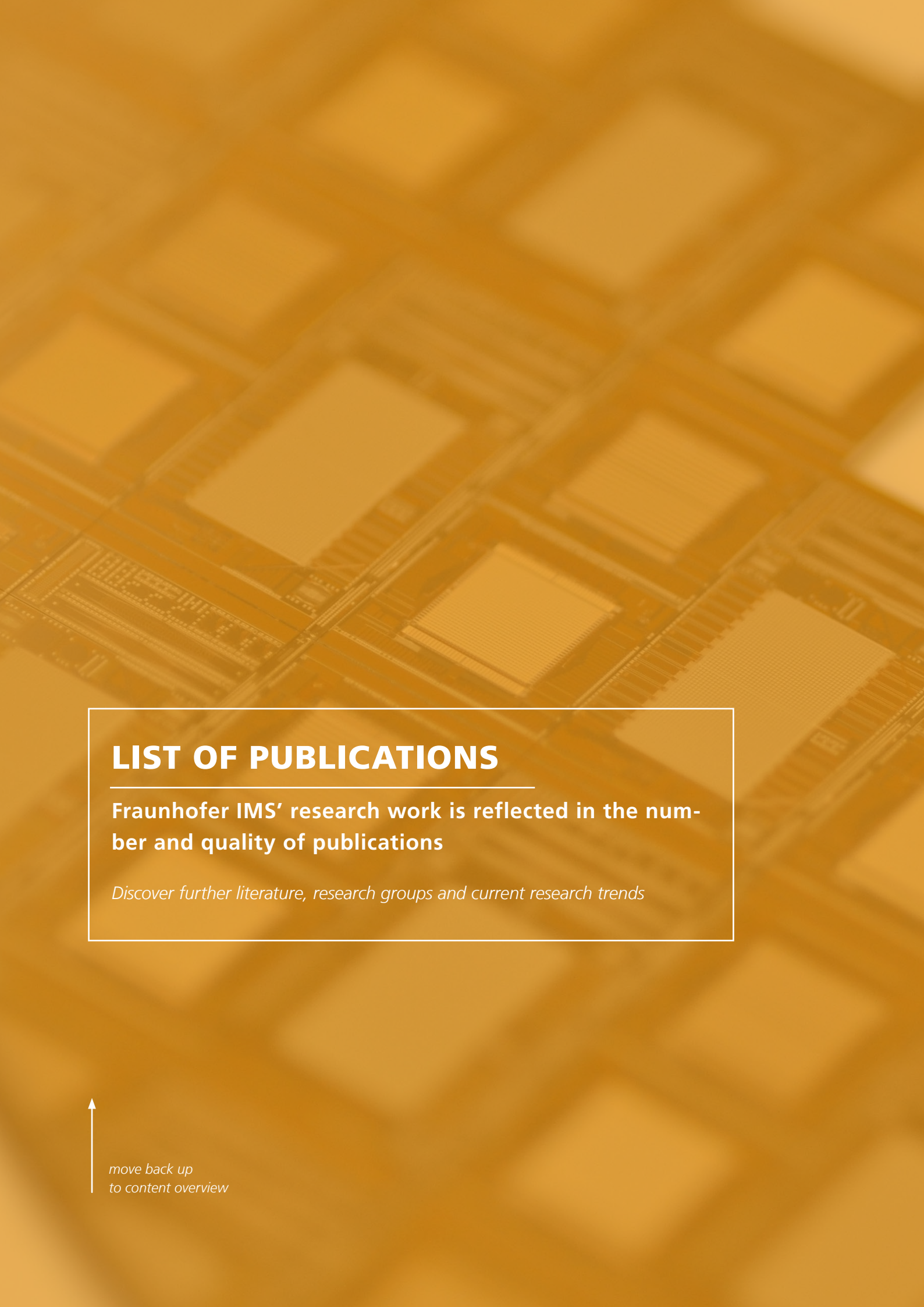

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Fraunhofer IMS' research work is reflected in the number and quality of publications

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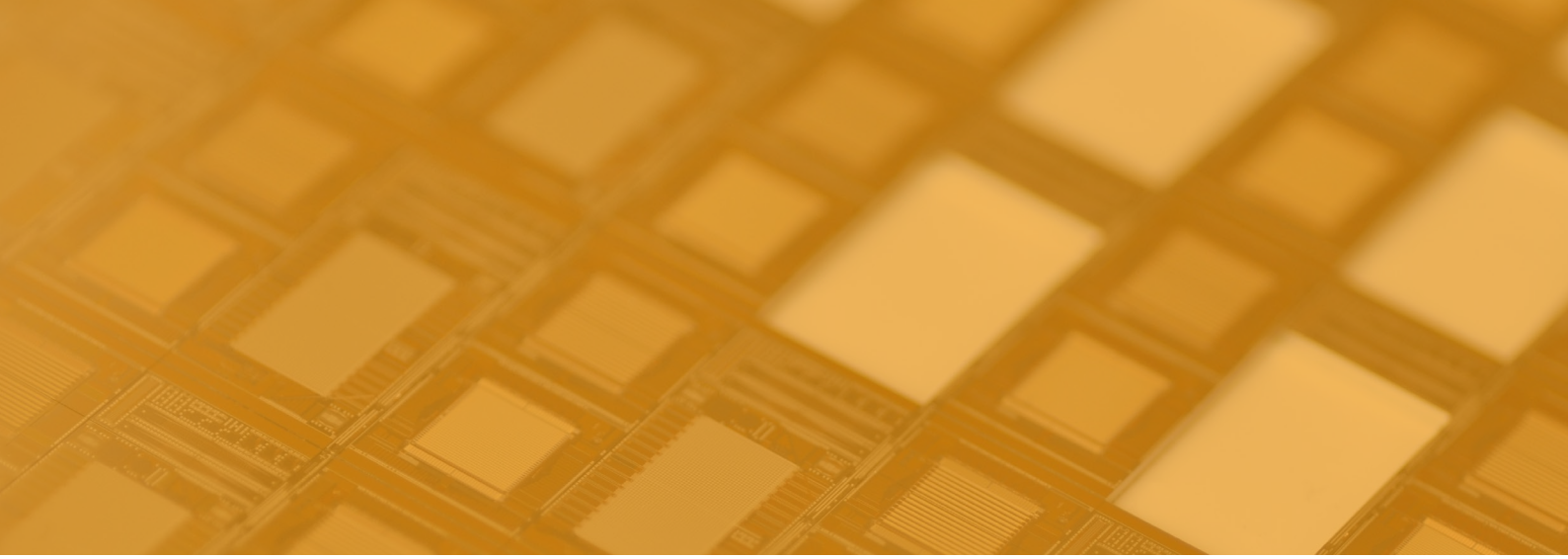

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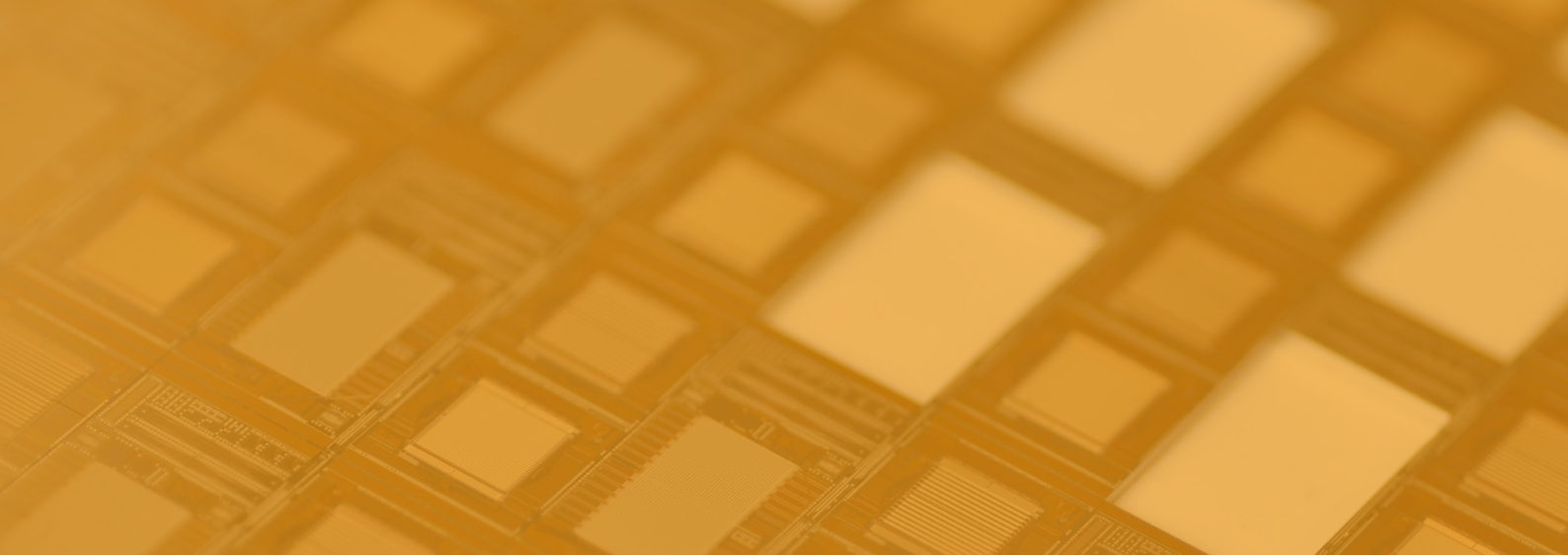

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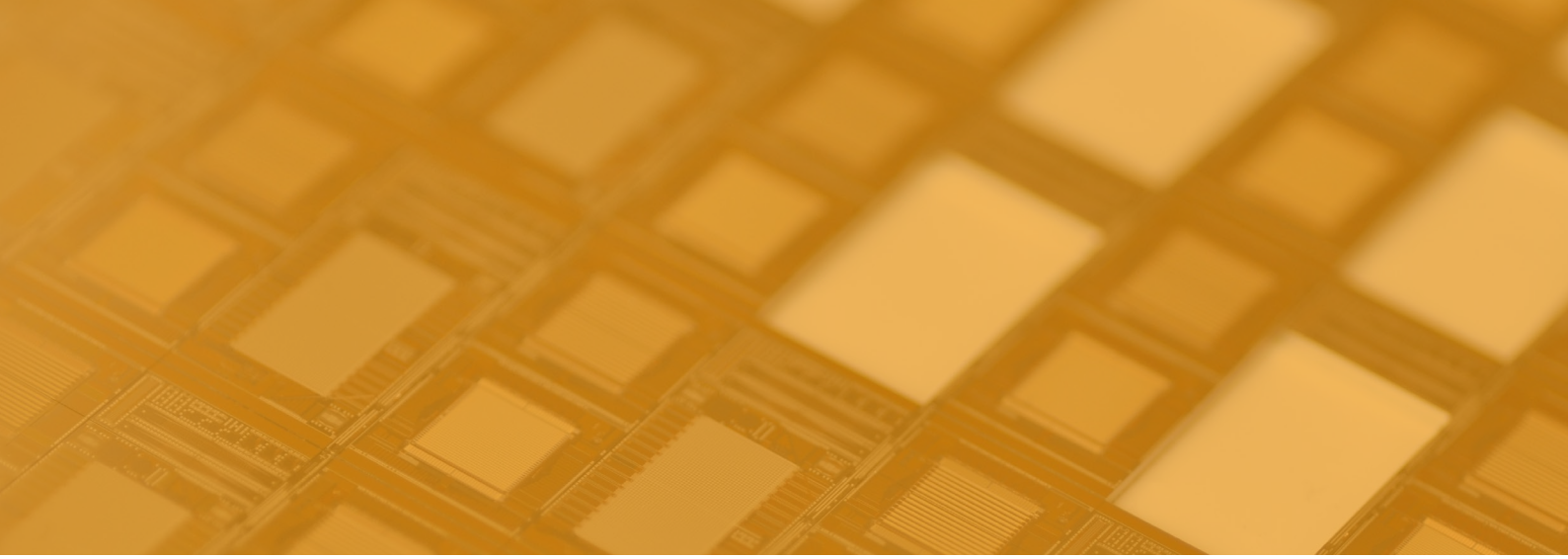

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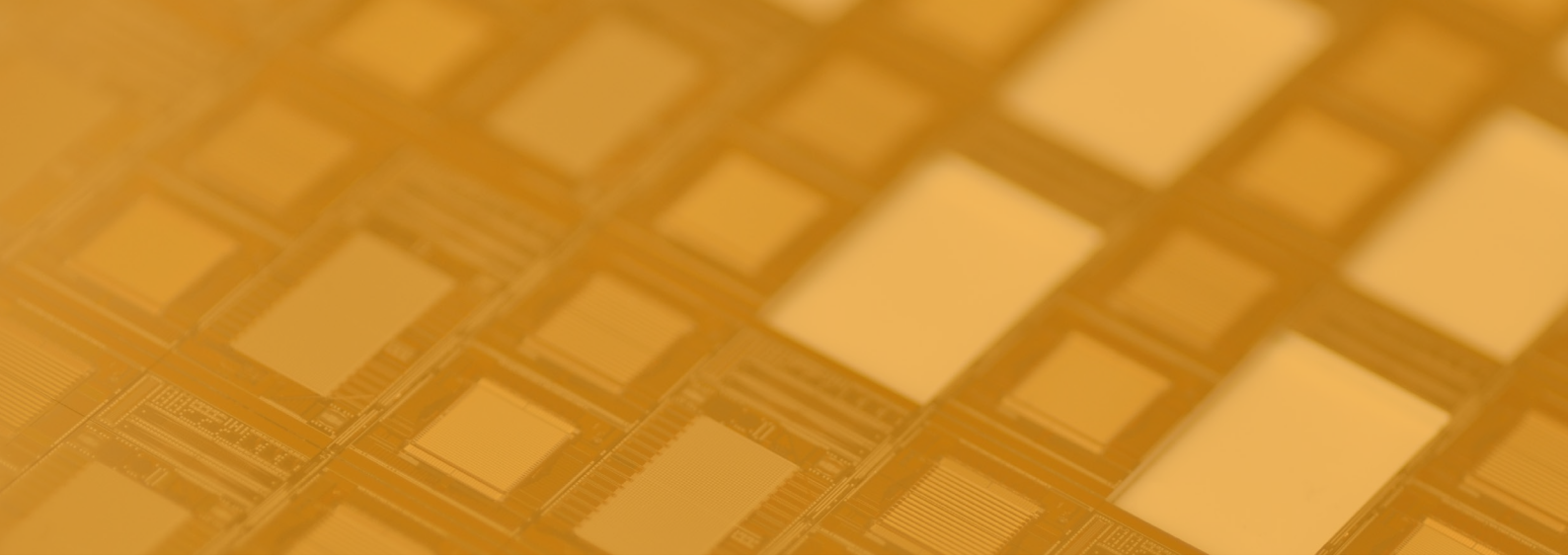

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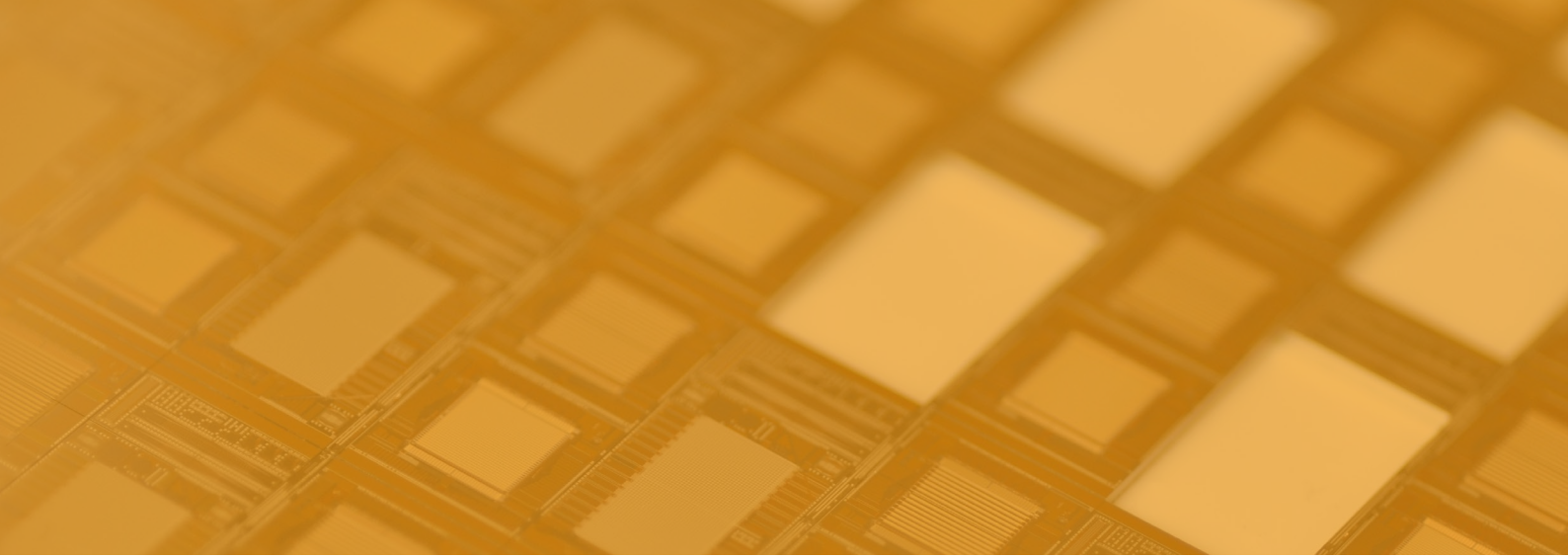

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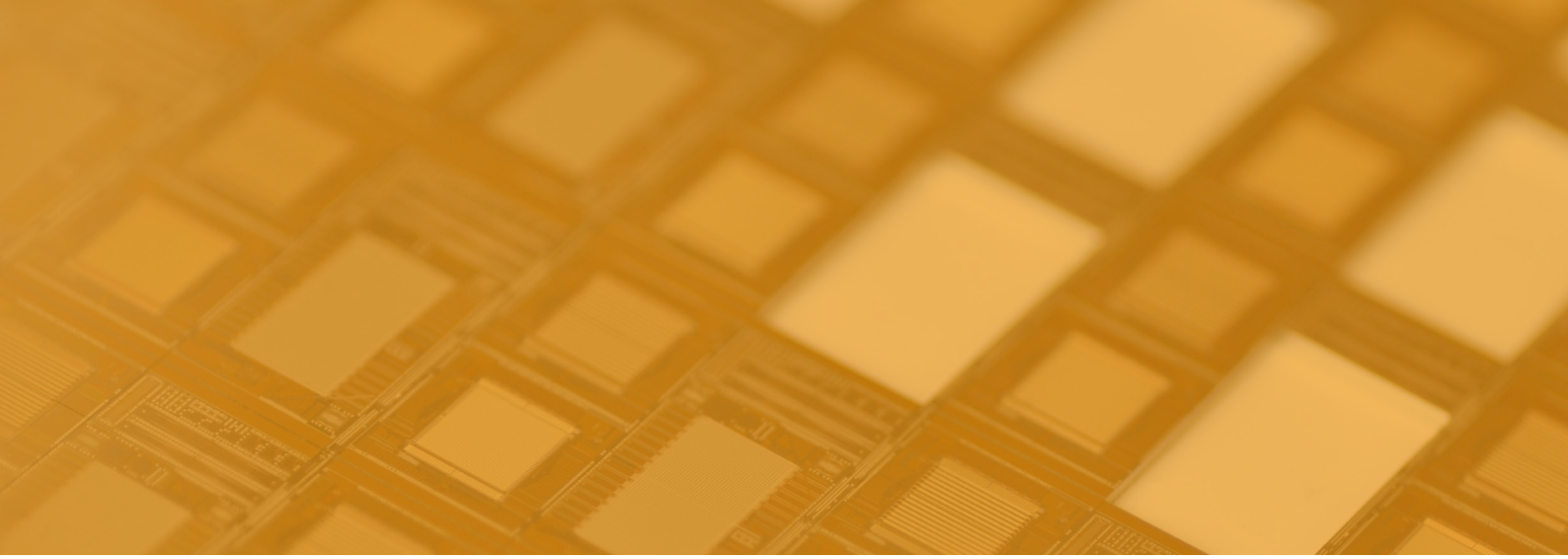

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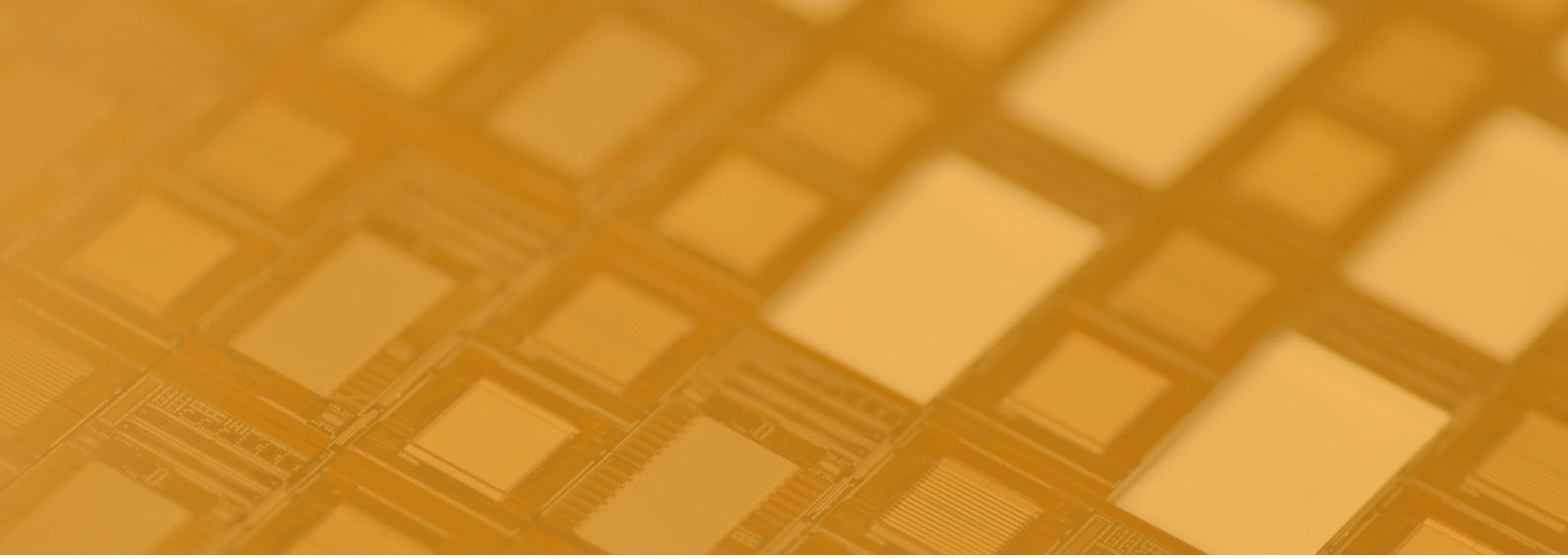

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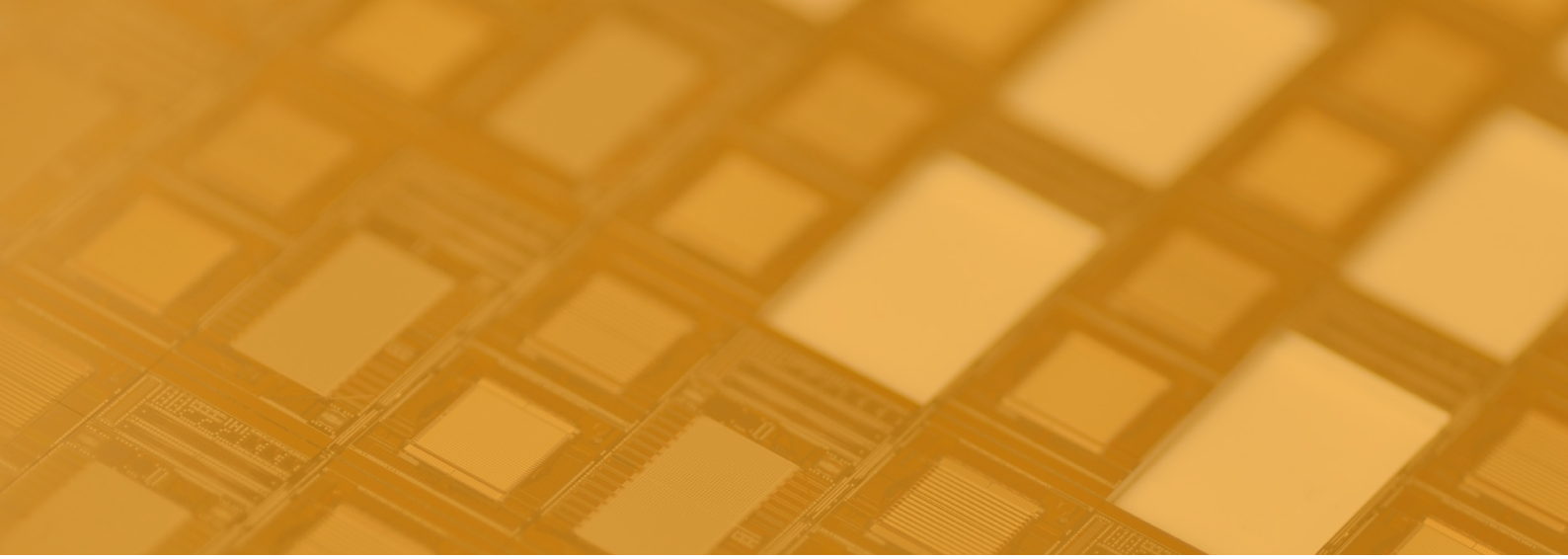

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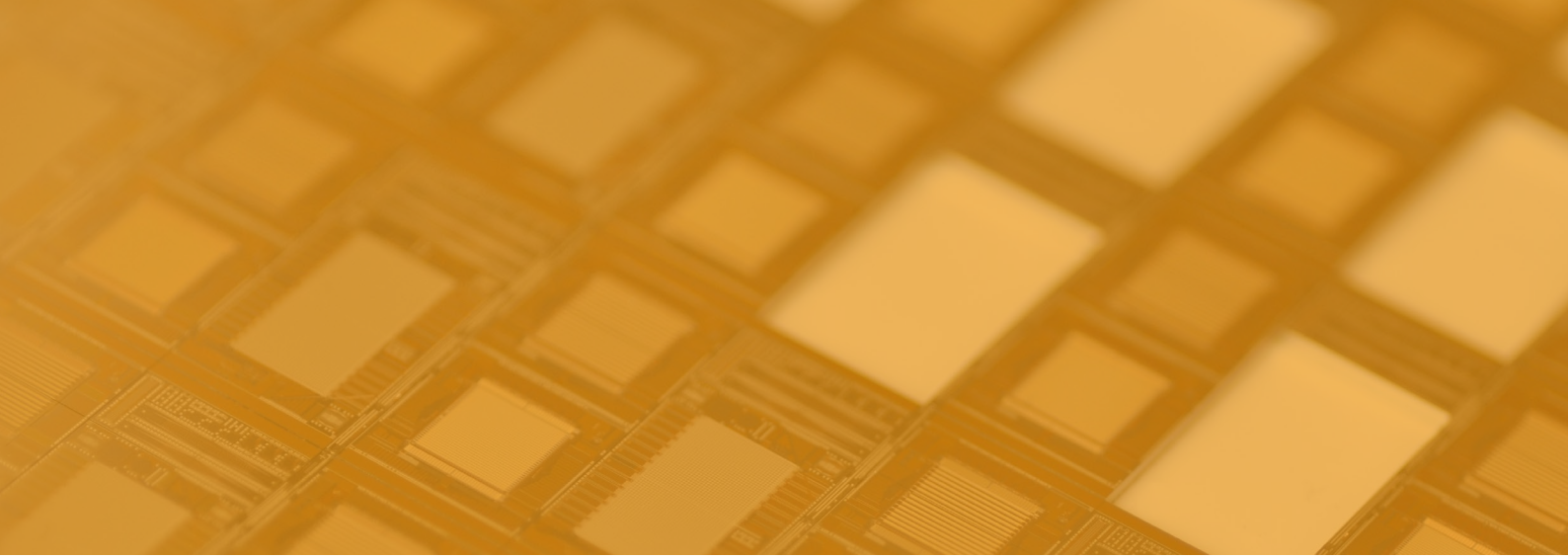

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