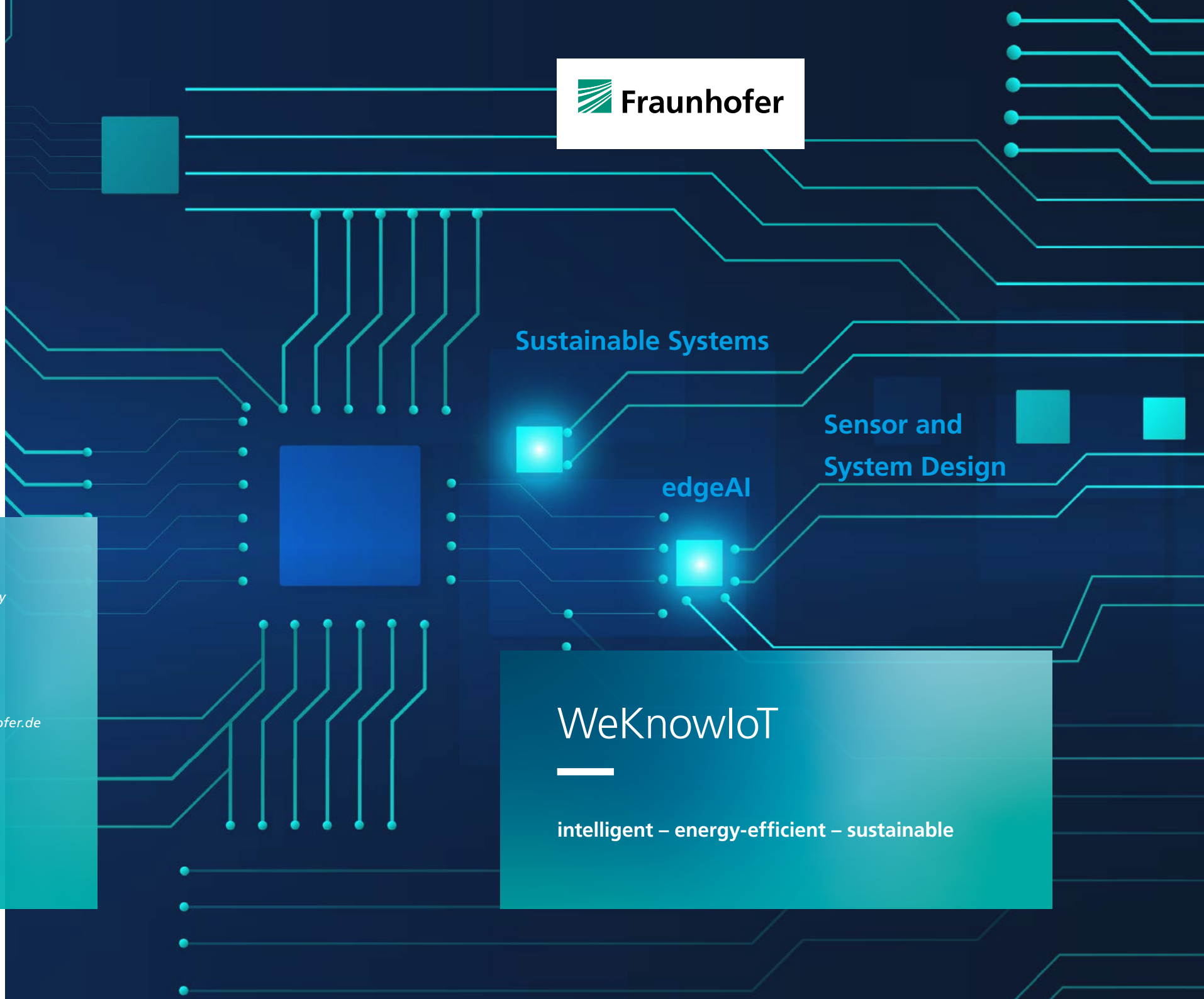

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WeKnowIoT

intelligent – energy-efficient – sustainable

There is room for AI in the smallest space

AI, ML – these letters stand for a new era, artificial intelligence and machine learning, which enriches many areas and applications – including embedded systems. Here, AI and ML stand for speed, increased efficiency and flexibility in the calculation and analysis of complex tasks. Especially when systems, sensors and chips are to be designed under the clear focus of sustainability and resource efficiency in development and for their use in applications.

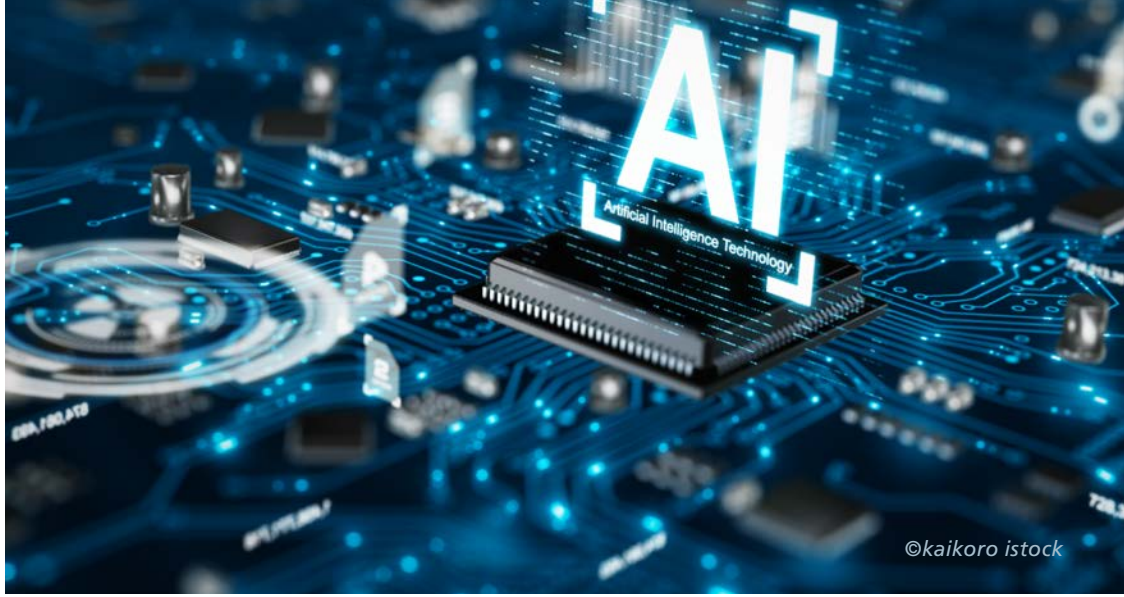
Optimal exploration of the design space

Space for extensive analysis and pre-processing in existing hardware and embedded systems is mostly extremely limited. So the key question is, how to still implement powerful AI/ML applications under these constraints. The solution is multi-objective design space exploration to suit both, the restricted hardware and the application. To this end, experts at the Fraunhofer Institute for Integrated Circuits IIS develop automatic exploration and optimization techniques using reinforcement learning and genetic algorithms to quickly explore a wide variety of solutions including classical machine learning pipelines and efficiently compressed deep learning models.
With embeddif.[ai] – the Fraunhofer IIS offers rapid development of AI solutions for various embedded hardware systems.

Customers can run AI applications energy-efficiently on-site, independent of a cloud server. These advantages enable companies to use artificial intelligence in the smallest possible space for their applications.

As close as possible to the action

Using AI and ML is a hard-to-beat plus, especially for embedded sensors and systems, to ensure the efficiency effect through fast data analysis as close as possible to the data acquisition and any actuator technology. Short distances and thus low delays, no additional analysis hardware or complex cloud connectivity, which are at the expense of energy consumption, sustainability and efficiency. When selecting and applying AI pipelines, the scientists focus on methods that are implemented as fast and energy-efficiently as possible directly



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into commercial microcontrollers, FPGAs or graphics cards and make best use of the limited space available. In this way, customized adaptation makes it possible to integrate AI in existing hardware right down to the sensor, the camera or connected embedded modules. Fraunhofer IIS offers Joint Labs to realize customers edge AI applications together with extensive know-how transfer. Furthermore embedded AI development frameworks can be provided as a kick-start for system programmers in companies which can be adapted for their applications including training and support.

When AI moves right into the chip

In addition to in-depth knowledge and selection of AI methods and adaptation for existing hardware, the scientists at Fraunhofer IIS are taking another step. Currently, they are working in the field of neuromorphic computing and developing chips with an architecture that is based on biological neuronal networks. In addition, Fraunhofer IIS is working on integrated circuits for convolutional (CNNs) and spiking neural networks (SNNs) worked in qualified CMOS technologies, which, depending on the application, are scalable and configurable. So they are able to offer a higher parallel processing and lower on-chip data transfer as von Neumann-based solutions. The developed software tools are used for training networks as well as the transfer of the networks to the hardware.

More information:

An energy-efficient neural network

Dr. Johannes Leugering researches a novel neuromorphic hardware design at Fraunhofer IIS: Spiking Neural Networks (SNNs). A conversation about pulsing neurons, the revival of analog circuits and event-based cameras.

Johannes Leugering, ©Fraunhofer IIS/Paul Pulkert

Can you explain what SNNs are?

Basically, SNNs function similarly to a classic neural network. The difference lies in the way the neurons transmit signals. SNNs send information in the form of short pulses that are weighted and summed by each neuron. However, a neuron fires its own pulse only when the sum of incoming signals has exceeded a critical threshold. The more signals that hit a neuron, the faster it pulses. We have copied this idea from biology. In principle, it is a simplified representation of information processing in the human brain.

What is the advantage over classic Deep Learning?

In Deep Learning, data packets are continuously sent out that don't necessarily contain relevant information. Each neuron at every time-step must transmit a stream of real values to all its target neurons.

If we now imagine a large network with hundreds of thousands of neurons, we quickly end up with a volume of data that can be a problem.

SNNs are designed to avoid just that. The trick is to send a very small amount of information only occasionally, just when something interesting has happened. In this way, we reduce the amount of data and, in turn, the energy consumption.

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What makes SNNs interesting for chip developers?

Communication via pulses is particularly well suited for implementation in hardware. This is exactly what we are working on at Fraunhofer IIS, because it requires special hardware. It's true that a pulse-based design is more complicated because it's less predictable when to send what data. But in turn, SNNs can be implemented in analog electronics. One could also speak of a revival of analog circuits. That's what's fascinating about SNNs from my point of view. They combine analog computation within the neuron with digital communication between them. The best of both worlds, so to speak: the efficiency from the analog and the robustness from the digital.

Can you give an example of where SNNs could be applied in practice?

Event-based cameras are an interesting example. This is an application that could be groundbreaking for autonomous robots. Let's think about a drone. The camera must have a fast response time. It must be able to handle variations in lighting conditions. Event-based cameras are inspired by the way the human retina works and thus produce pulses as output signals as well. So it seems obvious to use SNNs that can work with such data.

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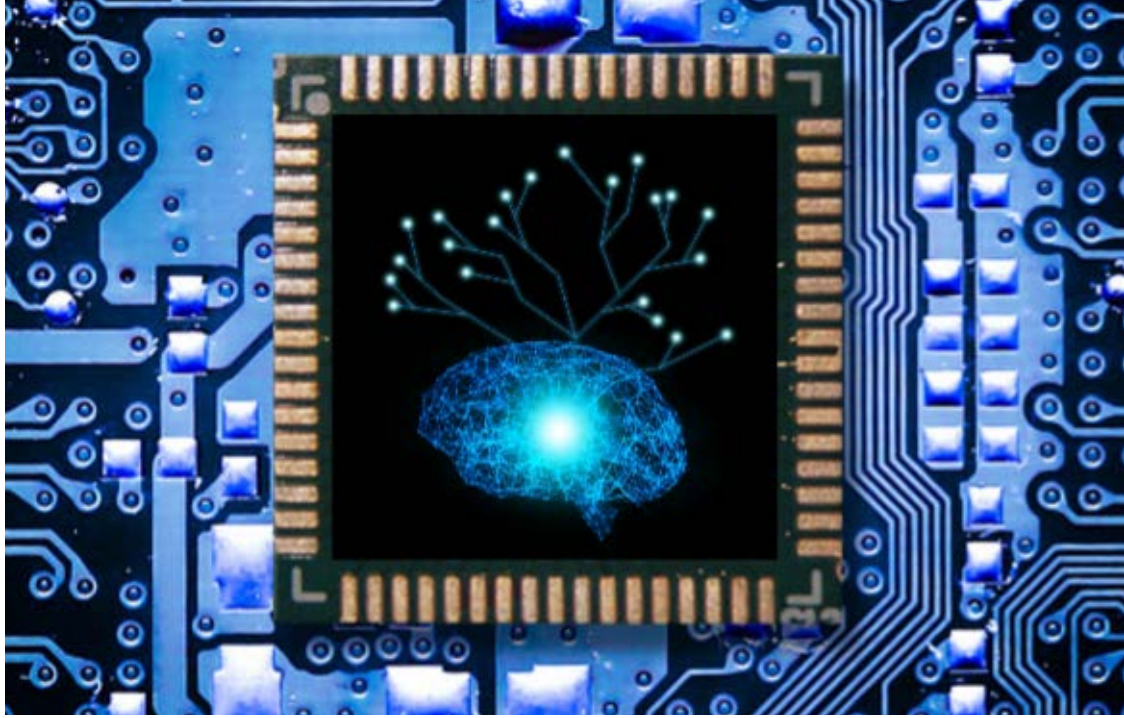
Neuromorphic hardware and software for edgeAI applications

Fraunhofer IIS is an innovation driver in the field of neuromorphic computing and placing it among theworld leaders in its field. Chips are being developed with an architecture that is based on biological neuronal networks. In addition, Fraunhofer IIS is working on integrated circuits for convolutional (CNNs) and spiking neural networks (SNNs) worked in qualified CMOS technologies, which, depending on the application, are scalable and configurable. Our low-power, low-latency neuromorphic processing units (NPUs) for CNNs have, by means of analog circuits, a higher parallel processing and lower on-chip data transfer as von Neumann-based solutions. The developed software tools are used for training networks as well as the transfer of the networks to the hardware.



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»Our goal is to develop a complete chain of neuromorphic hardware – or to put it more simply, to create an alternative to conventional computer processors modeled on the human brain.«

Strategically important and sustainable Research field

The distinctive quality of the Fraunhofer IIS neuromorphic solutions is that the hardware and software development work seamlessly with one another and both components are coordinated with each other from the outset. This special hardware-software co-design flow makes the rapid development of highly complex designs possible, in particular through our generator tool for the synthesis of neuronal Networks (NNs). To this end, we combine our expertise from the areas of low-power IC design, neural network (NN) algorithms, software tools, system and circuit architecture design, and the specific domain knowledge of the application, such as sensor technology, audio signal and image processing, message transmission and localization. The combination of these competencies and domain knowledge enables the implementation of application-specific complete solutions that enable better system performance than generic solutions.

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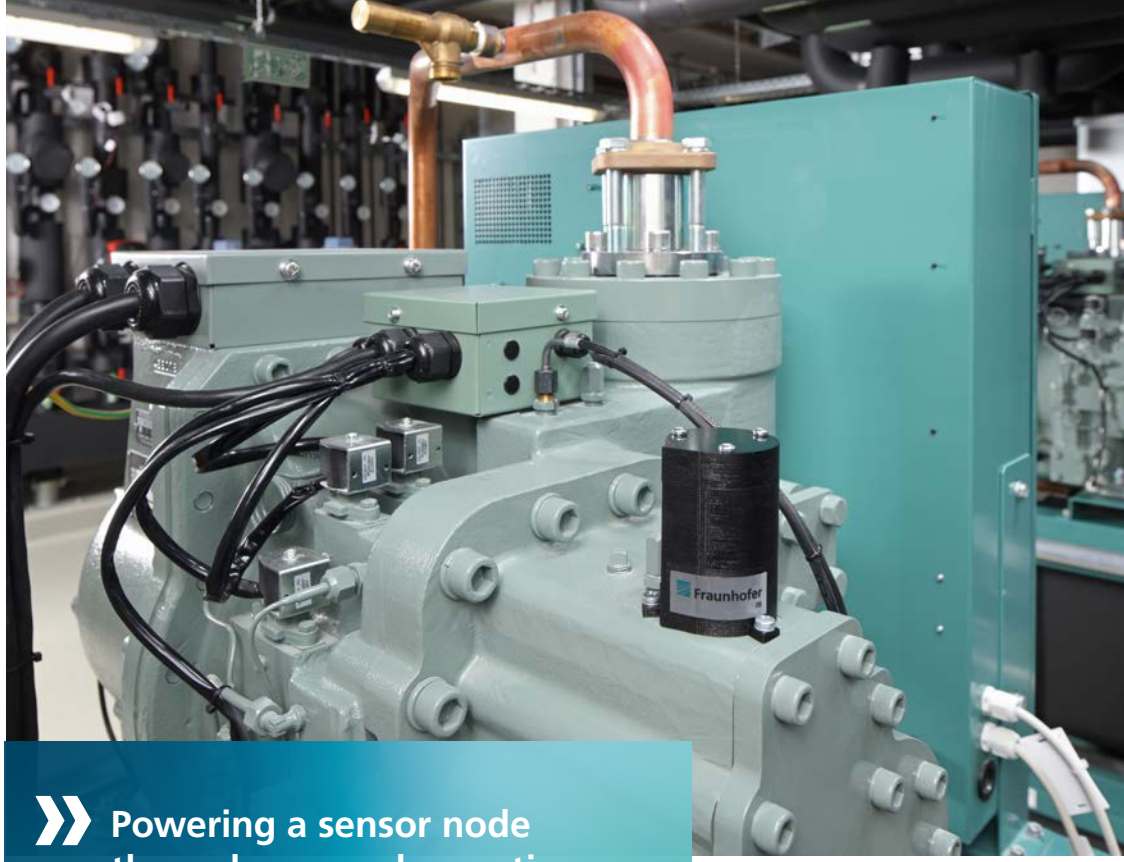
Energy Harvesting: Small Source – Big Effect

Sensors are key elements of the Internet of Things (IoT). They collect information, for example, about the condition of a machine or an infrastructure, process it and pass it on. The numerous sensors can obtain the required energy from batteries or via a cable connection. Fraunhofer researchers have now found a way to harvest enough energy to operate these sensors using vibrations from machines, equipment or buildings, as well as from temperature differences between pipes, ducts or valves, and the environment.

"Powering a sensor node through energy harvesting technology makes it independent from other energy supplies. This saves the cost arising from energy-storage devices, such as batteries, and eliminates the maintenance effort required for battery replacement. It also makes cable installations redundant," says Dr. Peter Spies from the Fraunhofer Institute for Integrated Circuits IIS in Nuremberg, explaining the advantages. The autonomous sensors are used for data collection and transmission, e.g., for the condition monitoring of machines, buildings or bridges, as well as for smart metering systems.

Spies and his team have been researching for some time how and where energy harvesting technologies can be optimized and deployed.

Due to the rise in energy prices, their field of research is rapidly gaining relevance, and inquiries from industry are piling up. Their latest development is a sensor node that collects and transmits utility data in a 5G network over the NB-IoT standard. To ensure that the modules and sensors can be operated energy independently, they were specially designed and optimized for energy consumption. This opens up new possibilities for autonomously powering not only LPWANs (low-power wide-area networks) but also other radio systems with higher energy consumption and more advanced functionalities, such as bidirectional communication. The systems can then also be operated in a public network.



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»Powering a sensor node through energy harvesting technology makes it independent from other energy supplies. This saves the cost arising from energy-storage devices.«

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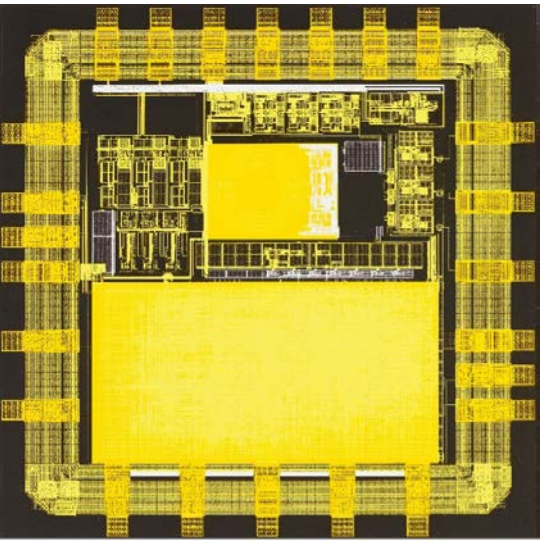
RFicient®

The number of wirelessly networked devices is growing rapidly, both among private consumers and in industry. For devices to be available at all times, however, their wireless receiver needs to be permanently switched on, which limits the battery life of small, battery-powered IoT nodes to just a few weeks. The RFicient® chip, developed by the Fraunhofer Institute for Integrated Circuits IIS, represents a huge leap forward.



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Our chip enables us to save up to 99 percent of power – so a battery that would have managed just over a month with conventional technology can now last ten years. The appeal of this product lies in the fact that, even with the extended battery life, the sensor node is still ready to receive signals at any time: it needs just 30 milliseconds to respond by performing an action. While other wake-up receivers are often switched off for minutes at a time and can sometimes take too long to respond, the RFicient® chip guarantees an immediate response. This is important not only in time-critical applications, but also in situations where there are many services running simultaneously or many different nodes being queried – such as at airports, train stations or football stadiums.

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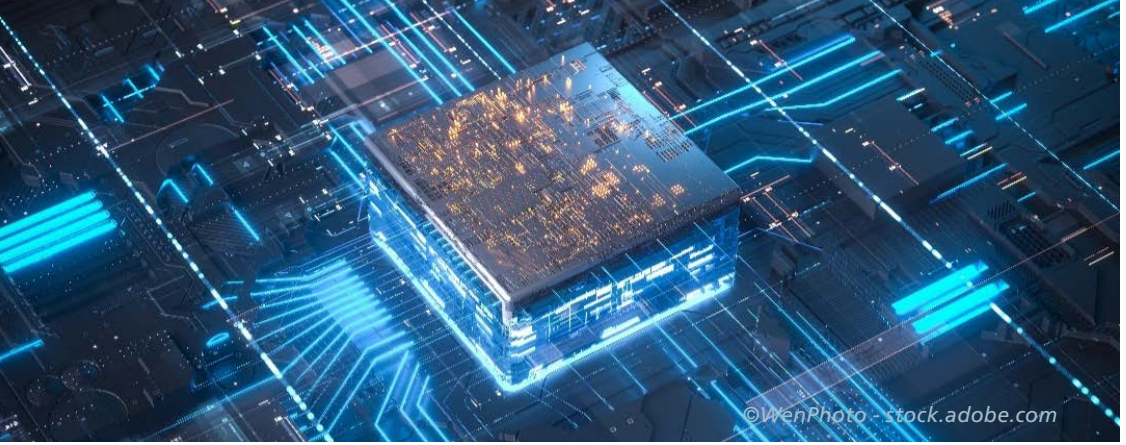

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We Create Efficient Electronics for the Connected World of Tomorrow

At Fraunhofer IIS/EAS, we develop and test new electronic design concepts that enable safe and reliable end products for a world that is becoming increasingly connected. For this purpose, we conduct contract research on early damage detection, virtual testing and modern system packaging solutions for electronic systems. As a partner of the industry, our goal is to support companies with our expertise and research.

Early damage detection makes it possible to detect damage to electronic components before failures occurs. This enables repair or replacement without expensive downtime or redundancy.

With virtual testing the behavior of hardware in different situations can be simulated as accurately as required in a virtual manner to improve the robustness of a system. One of the main application areas is the software-defined vehicle.

Modern system packaging solutions are a must for the development of microelectronics that meet the steadily increasing demands of miniaturization and increasing data throughput.

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Prof. Dr.
Albert Heuberger
Executive Director of
Fraunhofer IIS

Chip design and Production: Perspectives and role in Europe´s competitiveness

Keynote

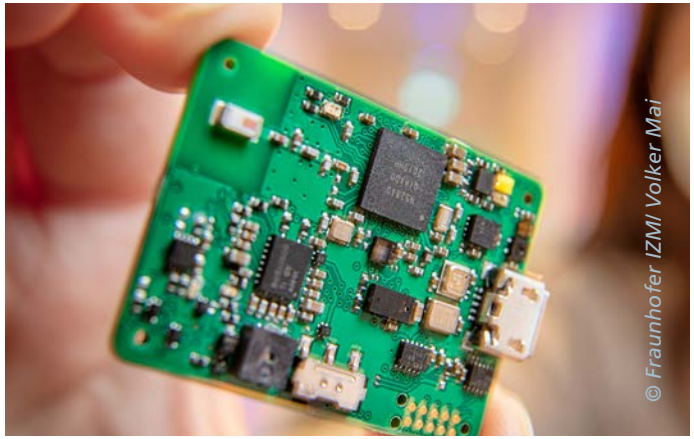
Thursday 16 March 2023
10:00 – 11:00 a.m.
NCC East | Level 1 | Room Sydney

»In the process from the idea to silicon, chip design is the engine of product innovation and thus the key to Europe´s competitiveness.«

#WeKnowHow

IIoT wireless sensor platform and plug & play radar construction kit

Smart fabrication, smart logistics, or smart farming: There is no shortage of ideas for wireless or contactless sensor applications. But until now, testing possible applications meant the time-consuming, piece-by-piece configuration of sensor and data processing technology.



The modular platform Swarmy-V2 acquires sensor data and can adjust its orientation flexibly

Fraunhofer IZM has developed two plug & play sensor platforms for this purpose. Ready for use at short notice, the platforms offer users a flying start for monitoring dynamic workflows in process automation or in machine diagnostics and maintenance.

© Fraunhofer IZM/ Volker Mai

The camera radar module in its housing

Whatever infrastructure is already in place, the »Swarmy« sensor-actuator platform enables the configuration of modular sensor setups for a variety of common variables, including the means to collect, process, and display data. By integrating swarm robotics, the »Swarmy-V2« platform is set to become even smarter.

A universal radar platform for 24, 60, and 79 GHz applications is also available for the efficient implementation of radar projects. It covers ranges from 0.1 to 260 meters with an angular resolution of less than 10°.

Both kits come with uniform interfaces and a configuration process, modules, and assemblies designed according to the Lego principle.

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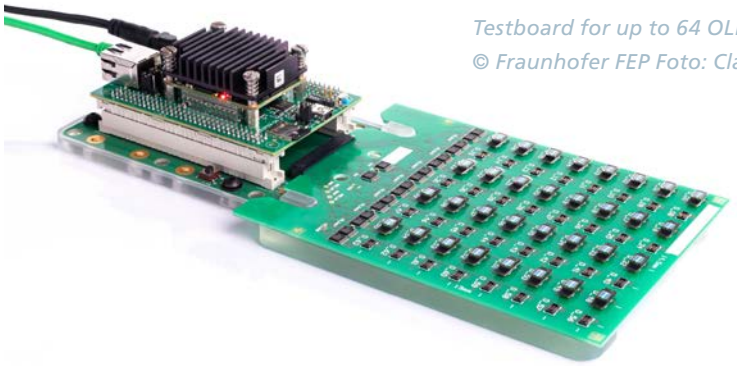

Testboard for up to 64 OLED microdisplays
© Fraunhofer FEP Foto: Claudia Jacquemin

Ultra-low power OLED microdisplays – ready for transfer to industry

OLED microdisplays researched and developed at Fraunhofer FEP have already been offered for several years as evaluation kits. In addition to the design of application- and customer-specific microdisplay chips made possible by means of integrated circuit design, the industry-compatible, standardized manufacturing process technology development up to testing and characterization methods plays an important role. For the latter, a 64-device microdisplay test unit for characterization upon delivery or/and receipt of goods by customers will now be presented for the first time at embedded world 2023.

Large-volume applications of microdisplays were in the past mainly limited to electronic viewfinders and projectors. Especially since the emergence of consumer-ready VR and AR glasses the microdisplay market is increasingly shifting into these areas.

Fraunhofer FEP offers R&D for customer- and application-specific OLED microdisplays and sensors and also corresponding evaluation kits for testing and development purposes to industrial partners. Now the device designs and manufacturing processes for ultra-low power OLED microdisplays have been optimized in such a way that industrial manufacturing environments can be verified under comparable conditions. Now there are advanced opportunities for transfer to industrial customers, e.g. through design/process transfer and licensing for customers' own products, or pilot manufacturing at medium volumes for microdisplay devices that are not available elsewhere in the market.

Martin Rolle, engineer in IC and system design, explains: »We have been able to significantly expand and optimize our pilot-fabrication processes in the cleanroom and with our external partners. Pilot-fabrication capability also includes test regimes and the characterization of components. Standardized test regimes now help to quickly develop and establish customized microdisplays for our customers. Part of this is a new test board, equipped with 64 microdisplay chips each for initial evaluation, which we present at embedded world 2023 for the first time.«

electronic displays Conference 2023

March 16, 2023
Session 9: OLEDs, 11:00 – 11:20 a.m.
Room Shanghai

OLED-on-Silicon Platform for High-resolution and Ultra-low Power Microdisplays

Dr. Uwe Vogel, Head of Business Unit Microdisplays and Sensors, Deputy Director, Fraunhofer FEP

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secureAR – Modular AR service platform for industrial production

The production of the future faces constantly growing requirements for manufacturing optimization. Augmented reality (AR) assistance systems for employees support this and open up new possibilities. In the secureAR project, an innovative, cloud-based service platform is being researched for this purpose. Fraunhofer FEP is developing a novel hardware platform with ultra-low-power microdisplays for this purpose, which will be used in an AR assistance system.

In the future, factories will have to manufacture customized individual products more flexibly and achieve greater profitability. Modern AR assistance systems support employees in this process and can be integrated into production and service processes, improving working conditions and production processes.

The joint project secureAR is working on a cross-industry, cloud-based service platform with open industry interfaces that collects data along the entire value creation source. This enables location- and situation-based provision and visualization of data via a new AR assistance system.

Due to its modular design, this AR system is easily adaptable to all industrial scenarios and can be easily integrated into personal protective equipment. Fraunhofer FEP developed tiny, low-power OLED microdisplays for this purpose, enabling a lightweight ergonomic AR system that can be used both binocularly and monocularly. In addition, it is expandable with sensors and interfaces.

The AR system´s data is acquired and transmitted on a sensor base and transferred directly to secureAR's open cloud-based service platform to protect sensitive enterprise data. Secure data transfer is ensured by the open source operating system L4Re. Thus, the joint project makes an important contribution to Germany's and Europe's digital sovereignty.

More information:

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Embedded systems: looking ahead to the future with AI and sustainability

At the embedded world Exhibition&Conference from March 14 to 16, 2023, five Fraunhofer institutes will present their developments in the fields of edge AI, sustainable systems, and sensor and system design in Hall 4, Booth 422.

Under the motto “intelligent. efficient.sustainable,” the Fraunhofer experts will showcase their latest technologies and projects at the international trade show for embedded solutions in Nuremberg.

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Our solutions for a smart world«

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