Fraunhofer IISB

Fraunhofer Institute for
Integrated Systems and Device Technology IISB

Annual Report 2023

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Achievements and Results

»I consider it the best professional decision of my life to have taken up this job!«

Prof. Jörg Schulze, Director of Fraunhofer IISB and Chairholder and Head of Chair of Electron Devices at the FAU Erlangen-Nürnberg © Elisabeth Iglhaut / Fraunhofer IISB

Editorial

Looking back on now more than two years as Institute Director at the IISB, I consider it the best professional decision of my life to have taken up this job. The Institute, with its topical breadth and deep expertise, offers so many capabilities to contribute to our economic strength and solve our global societal challenges.

This breadth means that the use of value chains is becoming increasingly important. A classic example of this is our well-established end-to-end value chain for silicon carbide from material to system, which is consistently available at one location. The IISB is the only research institute that represents this. But we also use comprehensive synergies and interfaces at the institute for ultra-wide bandgap semiconductors or power electronics. The expansion of value chains, the associated learning, and the creation of the necessary structures are key components of our continuous strategy process.

This enables us to perfect our offering to our customers, who are also increasingly thinking in terms of value chains. This includes our extremely successful IISB model for joint labs with industry partners. We also use proprietary transfer instruments such as the Leistungszentrum Elektroniksysteme (LZE) and coordination with our partner institutes in the Research Fab Microelectronics Germany (FMD).

In addition to silicon carbide, ultrawide-bandgap semiconductors are more and more becoming the focus of our work. The absolute technical highlight in 2023 was our first 1-inch aluminum nitride wafer made from our own crystal material. However, it is not enough to be able to produce excellent crystal material as a basis; in terms of the value chain, the requirements of the desired electron devices and system applications must be considered from the outset.

What's cooler than cool? Cryogenic! In our business area of power electronic systems, we were absolutely thrilled to contribute the first cryogenically cooled 500 kW drive inverter for an industrial superconducting propulsion system. Concerning project volume, the IISB with its power electronics for electric aircrafts is currently one of the biggest avionics institutes within Fraunhofer. This deeply encourages us to continue on this path.

Tapping into other areas of mobility such as aviation and shipping with state-of-the-art power electronics and novel semiconductors gives our industry additional stability in times of transformation in the automotive market.

Inspired by the well-known Bauhaus concept, the IISB, in cooperation with numerous partners, is also initiating dedicated activities for academic and, above all, technical training in microelectronics. The newly gained political attention for chips and semiconductors, the striving for technological sovereignty and availability as well as the planned settlement of international players in Germany imply a need for specialists not only with high qualifications but also in considerable numbers.

We can also look back on great successes in the promotion of young talents: the EVOLONICS student team, jointly supported by the IISB and FAU, attracted immense media attention with its drone system for fighting forest fires.

With this, I would like to warmly recommend to you to find out more about our current activities, hot topics, and R&D work in our annual report.

Sincerely yours,

Prof. Jörg Schulze
(Erlangen, March 2024)

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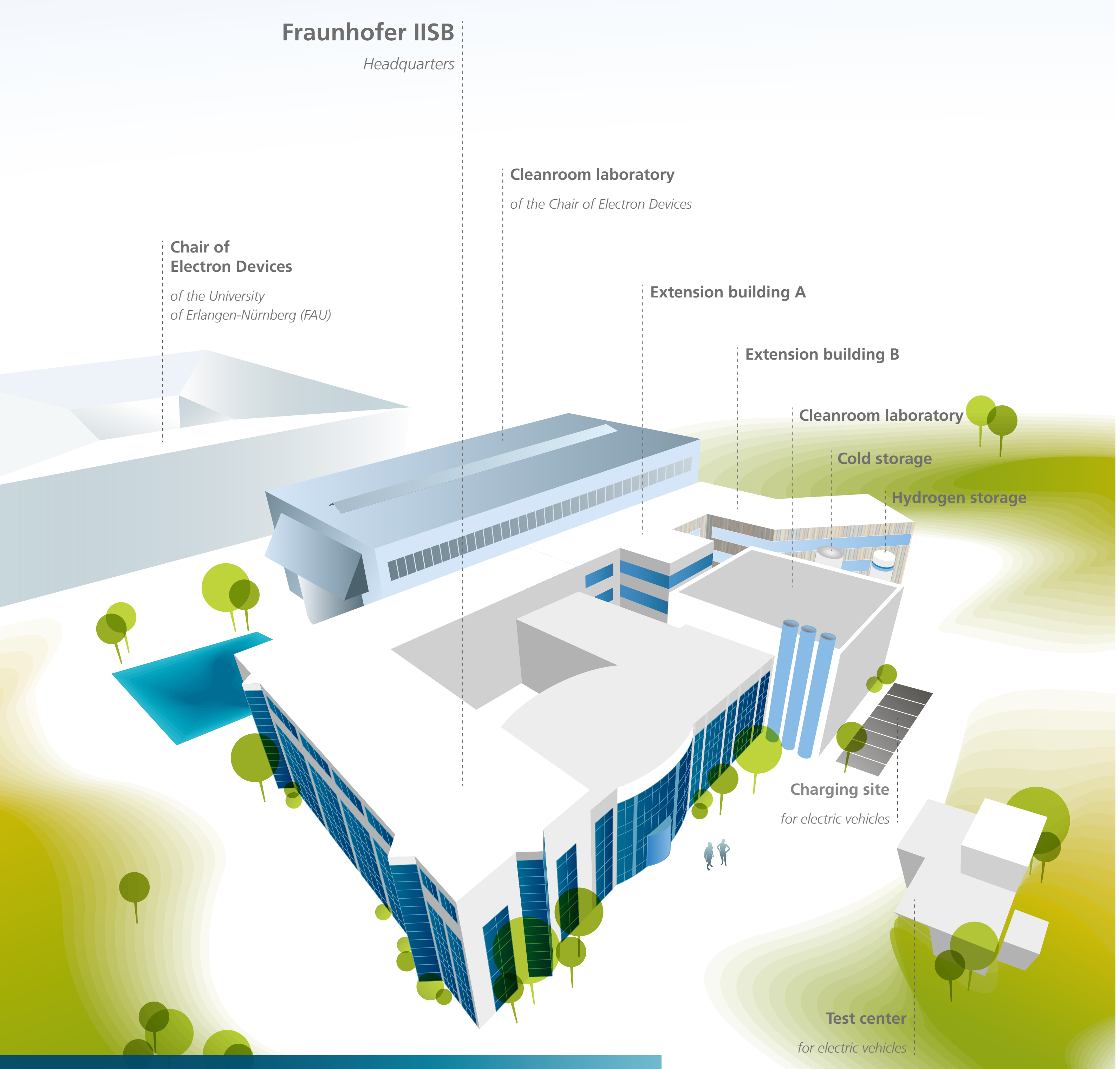

At a Glance

Profile

Intelligent Power Electronic Systems and Technologies - following this motto, the Fraunhofer Institute for Integrated Systems and Device Technology IISB, founded in 1985, conducts applied research and development for the direct benefit of industry and society. With scientific expertise and comprehensive systems know-how, the IISB supports customers and partners worldwide in transferring current research results into competitive products, for example for electric vehicles, aviation, production, and energy supply.

The institute consolidates its activities in the two major business areas of Semiconductors and Power Electronic Systems. In doing so, it comprehensively covers the entire value chain from basic materials to semiconductor device, process, and module technologies to complete electronics and energy systems. As a unique European competence center for the semiconductor material silicon carbide (SiC), the IISB is a pioneer in the development of highly efficient power electronics even for the most extreme requirements. With its solutions, the IISB repeatedly sets benchmarks in energy efficiency and performance. By integrating intelligent data-based functionalities, new use cases are continuously emerging.

The IISB employs about 335 people. Its headquarters are in Erlangen, with another branch at the Fraunhofer Technology Center High Performance Materials (THM) in Freiberg. The institute cooperates closely with the Friedrich-Alexander-Universität Erlangen-Nürnberg (FAU), the TU Berkakademie Freiberg and the University of Bayreuth. The IISB is a founding member of the Energie Campus Nürnberg (EnCN) as well as the Leistungszentrum Elektroniksysteme (LZE). In joint projects and associations, Fraunhofer IISB cooperates with numerous national and international partners.

iisb.fraunhofer.de/network-cooperations

History

The Fraunhofer Institute for Integrated Systems and Device Technology IISB in Erlangen is an established center of applied R&D for intelligent electronic systems, power electronics, semiconductor technology, and materials development in the Nuremberg metropolitan region, Germany, and Europe.

It was founded in 1985 as the Electron Devices department AIS-B of the Fraunhofer Working Group for Integrated Circuits. In 1993, it became a Fraunhofer institute (IIS-B), but was still formally linked to its affiliate institute IIS-A, today's Fraunhofer Institute for Integrated Circuits IIS.

In 2003, IIS and IISB became completely independent from each other as two individual Fraunhofer institutes. From 1985 until 2008, Prof. Heiner Ryssel was the head of the IISB. From 2008 to 2018, Prof. Lothar Frey was director, followed by Prof. Martin März until September 2021. Since then, the institute is led by Prof. Jörg Schulze.

From the beginning, the IISB has been closely cooperating with the University of Erlangen-Nürnberg (FAU). In 2015, the IISB together with the IIS and the FAU Erlangen-Nürnberg founded the »Leistungszentrum Elektroniksysteme« (LZE).

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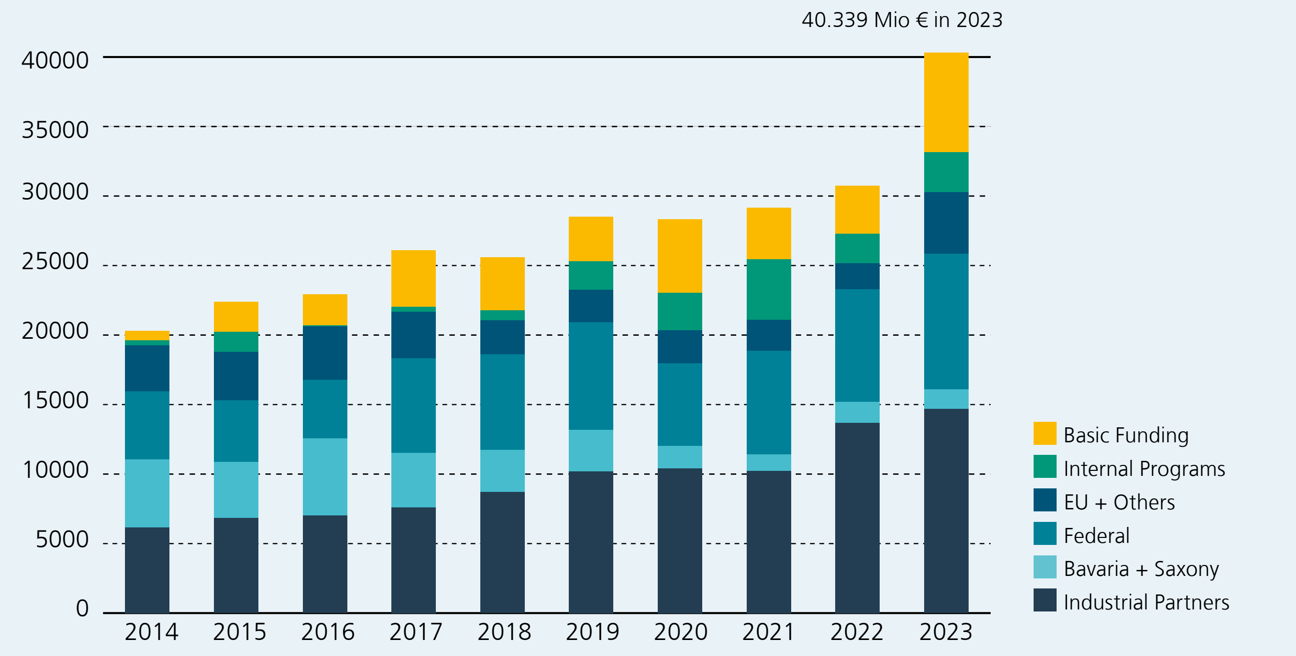
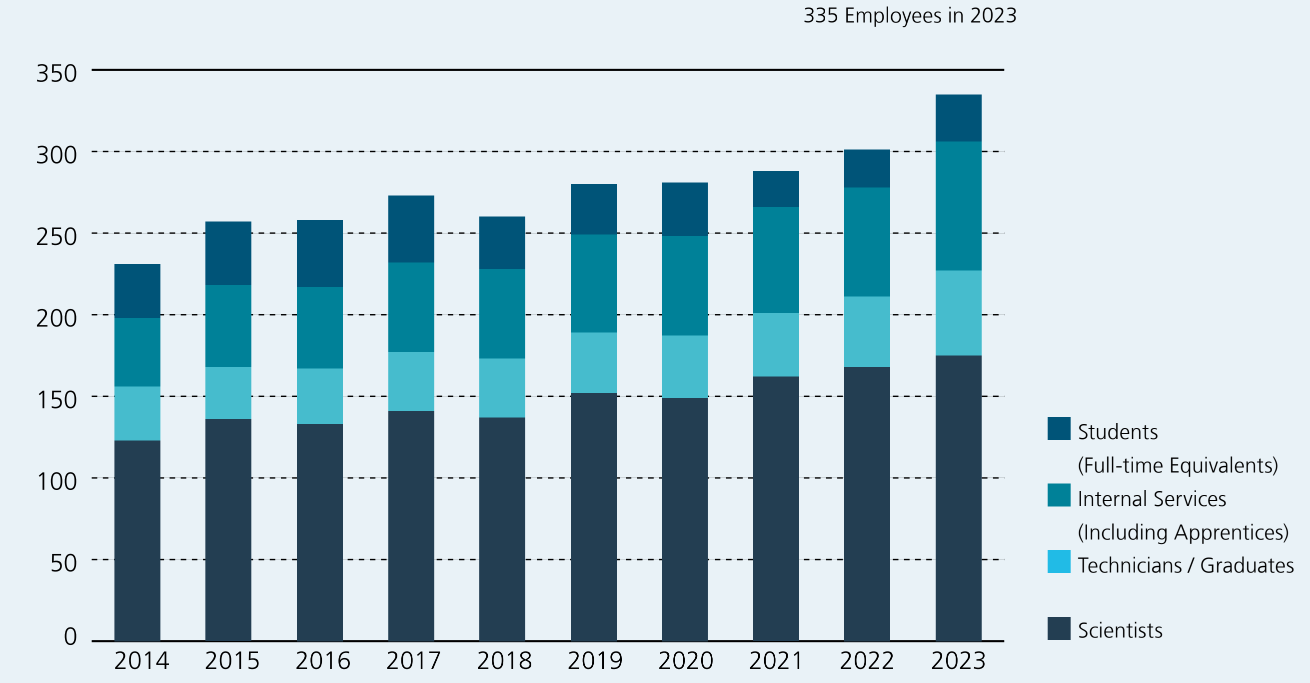
The IISB Advisory Board Consists of Members From Science, Industry and Politics Who Advise the IISB Directorate on Strategic and Structural Development Issues.

Operating Budget



Staff Development



Fraunhofer IISB: One Institute, Many Opportunities © Elisabeth Iglhaut I Fraunhofer IISB

Organizational Chart 2023

Director: J. Schulze

Divisions

- **Energy Materials and UWBG Semiconductor Technology** — J. Heitmann
- **Semiconductor Production Technology** — J. Schulze
- **Power Electronic Systems** — M. März
- **Intelligent Energy Systems** — V. Lorentz

Departments

- **Energy Materials and Test Devices** — U. Wunderwald
- **Materials** — J. Friedrich
- **Advanced R&D** — M. Jank
- **Front End** — S. Oertel
- **Modeling and Artificial Intelligence** — A. Roßkopf
- **Vehicle Electronics** — B. Eckardt
- **Intelligent Energy Systems** — V. Lorentz

Others

- **Central Services** — J. Schulze (acting)
- **π-Fab Management** — M. Pfeffer
- **Strategic Initiatives** — B. Fischer

»The IISB specializes in highly efficient wide and ultrawide bandgap power electronics. We are particularly proud of our unique symbiosis of semiconductor technology, system knowledge and application focus. For our customers and partners, we combine material and device expertise with complex system development and artificial intelligence. This is how we create the next generation of power electronics!«

Prof. Jörg Schulze, Director of Fraunhofer IISB

Division
Energy Materials and
UWBG Semiconductor Technology

»High-performance materials such as new semiconductor and energy materials are fundamental to solve the major challenges of our time: the transformation of our energy system towards sustainability, intelligent mobility and digitalization. Our main interest is a profound understanding of the material properties in order to develop new processes and integration schemes for the need of battery and semiconductor technology. At the IISB's branch office in Freiberg, Saxony, we investigate new, high-performance materials and the associated efficient manufacturing processes together with our partners, the Fraunhofer IKTS and the Institute of Applied Physics (IAP) of the TU Bergakademie Freiberg.«

Prof. Johannes Heitmann,
Head of Energy Materials and UWBG Semiconductor Technology Division,
Head of Technology Center High Performance Materials THM and
Director of the Institute of Applied Physics
of the TU Bergakademie Freiberg
© Daniel Karmann / Fraunhofer IISB

We developed novel Li-free Al-ion batteries, which are based on cost-effective electrode materials and non-flammable electrolytes, achieving high charging currents and high cycle stability. Researching a totally new battery approach allows us to address a recycling friendly design and to establish a model system for the realization of a circular economy already in an early stage of technology development.

In the field of semiconductor materials and devices, one major point of our work is to evaluate the role of defects for the reliability and functionality of upcoming power electronic or quantum devices based on ultrawide-bandgap materials. The development of processes and materials and their integration into prototypes and test vehicles are among the most important tools we use here. We are developing in-operando characterization techniques using spectroscopy and X-ray metrology for the characterization of our devices in working conditions or for the identification and recognition in sorting and recycling processes.

The Fraunhofer THM is a research partner for industry within the framework of industrial contracts and publicly funded projects in the production, application, and recycling of semiconductor and energy materials.

thm.fraunhofer.de

Division Semiconductor Production Technology

»Semiconductors based on wide-bandgap materials help to significantly reduce losses in electrical energy conversion. On industrial scale, silicon carbide has established itself in power electronics, and devices based on gallium nitride are on the rise. It is foreseeable, however, that even these high-performance technologies will be surpassed by semiconductors with an ultra-wide band gap. One very promising UWBG material is aluminum nitride. In order to make it accessible to industry in the medium term and to build up an international leadership position, we are establishing a German value chain for AlN technology together with strategic partners in the frame of the FMD.«

Prof. Jörg Schulze,
Director of Fraunhofer IISB,
Head of Semiconductor Production Technology Division and
Chair of Electron Devices (LEB)
of the Friedrich-Alexander-Universität Erlangen-Nürnberg

The R&D portfolio of Fraunhofer IISB in semiconductor technology comprises the development of crystalline and other functional materials, device and processing technologies in a comprehensive cleanroom environment, as well as packaging and innovative power modules. This is supported by characterization and metrology, test and reliability, modeling and artificial intelligence.

In that context, the Division Semiconductor Production Technology represents the first half of our end-to-end value chain from materials to systems, which is accompanied by a deep understanding of the respective application areas. Our unique SiC prototyping fab ensures high flexibility with regard to our customers' needs. In addition, we very successfully pursue technology development on ultra-wide-bandgap semiconductors, especially in the field of high-class substrates.

In a powerful network, we are continuously extending our activities on our new education concept, the µe-bauhaus Erlangen-Nürnberg, for the combination of academic and technical education in order to train highly qualified professionals for industry. Within the Fraunhofer-Gesellschaft and the Research Fab Microelectronics Germany (FMD), the IISB is the competence center and contact point for power semiconductors.

Materials

»We have profound experience in the areas of semiconductor crystal growth, epitaxy, and device processing including characterization and modeling.«

Dr. Jochen Friedrich, Head of Materials Department © Amelie Schardt / Fraunhofer IISB

The R&D activities of the IISB cover the complete value chain for complex and intelligent electronic systems, from basic materials to devices and modules all the way to complete systems for application in mobility and energy technologies, with power electronics being a consistent backbone of the institute.

We support material, device, and equipment manufacturers as well as their suppliers with scientific-technological solutions in the field of production and characterization of crystals, epitaxial layers, and devices. We improve the material quality and reduce the production cost. We identify defects harmful for device performance and reliability and find solutions to avoid them. We develop technologies for new materials, and tailor the material properties for new applications.

Our focus is on semiconductors for power electronics, communication electronics, sensors & detectors, and quantum technologies. Our strategy is to optimize manufacturing processes through a combination of experimental process analysis, tailored characterization techniques and numerical modeling.

For that purpose, we have a well-suited infrastructure consisting of R&D furnaces and epitaxial reactors, state-of-the-art metrology tools for investigating the physical, chemical, electrical, and structural material properties, and powerful simulation programs for heat and mass transport calculations.

iisb.fraunhofer.de/materials

Spotlight: SiC Epitaxy and Material Characterization

The IISB started working on SiC epitaxy in a time when the small SiC community claimed it was the ideal material for power electronics, but the module and system developers distrusted the defective material and the immature technology. Today, it is even more impressive to see the current maturity and the SiC revolution of the power electronics branch – SiC is a key enabler for sustainable mobility and power generation and distribution. The energy transition is unthinkable without SiC technology. We are proud to be a part of it.

SiC Epitaxy and Material Characterization: Key Competences for SiC Based Power Electronics

The 4H-Silicon Carbide (SiC) homoepitaxial layer is the centerpiece of each and every SiC device - for both power electronics and quantum technology applications - as the epilayer thickness, doping concentration and defectivity are defining the performance and lifetime of the later device. The uniformity of epilayer thickness and doping as well as the defectivity are crucially determining the device production yield. SiC material is still (as most other semiconductor materials) not free of defects; it can contain point defects, dislocations, stacking faults and 3-dimensional defects - their impact on devices is ranging between harmless and "killer defect".

Scientific investigations keep aiming for a deeper understanding of defect origins, strategies for their avoidance as well as their impact on device performance and reliability. While epitaxy development for power electronic devices is mainly focusing on extended defects like stacking faults and dislocations, quantum technology is taking the point defect control to extremes: to control single silicon vacancies (VSi) in 4H-SiC, the spin background needs to be reduced by several orders of magnitude below typical values for power electronic applications, e.g. by eliminating intrinsic point defects, dopants, and isotope mixtures. Hence, it is crucial for the further development of the epitaxial growth process and quality control of the 4H-SiC material to be able to measure these key properties precisely and reproducibly, i.e. epilayer thickness, doping and defectivity. In other words, the improvements in material quality are pushing the metrology developments and vice versa.

Epitaxy and Metrology Capabilities at the IISB

In 2024, the IISB will celebrate the 10^{th} anniversary of its partnership with AIXTRON SE, who is today the leading equipment supplier in the world for SiC epitaxial reactors. Currently, several planetary reactors are running in the joint lab for hardware and process development in Erlangen, including the latest G10-SiC reactors in 9 x 150 mm and 6 x 200 mm configurations for process tuning and customer demonstrations. Although still the majority of SiC wafers is 150 mm in diameter, the reactors also show excellent results on 200 mm SiC substrates. Standard epilayers for 1.2 kV blocking class are about 10 µm thick with an intentional n-type doping concentration of 1-2 x 10^{16} cm^{-3} and optimized defectivity.

All epiwafers directly enter the standardized characterization loop including defect measurements with a Lasertec SICA 88, epilayer thickness with a Semilab EIR 2201 and doping control

Fraunhofer IISB Is Setting up a New Joint Lab With Semilab Zrt, an Established and Leading Metrology Supplier for Semiconductor Metrology. © Daniel Karmann / Fraunhofer IISB

Division Semiconductor Production Technology

with a Semilab CnCV 230. These metrology tools are industrial standard tools and contamination free, hence the epiwafers stay clean and do not need a subsequential cleaning. The SiC epitaxy reactors as well as the standard metrology tools are automated for high throughput and minimizing the risk of manual wafer handling. As today's 1.2 kV epilayers have an excellent and cutting-edge thickness uniformity, the specifications for the metrology tools in terms of measurement resolution, accuracy and repeatability at high throughput are very demanding.

Epitaxy for Next Generation Devices (NGD)
The 4H-SiC substrate market is currently much more volatile and dynamic than in the past years and decades: many new vendors enter the market with large capacities and high crystal quality, "engineered substrates" and thinner substrates claim to have a smaller carbon and energy footprint as well as resistance than conventional substrates. The mature epigrowth processes must be transferred and finetuned to the "new" SiC substrates, i.e. to their surface quality, defectivity, mechanical and optical properties, to keep the epilayer quality and uniformity as high as for conventional substrates.

Next generation power devices demand for larger epilayer thickness, e.g. 30 µm for 3.3 kV blocking voltage, in combination with lower doping in the 10^{15} cm^{-3} range. Hence, the background doping needs to be reduced accordingly. The IISB's solid-state circuit breaker as well as super junction (SJ) technology needs epitaxial overgrowth of ion implanted regions and / or epitaxial trench filling. These two technological routes are competing as each route has its specific advantages and risks, and currently it is unclear who will win the race.

For the SiC-based sensors, there is a need to develop thin and precisely stacked epilayers with alternating dopants (nitrogen and aluminum) and doping concentrations, which requires completely different epigrowth processes and metrology solutions than the NGD in power electronic applications. Quantum technology applications require extremely low point defect concentrations, i.e. the intrinsic points defects like C or Si vacancies as well as impurities, need to be suppressed as far as possible. Additionally, also nuclear spins need to be minimized, hence, isotopically enriched $^{28}Si^{12}C$ needs to be grown with alternative precursors such as ^{12}C methane. Ideally, such extremely pure epilayers are grown on a-plane substrates (instead of conventional c-plane substrates) to access the spin center optically.

These epigrowth developments are covered by several publicly funded projects such as the Transform, Fastlane, and Green Epitaxy projects, but also in bilateral cooperations with industrial partners. These cooperations with our partners will enable us to meet our future milestone and development goals.

Future Trends in Material Characterization
As said in the beginning: the improvements in material quality are pushing the metrology developments and vice versa - we see some urgent metrology developments ahead. Because we are running several epigrowth reactors for production in the joint lab, the capacity and throughput in standard characterization (thickness, doping, defectivity) needs to be increased without installing additional tools - and the precision and reliability of the measurements will be pushed further to the limits.

Minimizing the background doping and point defects in epilayers requires additional, renowned measurement techniques - minority carrier lifetime as well as variants of photoluminescence (PL) measurements will be available soon in modern disguise. To address all these metrology issues, we are starting a partnership with Semilab in 2024 (announced already in 2023), who is an established and leading metrology supplier for semiconductor metrology.

Besides the improvements of individual metrology methods and tools, the comprehensive analysis of characterization results from different tools or methods along the device processing line to the final on-wafer tests is the key to reveal the origin and impact of defects on device performance. Many wafers with thousands of devices are needed as statistical base for such an approach – as well as an elegant and effective software solution to align and analyze the data. This will be the next, exciting step in SiC material characterization.

The SiC Epitaxy Group at Fraunhofer IISB
Our core task is the technological and scientific development of SiC epitaxy and metrology. We are supporting projects, colleagues, and partners with SiC material, epiwafers, measurements, our experience and equipment. And we are developing the epitaxy demo lab to an international show room for SiC partners, i.e. we are providing a platform for industrial partners to optimize their tools for SiC technology and bring them into the SiC community. We are also supporting technological newcomers entering the SiC technology. As we are experts on SiC material aspects, we have a watchful eye on the interaction of defects and device processing.

iisb.fraunhofer.de/siliconcarbide

Several Planetary Reactors Are Running in the Joint Lab for Hardware and Process Development with AIXTRON SE, Including the Latest G10-SiC Reactors in 9 x 150 mm and 6 x 200 mm Configurations for Process Tuning and Customer Demonstrations.
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Advanced R&D, Front End and π-Fab Management

»Our common goal is the coordinated provision of an efficient, quality-assured process and development environment for Si and (U)WBG device prototypes as well as associated training and education concepts.«

Dr. Susanne Oertel, Head of Front End, Dr. Markus Pfeffer, Head of π-Fab Management, and Dr. Michael Jank, Head of Advanced R&D.
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With a reorganization of responsibilities in the area of semiconductor devices and processing, the unit, which has been operating under the well-known π-FAB concept at the IISB for years, was given a solid foundation for further development.

π-Fab Management

Traditional management functions are now bundled in a new team, which is positioned between the two departments Advanced R&D and Front End. Under the leadership of Dr. Markus Pfeffer, the π-FAB management group is now responsible for the quality management and assurance, infrastructure, in particular clean room operation with air conditioning and central media supply, and process control, in a special way the operation and enhancement of the Management Execution System MES in association with FMD partners.

The reorganization not only relieves the specialist departments of the management and tracking of the central tasks, but allows them to contribute their technological expertise via agile teams to address common issues.

Front End

The Front End department headed by Dr. Susanne Oertel is responsible for semiconductor processes and accompanying metrology in the clean room laboratory. In addition to ensuring operation and system maintenance, this includes the availability and further development of manufacturing processes with the aim of high availability and stability.

In line with the wide range of vertical tasks, the department has been organized into technology areas, each with experienced area managers who independently carry out all requirements from predictive maintenance and ensuring system specifications through to classic process engineering. Due to their many years of experience and expertise, some area managers have additional tasks, such as assignments (e.g. safety, hazardous substances, waste disposal) and other important activities, like inventory checks and reordering chemicals, gases and consumables.

Furthermore, the Front End department trains apprentices in microtechnology each year. The experienced team of instructors has been promoting the microtechnologist apprenticeship for many years at job fairs, through presentations at schools, by taking part in Girls' Day and by organizing internships

for pupils. On the one hand, the microtechnologist training program aims to provide the institute's own junior technical staff and, on the other hand, to qualify microtechnologists for industry and other research institutes after three years of apprenticeship.

Advanced R&D

The department of Advanced R&D initiates and promotes research and development tasks to establish new device concepts and improve existing technologies. Under the leadership of Dr. Michael Jank, the department works on SiC MOS and bipolar components, SiC CMOS ICs, sensors and detectors. Also, special silicon devices are being developed that enable power electronic applications and the efficient use of SiC components in line with the IISB's strategic orientation.

All topics and tasks are defined and handled in close cooperation with the Materials, Modeling and Artificial Intelligence as well as the Vehicle Electronics and Intelligent Energy Systems departments. In enhancement to traditional device research, a wide range of projects are carried out, from service contracts with just a few process steps to prototype manufacturing with a high degree of technological maturity.

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The µe-bauhaus erlangen-nürnberg

The new structure makes it possible to coordinate the usage of the cleanroom laboratory across the board and optimally utilize capacities. For each requirement, individual responsibilities are assigned in the departments. The core team at the front end is supported by employees from the research sector. For this purpose, the concept of the Doctoral Student Line was developed, which, in addition to increasing capacity for processing, above all enables an in-depth networking. This guarantees that the device developers are more closely linked to the implementation of "their" processes and can gain a deeper understanding of the key process steps.

This close integration of technical and scientific disciplines results from the implementation of the Bauhaus concept, which is established at the IISB together with the Chair of LEB at FAU, from industrial and student training to the integration of doctoral students.

The common goal of all the teams involved is the coordinated provision of an efficient, quality-assured process and development environment for Si and (U)WBG device prototypes as well as associated training and education concepts. In this way, excellent research and services can also be made available and realized for our industrial and public clients.

The π-Fab Management Team: Maximilian Beier-Ardizzon, Cleanroom Infrastructure Management, Dr. Markus Pfeffer, Head of π-Fab Management, Dr. Sabrina Anger, Quality Assurance, and Katharina Gleich, Quality Management.
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Spotlight: IC Services by Fraunhofer IISB within EUROPRACTICE

As a unique European competence center for the semiconductor material silicon carbide (SiC), Fraunhofer IISB is a pioneer in the development of highly efficient power electronics. Here, the institute's research activities cover the entire value chain - from basic semiconductor materials to power electronic systems. In addition to the advantages that SiC offers over silicon in the area of power semiconductor devices, it also has other material properties that open up fundamentally new areas of application, such as the use of SiC devices and circuits at very high temperatures of up to 600 °C.

As part of EUROPRACTICE, the IISB offers its customers and research partners access to its high-temperature-capable 2-µm SiC CMOS technology, which enables the integration both of logic and analog circuits as well as sensors and lateral power transistors.

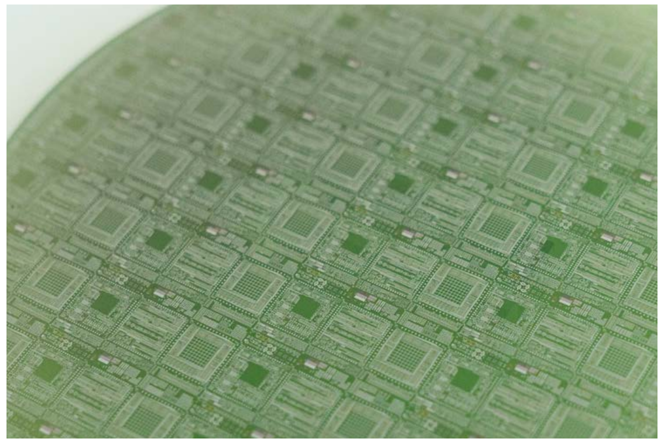
The technological basis is a continuous and industry-compatible process line for SiC wafers with diameters of 150 mm and 200 mm, which includes advanced hetero-integration and patterning technologies. The range is completed by a technological portfolio for packaging and interconnection technology as well as for extensive reliability tests of electron devices and modules.

The multi-project wafer (MPW) service, which is provided by the IISB via EUROPRACTICE Early Access, is intended specifically for universities and research centers, as it enables the development of SiC CMOS circuits at low manufacturing costs. Customers allocate a part of the available wafer area with their designs, get the finished chips for metrology and characterization and can then optimize their circuits. The availability of a first version of a Cadence-based Process Design Kit (PDK) enables an easy integration of circuit design and modeling into the customers' standard development workflows.

The integrated circuits processed on the basis of IISB's SiC technology can be operated at temperatures of up to approx. 600 °C. Additional optional process modules are available for the manufacturing of lateral high-voltage devices up to around 900 V or for the utilization of special back-end processes - for example wafer thinning or sinterable backside metallization. Moreover, the technology can be adapted to process special optical SiC devices or to integrate quantum sensors.

EUROPRACTICE
IC SERVICE

The EUROPRACTICE IC Services platform is a one-stop shop for all services related to the design and manufacture of electron devices and intelligent integrated systems. This includes access to a wide range of CAD tools, training and state-of-the-art process technologies.



Sensor Arrays and Integrated Circuits on a 4H-SiC Wafer Processed as Part of a EUROPRACTICE Wafer Run.
© Elisabeth Iglhaut / Fraunhofer IISB

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Europe's Only High-Temperature 4H-SiC CMOS Technology: IISB's SiC CMOS Early Access Technology Enables Fabrication of Integrated Analog & Digital Circuits on 150 mm Wafers Which Can Operate at Temperatures up to Approx. 600 °C. Custom Solutions Also Allow for Integration of Sensors, e.g. UV and Temperature, as Well as Lateral Power Devices.
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Division Semiconductor Production Technology

Spotlight: SiC UV Diodes on Mars Mission

Even in space, SiC demonstrates its outstanding physical properties: A SiC UV photodiode from the Berlin-based company sglux is on board the current NASA mission Mars 2020. The SiC chip with the heterostructures for the UV photodiode was processed at Fraunhofer IISB in Erlangen on the institute's own CMOS line. Since the Mars rover "Perseverance" landed on the surface of Mars on February 18, 2021, the SiC photodiode has been functioning with absolute reliability under extreme environmental conditions. The UV sensor is a component of the SHERLOC deep-UV Raman spectrometer, employed by NASA to search for traces of past life on the surface of the red planet.

A Class of its Own
Among WBG semiconductor materials, silicon carbide (SiC) has become particularly popular, and a wide range of commercial products is already available. In applications where the highest power densities and highest power conversion efficiencies are required, SiC devices with their superior electrical properties are already displacing conventional silicon power electronics.

But the special physical properties of the WBG semiconductor silicon carbide open up further interesting application options, such as in optoelectronics and sensor technology or for solid-state quantum electronics. For this reaseon, the Berlin-based high-tech company sglux relied on SiC sensor components at an early stage and successfully established itself on the market with SiC photodiodes for measuring ultraviolet radiation (UV). These photodiodes are used wherever safety is a top priority. This is the case, e.g., in medical technology for monitoring dialysis, in food processing for controlling sterilization processes, or in industry for controlling combustion processes.

The core components for the UV diodes, SiC chips with SiC heterostructures, are processed at Fraunhofer IISB in Erlangen, according to sglux specifications on the institute's own SiC CMOS line.

SiC Conquers Space
One of the most challenging operating environments for electronic components is certainly space. Here, all components must function absolutely reliably under extreme conditions, and even the smallest errors or failures can jeopardize the entire mission. Against this background, it is a great success for sglux GmbH from Berlin and also for Fraunhofer IISB that even NASA now belongs to the customer base of the SiC pioneers. During the current NASA mission MARS 2020, a SiC UV photodiode from sglux also landed on the red planet with the Mars rover "Perseverance" on February 18, 2021, and has been functioning reliably ever since.

The exceptional environment provides the perfect opportunity to demonstrate the reliability of sglux's products and the quality of the SiC sensors manufactured in small series at the IISB. "Perseverance" – which means endurance or tenacity – is the most advanced and elaborate rover NASA has ever sent to Mars. The roughly two-and-a-half billion dollar exploration vehicle is searching the Martian surface for traces of past microbial life and characterizing the planet's geology and climate, in preparation for a future manned Mars mission, among other things.

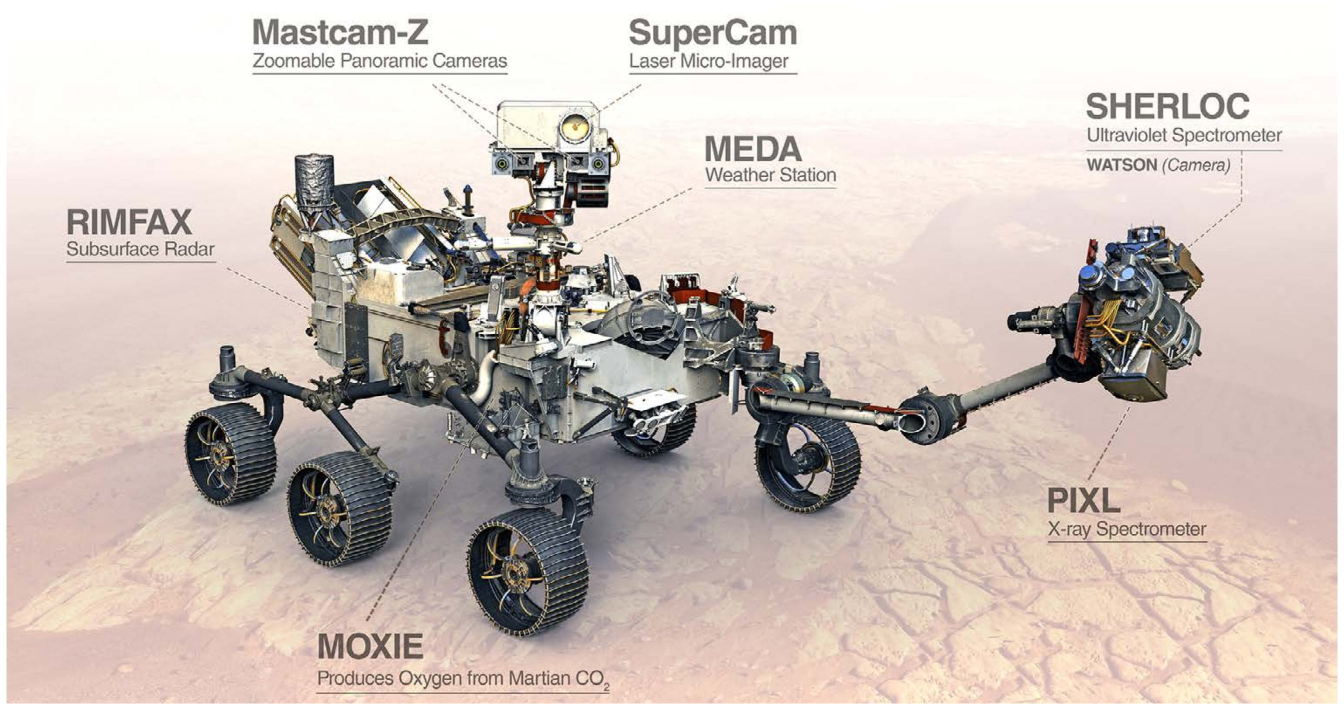
Life on Mars
Perseverance has a suite of state-of-the-art science instruments, among which a deep-UV Raman spectrometer attached to the rover's robotic arm plays a special role. Dubbed SHERLOC (Scanning Habitable Environments with Raman & Luminescence for Organics & Chemicals), the high-tech instrument is the first ever UV Raman spectrometer on Mars. There, it enables non-contact, spatially resolved and highly sensitive detection and characterization of organic matter and minerals on the surface and in the near subsurface. Meanwhile back on Earth, Raman spectroscopy, named after the physicist C. V. Raman, is used, for example, to study the material properties of semiconductor crystals.

Supported by a special camera called WATSON (Wide Angle Topographic Sensor for Operations and eNgi-neering) and a UV LASER, SHERLOC detects organic matter and minerals and creates topographic maps from them. Researchers on Earth then evaluate the measurement results and mineralogical maps to see if there is evidence of past water impact and signs of past life on Mars. Based on this, it will be decided which rock samples Perseverance should take and leave sealed in metal tubes on the surface of Mars for a future return to Earth (resample mission).

Ultimate Endurance Test
For its measurements, the UV Raman spectrometer uses a deep UV laser with a wavelength of 248.6 nm focused on a spot less than 100 µm in diameter. A SG01XL-5 SiC UV broadband photodiode from sglux is installed near the laser aperture, and detects the UV radiation power emitted by SHERLOC during spectral map measurements so that the laser output can be monitored when scanning the surface.

Before its use, sglux adapted the manufacturing process of this photodiode to its application and carried out elaborate selection, testing and characterization procedures. Subsequently, NASA subjected the candidates selected in this way to further tests and trials, for example on vibration resistance, behavior under strong acceleration, high-temperature resistance and alternating strength.

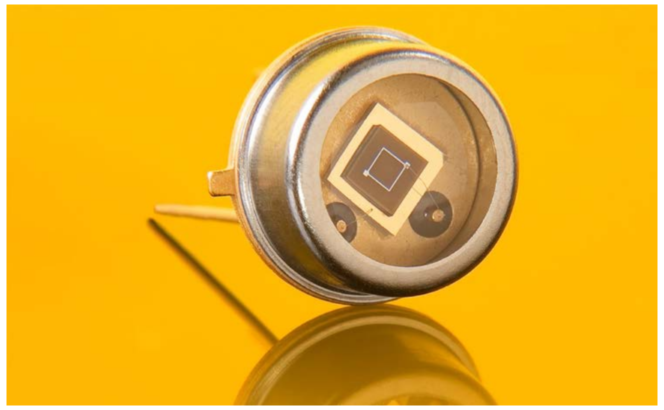
Artist's Rendering of the February 18, 2021 Landing of the Mars Rover Perseverance on Mars in Jezero Crater. The Main Goals of NASA's MARS 2020 Mission Are to Search for Signs of past Life and to Collect Rock and Soil Samples for Later Return to Earth © NASA / JPL-Caltech



Cutting-Edge Technology on the Mars Rover: Perseverance Possesses Seven Sophisticated Scientific Instruments for the Detailed Study of Its Environment. The Exploration Vehicle Has a Robotic Arm with the SHERLOC Deep-UV Raman Spectrometer mounted on the end © NASA / JPL-Caltech

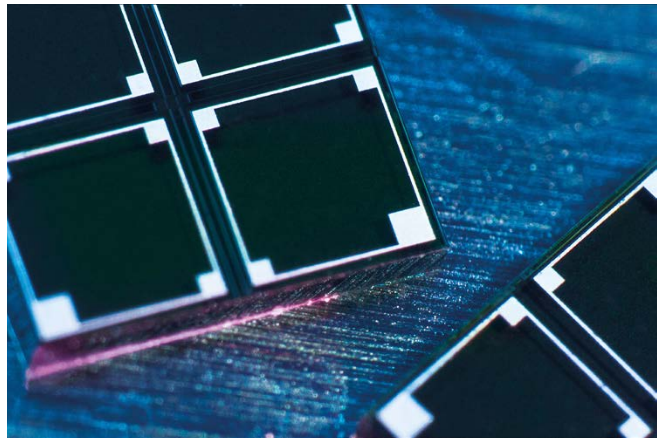
Unique Material Properties
Due to its unique properties, silicon carbide is currently the best semiconductor material for daylight-insensitive UV detectors and is ideal for use in difficult environments. The SiC-based photodiodes are almost completely blind to light in the visible wave range and impress with their high response speed. The small dark current in the femtoampere range ensures low noise, so that even very low UV radiation intensities can be measured reliably.

The SiC detectors tolerate comparatively high operating temperatures and operate stable in a temperature range from minus 55 to plus 170 °C. In this case, the temperature coefficient of the signal reaches values of less than 0.1 % per Kelvin and temperature-related changes in the measurement sensitivity can be compensated well. In addition, SiC has extreme radiation hardness, allowing the devices to retain their excellent electrical properties even when exposed to long and strong irradiation.



Highly Reliable, Space-Qualified and Daylight-Insensitive SG01XL-5 Broadband SiC UV Photodiode from Sglux in a Proven TO5 Package. The Aging-Resistant, Low-Noise and Fast-Response SiC UV Sensor Operates Stable over a Wide Temperature Range. The 7.6 X 7.6 mm² Silicon Carbide Chip, Which Was Processed at Fraunhofer IISB, Can Be Seen in the Center of the Housing © sglux

Economy and Science
New semiconductor materials such as silicon carbide always enable new applications. This gives newcomers and smaller companies in particular the opportunity to actively create value in the high-tech sector with innovative in-house developments. This commonly requires highly specialized key components that must be reliably available despite low quantities. SMEs and start-ups in particular often find it difficult to turn their brilliant ideas into marketable products due to a lack of in-house resources. However, competitive pressure is also increasing for medium-sized companies, and the investment required for technological progress is growing steadily.



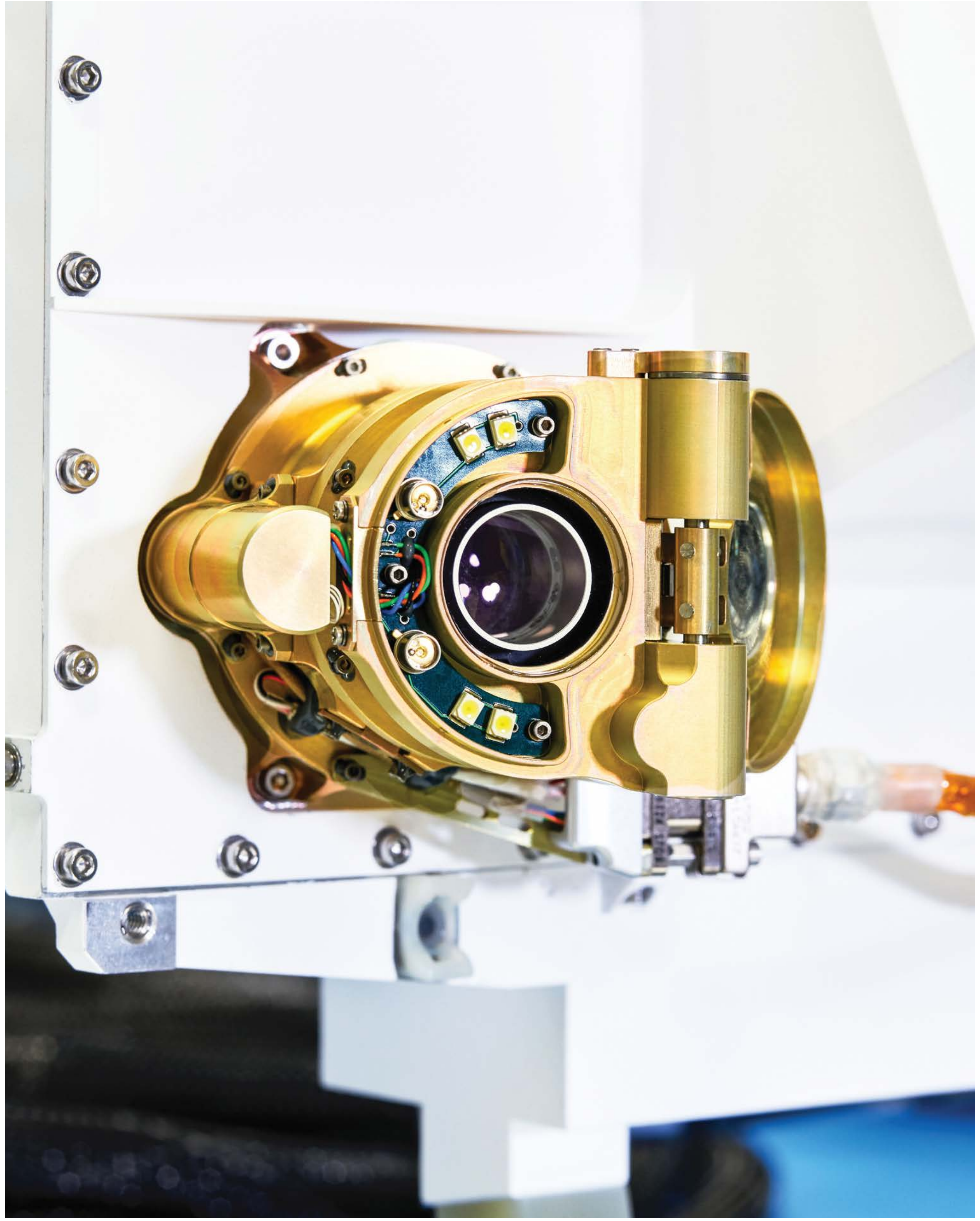
Close-up of Silicon Carbide Chips Processed at Fraunhofer IISB. The SiC Substrates Each Carry a 4x4 Sensor Array with Tunable Integrated and Ion-Implanted UV Photodiodes © Anja Grabinger / Fraunhofer IISB

The big players, on the other hand, have little room for experimentation in their large production environments, where capacity utilization and yield take absolute priority.

Against this background, it is essential to offer SMEs, mid-sized companies and also industry low-threshold access to high-tech infrastructure and know-how in the field of semiconductor technology. Great successes are possible through collaboration between innovative companies like sglux and research institutes such as Fraunhofer IISB, as impressively demonstrated by the example of sglux's SiC UV diodes, which have traveled

NASA MARS 2020 Mission Perseverance Rover: https://mars.nasa.gov/mars2020/

iisb.fraunhofer.de/sic-services



Close-up of the SHERLOC Deep-UV Raman Spectrometer on the Mars Rover Perseverance. The UV Spectrometer Is Equipped, among Other Things, with a SiC UV Photodiode by Sglux GmbH Berlin, Processed at Fraunhofer IISB in Erlangen. The UV Sensor with TO5 Housing Is Mounted to the Left of the Camera Lens and Measures the Radiation Power of the Raman Spectrometer in the Deep UV Range © NASA / JPL-Caltech

Modeling and Artificial Intelligence

»Nowadays, simulation is indispensable for the development of microelectronics, nanoelectronics, and power electronics.«

Dr. Andreas Roßkopf
Head of Modeling & Artificial Intelligence Department
© Elisabeth Iglhaut / Fraunhofer IISB

The work of our department is based on physical understanding and on the application of Artificial Intelligence, and ranges from equipment and processes to devices, circuits and electronic systems.

The department continues to combine the development of simulation capabilities with their application to technological challenges at the institute or with external partners: application knowledge is essential to guide tool development in terms of priorities and relevant effects. Our expertise in the capabilities and limitations of the physical models and algorithms used is fundamental to the efficient and reliable application of simulation.

Our work benefits from decades of experience in Technology Computer-Aided Design TCAD and a broad cooperation with highly qualified partners all over Europe, among others in European projects coordinated by us. Various results from our cooperative projects are widely used in industry and research within standard TCAD tools. This solid foundation has also allowed us to embark on new simulation approaches such as physics-informed Artificial Intelligence or new promising application areas such as supporting the development of quantum computing or its use for optimization tasks.

Among others, the department supports the development of silicon carbide devices at the IISB including the broad access to this technology via Europractice, the development and application of quantum computing in the Munich Quantum Valley initiative, and the industrial development of EUV lithography at the European level. The department has demonstrated that the combination of physics-based simulation with techniques from the area of Artificial Intelligence enables breakthrough developments in various application areas, e.g. masks for EUV lithography or circuits, systems for power electronics and extraction of optimization strategies based on experiments and physical simulation.

Following the retirement of my long-standing colleague and head of department Dr. Jürgen Lorenz, I am delighted to be strengthening this approach as the new Head of Department from December 2023.

iisb.fraunhofer.de/mki

Spotlight: Physics-Informed Neural Networks for Engineering

Current devices in the field of electronics have become increasingly sophisticated and complex. Just think of the transistor, which was a relatively simple structure of about 1 µm in size and has become an intricate device that is as small as a few nanometers today. But not only electric devices such as transistors or diodes, but also several other systems such as e.g., batteries or even induction plugs, are increasingly optimized and complex. For this to continue further, it is usually not feasible to construct new variations on intuition alone and hope that one of these variations outperforms the previous iteration. Instead, physical simulations are employed to give the search for improvement a direction and predict promising new candidates for the devices in question.

Historically numerical approaches, like finite element or finite volume method, Monte Carlo or density functional theory simulations have been used as the work horses of simulation. These methods are based on the solution of equations that describe the underlying physics of the system under consideration. During the last decade, it became increasingly popular to use machine learning algorithms for the prediction of physical results. These approaches do not include known equations, but instead are completely data-driven and try to extrapolate results from the learned datasets, which comes at the (often intractable) costs of generating the datasets first.

In recent years, Physics-Informed Neural Networks (PINNs) have emerged to mitigate such issues and accelerate scientific computing in various applications. PINNs are a type of neural network that incorporates prior knowledge about the underlying physical laws of a problem into the neural network architecture. This is achieved by adding physical constraints such as partial differential equations (PDEs), boundary and initial conditions into the loss function of the neural network to enforce the solutions to satisfy the governing equations of the considered physical system. When trained successfully, the PINN is able to approximate the relationship between input variables (e.g. spatial or temporal coordinates) and output variables (e.g. temperature or concentration quantities) according to the physical laws. To amortize the required training times (up to several hours on modern GPUs), advanced approaches like Operator Learning and parametrized PINNs aim at learning to predict the solution for a wide range of problems, e.g. based on different initial conditions or material properties, instead of solving single instance problems.

Furthermore, PINNs can easily be coupled with measurement data to learn from both physics and data in a hybrid manner,

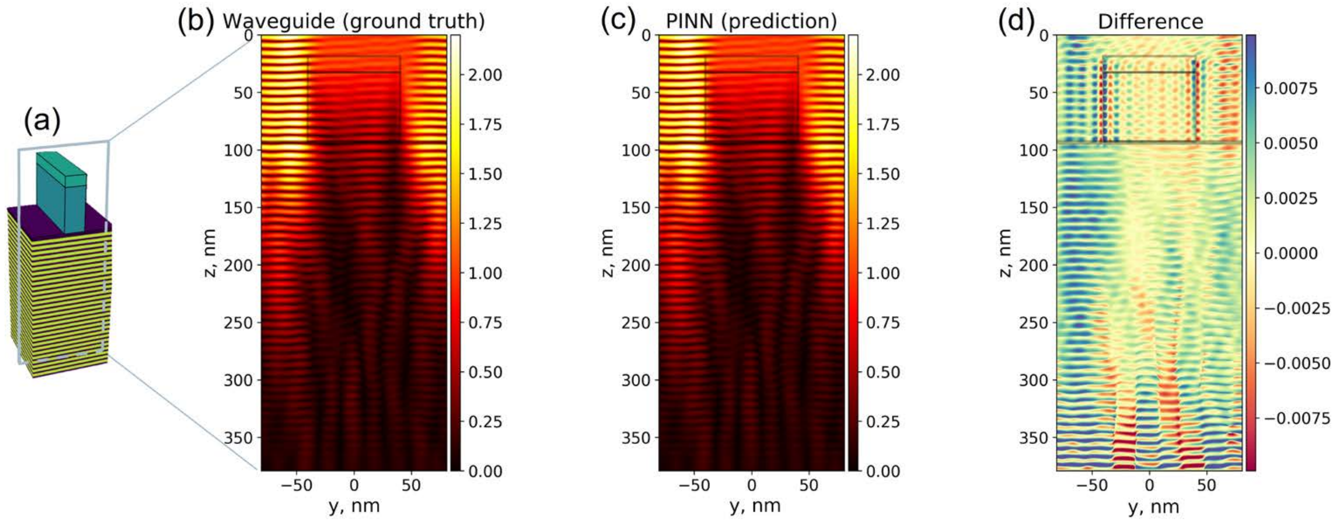


Fig. 1: Evaluation of PINN Prediction Accuracy by Comparison of Simulated Near E-Field from an EUV Mask: (a) 3D EUV Mask. Use Case: Horizontal Line on the Top of MoSi Multilayer. Feature Size: 20 nm with a Pitch of 40 nm (Wafer Scale); 80 nm with no Biasing (Mask Scale). Absorber: 60 nm Thick; TaBN Material. Illumination: A Plane Wave Under ϕ = 6 °; ϑ = 0°. (b) Amplitude Computed Numerically with Waveguide Method; (c) Amplitude Predicted by PINN; (d) Image Difference With Mean Absolute Percentage Error in xy-Plane MAPExy = 0.18 %; Mean Absolute Percentage Error MAPE = 0.91 %; RMS Error RMSE = 4.1E-3 a.u.
© Vlad Medvedev / Fraunhofer IISB

which is particularly interesting for complex systems that cannot be sufficiently described by PDEs and therefore require simulations to be calibrated by real-world data to reach the required accuracies.

At Fraunhofer IISB, the use of the PINN method for different application areas has been investigated, leading to very promising results. One prominent example is the modeling of EUV lithography where traditional electromagnetic field solvers are inefficient for large-scale technology problems. PINNs on the other hand, can simulate light scattering in several milliseconds without re-training and independently of problem complexity. The developed PINN model demonstrated significant speed-up (up to x10.000) with respect to the numerical solver for the simulation of the same setting. Compared to other machine learning approaches, a PINN can accurately simulate the near field without supervision by any experimental or rigorously simulated data. The PINN learns given physics and captures the optical and mask-induced 3D effects. The results of modeling near- and far-field diffraction (Fig. 1) using a PINN showcase an outstanding performance in terms of convergence behavior, stability, and accuracy. Lithographic process windows (Fig. 2) predicted with a PINN almost completely overlap with the reference results.

The good accuracy of the image metrics, which was observed in comparison with numerical simulations, demonstrates the potential of PINN for use in accurate image simulation for computational lithography applications.

Another successful application of PINNs is in the field of transformer design, where it is a common problem to find the geometric setup that minimizes core losses while obtaining

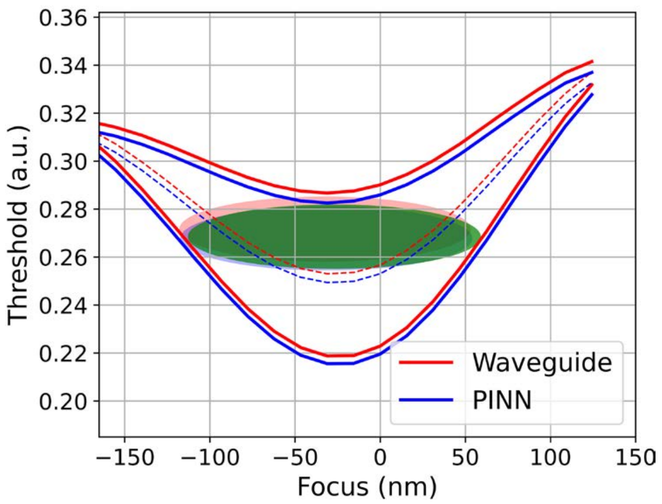


Fig. 2: Evaluation of PINN Performance in Lithographic Imaging of 20 nm Horizontal Line: Simulated Lithographic Process Windows © Vlad Medvedev / Fraunhofer IISB

certain circuit-related properties, e.g. ranges for the coupling and inductances. Here, we were able to demonstrate the applicability of PINNs by implementing convolution-based PINNs that are trained to solve the underlying magnetostatic problem for a wide range of geometric setups involving degrees of freedom for widths, heights and locations of ferrite structures and copper windings, cf. Figure 3. The problem is solved with two different excitations on the two transformer windings to extract inductances and coupling for the given setup. After training for several hours, a wide range of different axisymmetric geometries are evaluated within milliseconds to obtain results on inductances and couplings with errors below 1 %, cf. Fig. 4.

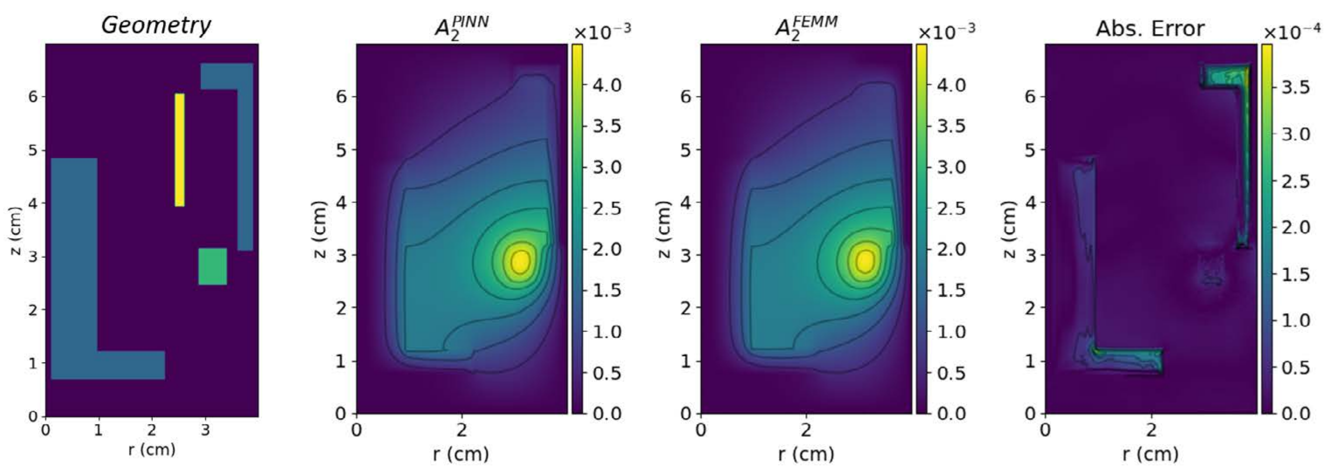


Fig 3: a) Transformer Geometry (Rotational Symmetry Axis at r=0) with Ferrite Structures (blue) and Two Copper Windings (Yellow and Green). (b)-(d): Evaluation of PINN Prediction (b) Versus FEMM Reference Solution (c) for the Resulting Magnetic Vector Potential in Case of Current Excitation in the Green Winding. (d) Shows the Difference Between PINN and FEMM Predictions © Vlad Medvedev / Fraunhofer IISB

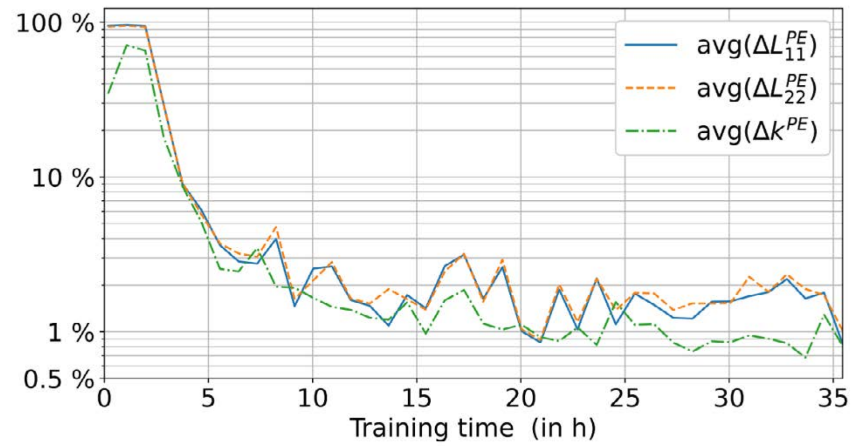


Fig 4: Evolution of Percentage Errors in PINN-Predicted Inductances L_{11}, L_{22} and Coupling k Based on 100 Randomly Selected Geometries © Vlad Medvedev / Fraunhofer IISB

Additional efforts at the IISB showcased the viability of PINNs in further applications, e.g. for the simulation of diffusion reaction processes during the diffusion of platinum in silicon or for solving the single-particle Schrödinger equation. In addition, several new projects including PINN methods are on the horizon or being worked on at the moment: PINNs can find a potential application in metasurface design within the European project FABulous. In the European project FASTEST, PINNs are used to improve modeling, design of experiments and test virtualization during the R&D phase of battery systems. The internal Fraunhofer project ESPINN will combine concepts from explainable AI with PINNs and investigate their application for silicidation and photoresist models.

PINNs provide the possibility of combining the best of the two established worlds of numerical simulation and data-driven machine learning. At the IISB, with its many research and engineering problems, this offers the opportunity to create models with previously unrivalled solution accuracy and speed, which will fundamentally change future engineering processes.

iisb.fraunhofer.de/ai-augmented-simulation

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Division
Power Electronic Systems

»Sustainability in energy supply and mobility is a key in meeting the imminent environmental and economic challenges our society is facing. Innovative solutions require fresh thinking, leaving beaten tracks, and a comprehensive view of the overall system. This is exactly the mission and motivation behind the research work at Fraunhofer IISB on intelligent power electronics and energy systems.«

Prof. Martin März,
Head of Power Electronic Systems Division and
Chair of Power Electronics (LEE)
of the Friedrich-Alexander-Universität Erlangen-Nürnberg
© Amelie Schardt / Fraunhofer IISB

One focus of our research work is on sustainable mobility systems whether in the automotive sector, commercial vehicles, ships, or aircrafts. Electric flying in particular poses enormous challenges for power electronics, especially with regard to safety, robustness, availability, power density, and weight. In addition, there are demanding technical boundary conditions such as cryogenic cooling media, the use of superconductors or cosmic radiation.

We are also constantly expanding our research activities in the area of local DC networks, particularly with regard to new protection components and converter concepts for applications up to the medium-voltage and megawatt power range.

Another important field of research is cognitive power electronics, i.e., power electronics that is able to generate maximum information about its environment – whether it is monitoring the stability of grids or the condition of customer systems and machines.

Vehicle Electronics

»Electric power trains become quite common for passenger cars, that can be seen on the public roads all over the world. But there is still a great demand in research for further improvements.«

Dr. Bernd Eckardt,
Head of Vehicle Electronics Department
© Anja Grabinger / Fraunhofer IISB

A growing number of new application in trucks, ships and even electrified aircrafts arise with a need for more powerful and application optimized power electronic solutions. Therefore, the focus of the Vehicle Electronics Department is to design the next generation of power electronics and get wide (e.g. SiC and GaN) and ultra-wide (e.g. AlN and GaO) bandgap semiconductors, advanced power electronic concepts and control strategies into new and challenging applications like aircrafts.

Together with our industry and research partners we can already today show power electronic solutions that will be in production in 2035. Therefore, the latest power semiconductors of SiC and GaN devices are considered and new power modules with low parasitic impedance and optimized thermal conductivity are developed. These modules are integrated in advanced mechatronic solutions for small size, low weight and high mechanical robustness to get the most advanced technology ready for the bench or test vehicle integration.

An upcoming topic beneath the SiC traction drive inverters of next generation electric vehicles, is the development of SiC and multi-level GaN inverters for high speed drives. These are needed for electric air compressors in fuel cell system spinning up to 160.000 RPM. The inverters must operate at switching frequencies in the range of 100 kHz to keep the magnetic losses in the motor as low as possible. The low switching losses of wide-bandgap semiconductors give a great benefit to improve the efficiency. Another important component for fuel cell applications are DC/DC converters, adapting the output voltage of the cell to the DC link voltage of the vehicle. For such applications, Fraunhofer IISB has more than 20 years of experience realizing custom designs of converters for any kinds of requirements. There are several converter prototypes running in test vehicles and trucks on the road to demonstrate the benefits of this new technology.

To cover the complete powertrain, the Vehicle Electronics Department extends its know-how to electric motor drives, the magnetic and mechanic design, the testing and the co-simulation of electric motors and power electronic drive inverters. This improves the performance of the drive systems and gives reliable data for performance and efficiency.

For reliable solutions, we operate a test lab for active and passive power cycling, for electromagnetic compatibility (EMC) and work on new solutions for active and passive EMC filters. This will further reduce the size and weight of next generation power converters.

Completely new requirements are posed by supra conducting powertrains operating at temperatures as low as -200 °C. The very low temperature changes the behavior of semiconductor devices, passive components and generates a very high thermomechanical stress on interconnections of different materials. To tackle these, challenges new test benches and simulation capabilities were set up and the first fully functional prototype systems for test bench applications were successfully supplied to our research partners.

During the last 20 years, we see the demand for power significantly growing. From tenth of kW to some MW. To tackle this challenge, we established our medium voltage and high-power lab, where we can handle voltage up to 30 kV, electric power up to 10 MW and test electric motors up to 1 MW.

This makes the Fraunhofer IISB to an excellent partner for the development of new power electronic solutions.

iisb.fraunhofer.de/vehicleelectronics

Spotlight: Reliability and Physics-based Lifetime Prediction

Silicon carbide based power semiconductors are playing a major role in todays advanced power electronics systems such as drive inverters and chargers for automotive application. After focusing on performance and efficiency of the systems and their devices, such as SiC-Diodes and SiC-MOSFETs, the scientific community enables astonishing, very compact SiC-solutions today – such as IISB's compact Mega-Watt-Inverters.

However, with the maturing of SiC-technology in the technology lifecycle and its adoption also in cost sensitive industries – such as automotive – the focus is shifting to low system costs at given superior performance. This innovation cycle is just about on going in automotive industry, moving leading edge power systems from:

- Si-IGBT with Si-(Free-wheeling)-diodes or Si-MOSFETs
- soldered to
- DCB (direct copper bonded Al_2O_3-ceramic substrates) with
- Al-wire top-side electrical interconnect
- in a frame module body filled with SilGel forming a full-bridge configuration (B6)
- using TIM (thermal-interface-material) and screws to mount to a water cooler (beside direct cooled solutions)

to todays technology using respectively striving to use:

- SiC-(Trench)-MOSFETs (***new*** semiconductor material / ***new*** semiconductor design)
- sintered (***new*** die-attach technology) to
- Si_3N_4-AMB substrates (***advanced*** substrate technology) with
- Cu-DTS (sintered copper die-top-system) with Cu-ribbons (***new*** top-side interconnect technology)
- as molded areal device forming half-bridge phases or even more integrated modules (***new*** packaging material / ***new*** formfactor and complexity for mold packages)
- soldered, sintered or glued as system-interconnect to a water-cooler

This giant leap and the large mix of technologies make us humble, when we look to reliability and lifetime prediction!

We Are Still Using Models like LESIT and CIPS2008
We are still using models like LESIT and CIPS2008 to estimate and extrapolate product lifetime from accelerated lifetime testing e.g. according to AQG 324. These empirical models have multiple (fit) parameters and exponents which need to be parameterized by lifetime experiments. The community invested substantial efforts in the last 20 years to do all the lifetime tests and validate these models for their specific designs, set of material and products.

$$N_f = a(\Delta T_j)^{-n} \cdot e^{\frac{E_a}{k_b \cdot T_{j,m}}}$$

$$N_f = \mathrm{K}(\Delta T_j)^{\beta_1} \cdot e^{\frac{\beta_2}{T_j + 273}} \cdot t_{on}^{\beta_3} \cdot I^{\beta_4} \cdot V^{\beta_5} \cdot D^{\beta_6}$$

$$N_f = A_0 \cdot A_1^{\beta} \cdot \Delta T_j^{-\beta} \cdot \Delta T_j^{\alpha} \cdot e^{\left(\frac{E_a}{k_B \cdot T_{jm}}\right)} \cdot \frac{C + t_{on}^{\gamma}}{C + 2^{\gamma}} \cdot k_{thickness}$$

$$\text{with} \quad \beta = e^{\left(\frac{-(\Delta T_j - T_0)}{\lambda}\right)}$$

From Top to Bottom: LESIT, CIPS08, and Semikron SKiM Model, with 3, 7 or 9 Parameters, Which Must Be Parameterized in the Experiment
© M. Held, P. Jacob, G. Nicoletti, P. Scacco and M.-H. Poech; R. Bayerer, T. Herrmann, T. Licht, J. Lutz and M. Feller; Semikron Danfoss

Division Power Electronic Systems

However, using SiC instead of Si (with E-modulus 450 GPa vs. 169 GPa), sintering instead of solder (different mesostructures: porosity vs. voids), different top-side interconnects including copper metal and large area system-interconnects this work would have to be done once again, but time-to-market will not allow for testing all aspects in hardware.

Leveraging on the Unique Properties of SiC
Leveraging on the unique properties of SiC, the leading-edge power electronic systems are moving towards higher voltages (1200 V) and allow higher chip-temperatures (175 °C and beyond) to gain more performance at cost as well as demand for longer operations time of automotive power electronics, e.g., up to 30,000 hours. At the same time, the margins for "over-engineering" are shrinking - *making "Design-to-Reliability" mandatory*.

Mission Profiles and FEM-Based Lifetime Prediction
Lifetime assessment of power electronics based on mission profiles is increasingly applied nowadays to obtain realistic lifetime predictions, considering application-close operational scenarios. Together with our system expert colleagues in the Vehicle Electronics department, we are using a drivetrain model and a thermal model. The information contained in the mission profile, such as motor speed and torque, can be translated into virtual junction temperature over the time profile of the power semiconductor device. Using a certain counting algorithm, characteristic temperature cycles, which contain the temperature amplitude ΔT, the mean temperature T_{mean} and the heating time t_{on}, can be extracted from the temperature profile. Subsequently, the calculation of the mission profile-based lifetime can be conducted by using experimentally obtained PCT lifetime models.

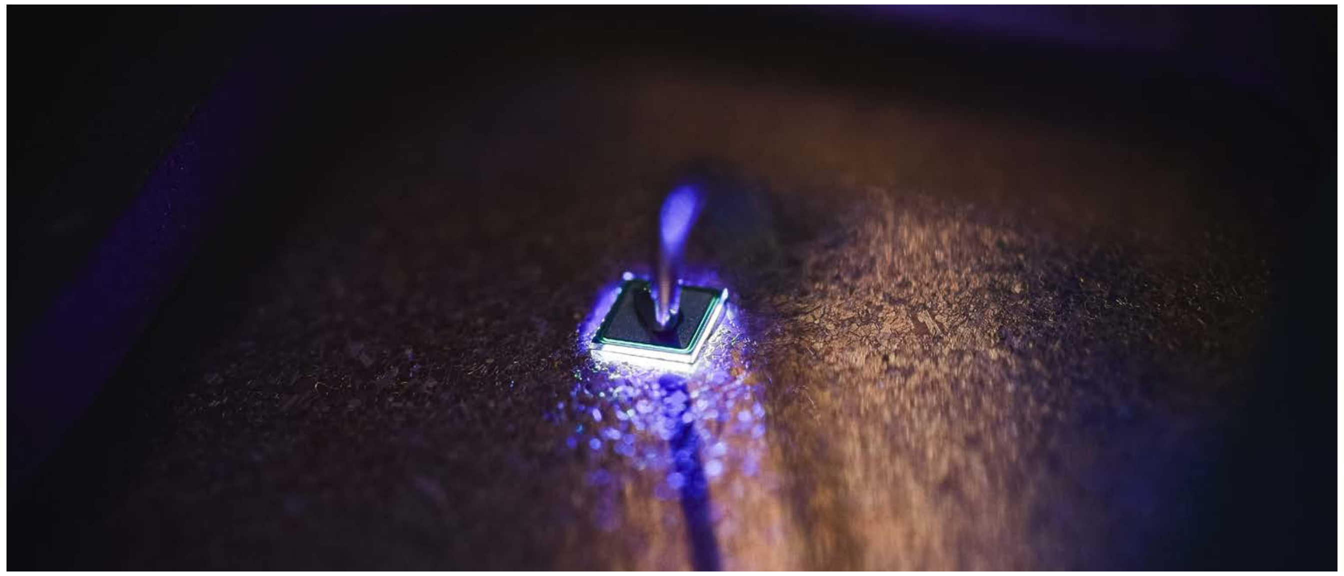
The IISB is going beyond the entrenched rainflow-counting method, since we showed that the chronology of stress cycles matters. Therefore, we use strongly coupled electro-, thermal-, and thermo-mechanic FEM-simulation to calculate stress and strain increments for mission profiles of accelerated lifetime test such as Temperature Shock (TST) or Power Cycling (PC_{min}, PC_{sec}) and extrapolate their lifetime resp. number of cycles to failure.

Performing the simulation ***and*** performing the lifetime tests gives us the unique opportunity to *calibrate our simulation to experimental lifetime data*. With this we can reduce the number of tests necessary while prototyping and development.

For more complex (longer) mission profile, we derive compact models bases on these calibrated FEM-simulations, allowing for improved physics-based lifetime prediction for application-relevant mission profiles.

New Test Requirements for SiC and Other Wide-Band-Gap Devices e.g. Within AQG324
However, beyond those package-related challenges, SiC power semiconductors also require special attention in material and semiconductor technology related reliability and lifetime aspects:

New and "not so new" failure modes in SiC devices such as Bipolar Degradation and Silicon Carbide "Corrosion" and - those only the elder ones can remember from early silicon power semiconductors, such as - Gate Oxide Degradation, Threshold Voltage Instability / Shift as well as Body Diode Degradation and its transient effects are requiring additional attention in system layout and lifetime engineering and testing.



SiC MPS diode during PC_{msec} with 2250 A/cm² © Sibasish Laha / Fraunhofer IISB

Division Power Electronic Systems

When implementing new lifetime tests on the SiC-semiconductor side, the IISB's "Test & Reliability" is leveraging very much from its long-term competence and the expert colleagues in "Materials" and "Semiconductor Devices".

PC_{msec} to Drive Bipolar Degradation in SiC Power Devices
As an IISB's interpretation of a high temperature forward bias test (dyn. HTFB acc. to AQG 324) we implemented a power cycling test with short heating pulses (t_{on} ≤ 1 ms), allowing for driving significant current densities through the devices' pn-junction of about 5-10 times its nominal values, while maintaining and measuring the junction temperature T_{vj} in its specification limits. Complemented by electrical characterization and failure analysis, including UV-photoluminescence studies of the generation of stacking faults and the interpretation of the impact of chip design, this comprehensive work - a master thesis in 2023 - was awarded ECPE Young Engineer Award / Best Paper in CIPS 2024.

iisb.fraunhofer.de/test-reliability

Spotlight: Megawatt Medium-Voltage Test Lab

The trend towards the use of electrical energy sources in stationary and mobile systems, for example with batteries or fuel cells, and the use of electrical consumers such as electric motors, electric heaters or heat pumps, is visible worldwide. This also increases the demand for electrical energy conversion - and consequently for power electronics. The paradigm shift away from fossil fuels and towards renewable energies is boosting the already high growth rates in power electronics.

This progress is particularly evident and now ubiquitous in the automotive sector, but the trend towards electrification is also gaining momentum in the railroad, shipping and commercial vehicle sectors. The power electronics used here must meet the highest standards of performance, efficiency and reliability. In order to address the growing demand of our customers and project partners for laboratory infrastructure for the megawatt and kilovolt range, Fraunhofer IISB is setting up a unique medium-voltage test field. Here, prototypes for power electronic components such as high-performance power converters, high-power electric drives or even entire electrical on-board grids can be developed and tested under realistic operating conditions.

The distinctive character of our medium-voltage test field is defined, among other things, by the experimental freedom it offers. Firstly, the facility is deliberately not designed for "24/7" utilization in the test bed. This means that test setups can remain unchanged over longer periods of time in order to investigate any challenges that may arise with the necessary care or to simulate a specific behavior. In this way, even unsystematic or only sporadically occurring anomalies can be detected, investigated and eliminated.

In addition, the exceptionally high flexibility with regard to the electrical and thermal supply and the modular compatibility of the equipment allows a very wide range of tests for electrical power converters in combination with drives and energy storage systems of all kinds and in a very wide power range.

However, the key factor in all of this is the expertise of our specialized team. With our know-how, we not only provide support for project planning, but also with the programming of a higher-level control system for the test setup as well as during practical execution and troubleshooting.

A current example of one of the first projects to be completed with great success is MVDC4S - Medium Voltage Direct Current for Ships. Here, in collaboration with AQ Inductive Components, Meyer Werft, Semikron Danfoss and Siemens Energy, a standard AC grid for cruise ships was replaced by a corresponding DC on-board grid. Besides greater efficiency, the upgrade to the DC grid also offers better integration of the battery and fuel cell. For this purpose, a section of a powerful ship DC grid was set up in the test field, prototypes for megawatt-class power converters were integrated and extensively tested under the most realistic operating conditions.

iisb.fraunhofer.de/mediumvoltage

Foto on Next Double Page: Overview of the Megawatt Medium-Voltage Test Lab at Fraunhofer IISB in Erlangen © Daniel Karmann / Fraunhofer IISB

Megawatt Medium-Voltage Test Lab

© Thomas Richter / Fraunhofer IISB

Division
Intelligent Energy Systems

»To reduce the CO_2 emissions, the share of electrification in transportation is increasing worldwide every year. The optimum combination of power conversion systems with energy storage systems to reach high energy efficiency at competitive costs can become very complex and often requires dynamic management. Therefore, in the Intelligent Energy Systems Division, we develop electric energy storage and electric power conversion systems providing the ability to detect, analyze and adapt themselves dynamically to their environment.«

Prof. Vincent Lorentz,
Head of Intelligent Energy Systems Division and
Chair of Electronics for Electrical Energy Storage (LEEE)
of the University of Bayreuth
© Anja Grabinger / Fraunhofer IISB

The Intelligent Energy Systems Division at Fraunhofer IISB develops electronic solutions and advanced technologies for the digitalization of energy storage and power conversion systems for mobile and stationary applications, thus building our Cognitive Power Electronics (CPE) ecosystem that covers the entire power range from a few milliwatts up to multiple megawatts.

We integrate innovative data analytic technologies into our solutions, enabling smart monitoring and diagnostics, and providing self-healing functionalities. These technologies are implemented and demonstrated in our cutting-edge electronic power converters, in our high-performance battery systems, including our disruptive open-source battery and fuel-cell management system foxBMS®, developed in close cooperation with the University of Bayreuth and its Bavarian Center for Battery Technology (BayBatt).

Our research and development efforts focus on power and control electronic hardware and software algorithms, as well as data processing technologies – using the latest developments in artificial intelligence – to detect anomalies in power conversion and energy management systems targeting the transportation and energy domains.

Intelligent Energy Systems

»We integrate smart monitoring and innovative diagnostic functions in our cutting-edge energy storage and power conversion systems, thus providing the highest energy efficiency and availability.«

Prof. Vincent Lorentz,
Head of Intelligent Energy Systems Department
© Anja Grabinger / Fraunhofer IISB

Our department develops and integrates innovative hardware and software solutions for the digitalization of electrical energy storage and conversion systems. We address mobile applications like automotive, airborne and waterborne as well as stationary applications for industry and renewables.

The Department Intelligent Energy Systems combines four research groups developing hardware and software solutions for electrical energy storage and electrical power conversion applications in the submarine, waterborne, road, railway, airborne, and space domains.

The group "Battery Systems" is working on innovative solutions for lithium-ion-based energy storage systems for mobile and stationary applications. The activities range from the development of battery management systems (e.g., foxBMS®), algorithms for battery state estimations and predictions, up to the design of battery systems for applications like racing cars, submarine, and airships.

The group "DC Grids" focuses on innovative solutions for DC grid systems. Its work ranges from applied research on safety and stability issues of DC networks, up to the development of innovative grid components, such as DC/DC converters and DC protection devices (e.g., solid-state circuit breakers). The group is also involved in standardizations such as in VDE/DKE, IEC, and IEEE Smart Grid.

The group "Industrial Power Electronics" supports its customers in solving complex power electronic challenges in the field of multi-level converters. The list of strengths of this group in the field of troubleshooting is long: many years of industrial application experience, fast response time, and familiarity with industrial processes and challenges.

The group "Data Analytics" helps its customers to get the most out of their data in the context of IoT and Industry 4.0. It takes an application-oriented approach that includes system analysis, data collection, filtering, clustering, and finally the development and implementation of algorithms in industrial processes or in embedded systems. The group also provides solutions and methods for the development of algorithms for anomaly detection and early fault recognition in complex systems.

The sum of these competences enables the development of cognitive power electronics (CPE), that consists of power electronics able to consider its environment (e.g., sources and loads, energy tariffs, system and network faults, grid stability, weather forecast) and adapt itself to it (e.g., in terms of energy efficiency, priorities, maintenance).

iisb.fraunhofer.de/ies

Spotlight: Open DC Grids for Industrial Plants

On March 31, 2023, the nationally funded project DC-INDUSTRIE 2 came to an end. Together with the first DC-INDUSTRIE project, over 6.5 years of funded projects concluded, with a total volume of 13.000.000 € and a total of 45 funded and associated partners. These funding projects have significantly contributed to the advancement of DC technology in the industry.

Within the research projects, various aspects of supplying entire production plants and halls with direct current were examined. Innovative components from converters to switching devices were developed and demonstration plants were built, characterized and evaluated. An outstanding example is Daimler's Factory 56, a 222,000 m² production hall with a 2 MW DC infrastructure. In various productive grids setups or retrofitted during the project, the consortium has demonstrated that DC power supply in production enables higher energy efficiency, better integration of renewables, reduction of infeed power as well as improved availability and reliability.

To provide a lasting framework for further work and to utilize the results of the funded projects beyond the project duration, the Open DC Alliance (ODCA) was founded in December 2022. Fraunhofer IISB is a founding member of this initiative. The ODCA is organizationally affiliated with the German Electro and Digital Industry Association (ZVEI) and aims to expand the DC ecosystem and drive standardization efforts. A significant milestone was the publication of the DC-INDUSTRIE system concept in version 3.0, which has received considerable recognition not only in Germany but also internationally. Simultaneously, standardization efforts are underway at national and international levels to transform the de facto standard into an actual standard. Bernd Wunder, Group Manager of DC Grids within the Intelligent Power Electronics department of Fraunhofer IISB, is the head of the IEC SyC LVDC working group for LVDC industry application and also represents Fraunhofer IISB in various DKE, IEC and ISO groups.

The topic of DC power in production has gained attention beyond the project consortium as well. One example is Schaltbau GmbH, which planned and built its new production site in Velden entirely on a DC basis from the start. Fraunhofer IISB staff was commissioned to conduct workshops for Schaltbau, on DC grids as well as to simulate the protective system of the NeXT Factory and perform selectivity analysis of fuses and switchgear in the electrical infrastructure. The production facility went into full operation in September 2023 and has already received the Lean and Green Award and was nominated for the Electrifying Ideas Award 2023.

The work of Fraunhofer IISB in the field of DC technology contributes significantly to increasing energy efficiency and sustainability in production. Through close collaboration with industrial partners and active participation in national and international standardization committees, Fraunhofer IISB contributes to establishing DC as a future-proof technology in the industry.

NeXT Factory: The new Schaltbau Production Site in Velden Was Entirely Planned and Built on a DC Basis © Schaltbau GmbH

odca.zvei.org/dc-industrie

iisb.fraunhofer.de/dc-grids

Division Intelligent Energy Systems

Spotlight: Optimization of the Energetic Building Infrastructure

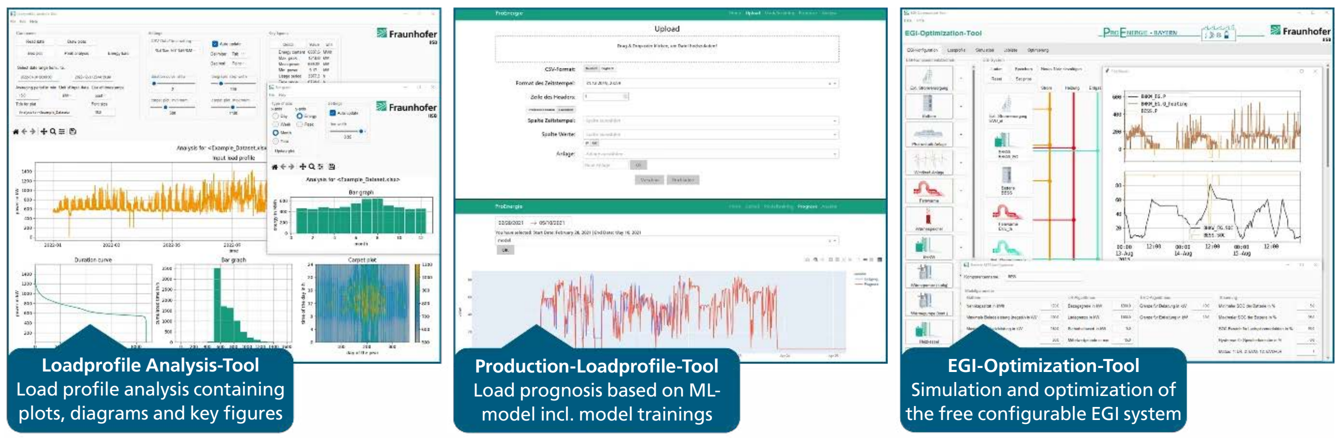
In the transformation of the energy system, buildings of industrial companies play a crucial role due to their high energy demand. Not only electricity and heating power is required, but also cooling power, gases, compressed air, and other energy carriers. Optimizing energy supply cannot be achieved by considering only one of these areas, as – caused by generation plants and consumers – there are close interconnections between the different networks and domains. This leads to high complexity in optimizing the energetic building infrastructure (EGI).

To support companies in planning and optimizing their EGI, a software toolbox has been developed in the frame of the research project ProEnergie – Bayern (founded by Bavarian Research Foundation), in collaboration with partners from academia and industry. This toolbox enables the analysis of energy data, calculation of load forecasts, as well as simulation and investigation of optimization measures. This can help to reduce costs and CO_2-emissions. The toolbox is available as open-source software free of charge.

Why Optimize the Energetic Building Infrastructure?
Companies need to be flexible in responding to changing production and market conditions. A key factor is the efficient and sustainable use of energy. The energy required by a company is provided by the building infrastructure, which includes energy converters like PV, heat pumps, combined heat and power plants, and chillers, as well as energy storage systems like batteries and heat / cold thermal energy storages. Additionally, there are connections to public grids (such as electricity, district heating, and gas) for importing and exporting energy.

The EGI-Optimization-Tool was Validated with Data of Partners from the Project Consortium as well as Measurements from the Real-world Laboratory for Intelligent Energy Systems at the IISB © Amelie Schardt / Fraunhofer IISB

The energy demand of a company often occurs mainly in production itself, for example, for process heat and cooling, supplying production equipment, and air conditioning. In addition to electrical power, heat, cold, gases, compressed air, and other forms of energy are used. However, offices and laboratories also require energy. To optimize energy supply, it is logical to optimize the existing EGI systems in a company and adapt them to new requirements. Operational strategies are used within the framework of intelligent energy management, which consider important boundary conditions and constraints. In addition, the energy system can be expanded, for example, by integrating energy storages, local renewable energy sources (e.g., PV), and waste heat recovery systems.



Three Tools were Developed in ProEnergie – Bayern for Analysis and Prognosis of Load Profiles as well as Simulation and Optimization of the Energetic Building Infrastructure (EGI) © Christopher Lange / Fraunhofer IISB

The individual subsystems are partly closely coupled through generation plants and consumers, so changes to individual systems can have significant impacts on the overall system. For example, optimizing the operation of a heat pump can lead to increased electrical peak loads – and thus increased electricity costs. This can be prevented by considering the interdependencies between the systems, which can be challenging without suitable tools. Therefore, the software toolbox from ProEnergie - Bayern supports companies in evaluating measures in their EGI with three specialized tools that cover the essential steps of data analysis, demand forecasting, and overall EGI optimization. The tools are available for free, and the complete source code, mostly written in Python, is fully disclosed as open-source software.

What are the Software Tools Used For?
The ProEnergie software toolbox includes three software tools that support companies in the necessary steps towards a holistic optimization of their energy system.

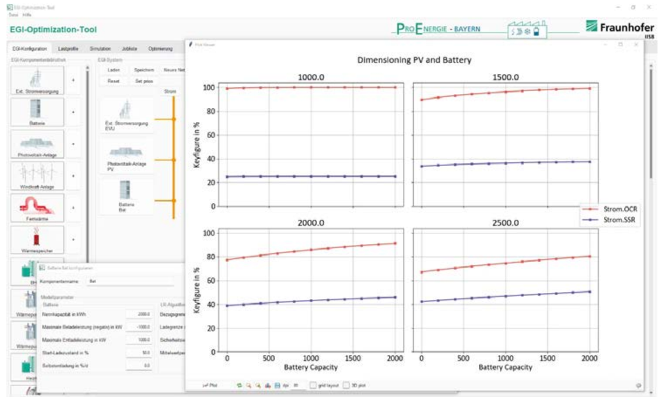
The Loadprofile-Analysis-Tool performs a systematic analysis of time series by calculating important key figures and providing graphical evaluations. It handles load and generation profiles as well as mass and volume flows. The analysis helps to determine the status quo, uncover dependencies in the energy system, and highlight relevant influencing factors.

While the first evaluates historical measurement data, the Production-Loadprofile-Tool allows for predicting future load profiles. It trains the prediction model using machine learning methods, based on historical production data, load profiles, and weather data. The trained model then calculates the predicted electricity, heat, cold, and gas demand. This helps identify critical periods with high load peaks and high utilization of the energy infrastructure.

The third software tool, the EGI-Optimization-Tool, enables the investigation of changes in the considered energy system. The user configures and parameterizes the EGI using an extensive library that includes component models (e.g., CHP plant including thermal energy storage), that also include operational strategies. The operational strategies ensure that all operating conditions of the system are considered (e.g., minimum operation time, power ramp-up) and that optimization goals, such as peak shaving, self-supply optimization, and efficiency enhancement, are applied. Once the system is configured, external data, such as load profiles, need to be imported. In addition to single simulations, parameter studies can be performed. Furthermore, parameters, such as the capacity of an energy storage, can be optimized based on a target variable. This way, all interventions in the EGI can be examined in advance, potential savings can be identified, and the impact on the entire system can be estimated.

The operational strategies are fully transparent due to the open-source release of the tools, making it easy to adapt them to real systems. The operational strategies have been implemented and validated on real installations in the real-world laboratory for intelligent energy systems at Fraunhofer IISB.

Availability of the Software Toolbox
With the software toolbox, companies now have a free and flexible solution for optimizing their EGI at their disposal, accessible at https://gitlab.cc-asp.fraunhofer.de/proenergie/. The impact of planned expansions and changes to the energy infrastructure can be examined beforehand, without affecting sensitive production processes.



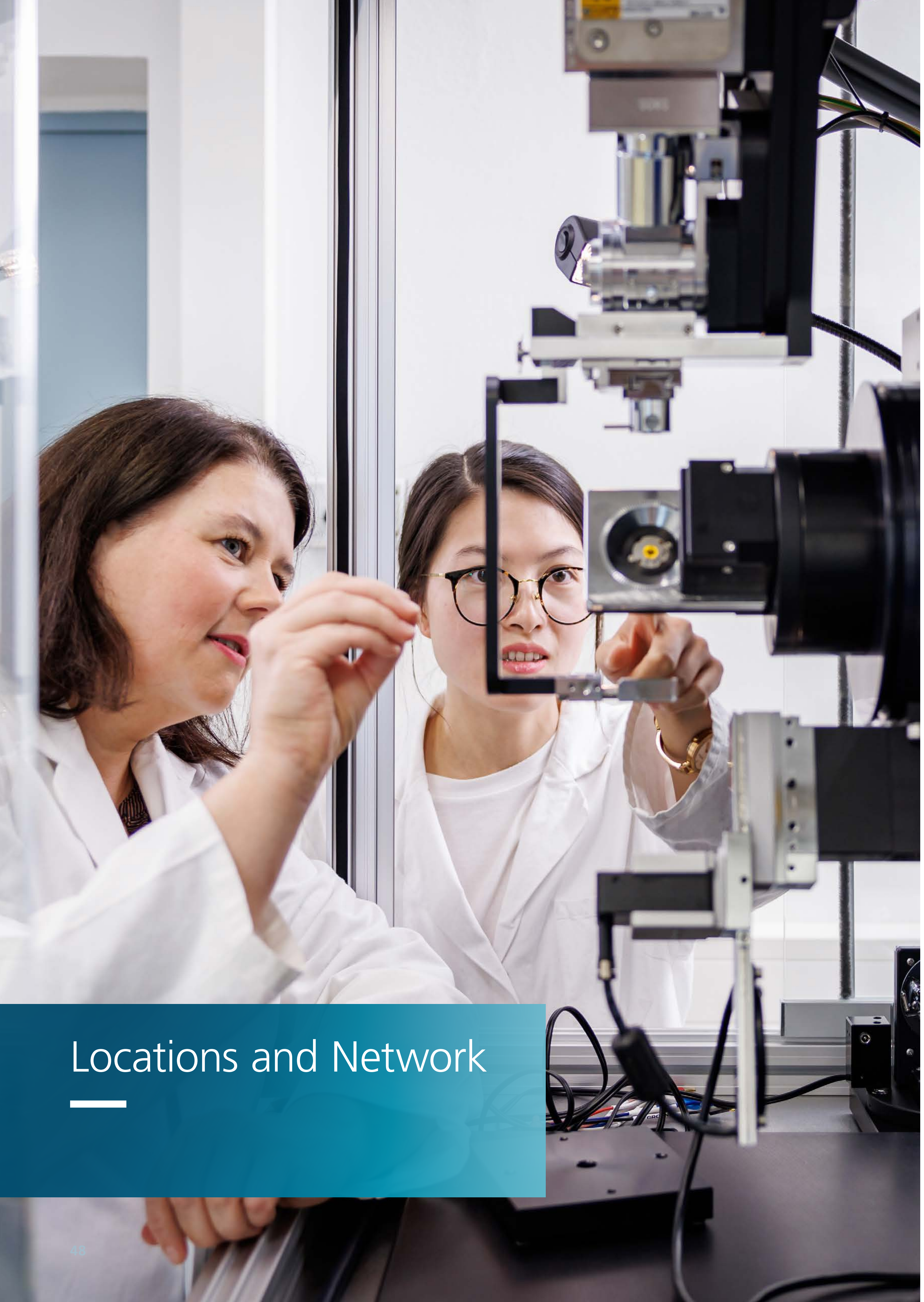
Exemplary Design of a PV System and its Associated Battery Using the EGI-Optimization-Tool. The Titles of the Plots Provide Information About the Peak Power of the PV Systems © Christopher Lange / Fraunhofer IISB

By utilizing the software tools, companies can gain confidence in their investments, such as in their own renewable energy generation, integration of energy storages, or modernization measures. Moreover, they can calculate the long-term cost-benefit ratio and enhance their self-supply-rate, enabling to cover part of their energy requirements themselves, ideally up to full climate neutrality.

proenergie-bayern.de

https://gitlab.cc-asp.fraunhofer.de/proenergie/

iisb.fraunhofer.de/energytechnologies



Locations and Network

Headquarters of Fraunhofer IISB

Schottkystrasse 10, 91058 Erlangen

The headquarters of Fraunhofer IISB in Erlangen are located close to the University of Erlangen-Nürnberg. About 10,000 m^2 of laboratories and office area allow research and development on a broad range of power electronics, semiconductor technology, and materials development.

The available infrastructure includes among others: a test center for electric cars, a medium-voltage test bench, an application center for DC grid technology, and an extensive cleanroom area for semiconductor technology on silicon and silicon carbide, which is partly operated together with the Chair of Electron Devices of the FAU Erlangen-Nürnberg.

The Fraunhofer IISB operates various crystal growth and wafering laboratories in which crystals and sub-strates can be grown from different semiconductor materials such as SiC, AlN or GaN. In addition to an advanced packaging line for power electronics, the institute also runs an environmental laboratory for testing active and passive components specifically geared towards the application areas of energy transmission, mobility, aerospace and industry.

iisb.fraunhofer.de

Technology Center High Performance Materials THM

Am St.-Niclas-Schacht 13, 09599 Freiberg

High-performance materials such as semiconductors and energy materials are fundamental to solving the major challenges of the future: Intelligent mobility, Industry 4.0, the energy transition, or the Internet of Things. Supported by the Free State of Saxony, Fraunhofer THM is a research and transfer platform of the Fraunhofer Institute for Integrated Systems and Device Technology IISB and the Fraunhofer Institute for Ceramic Technologies and Systems IKTS.

Together, semiconductor and energy materials are transferred into new applications and at the same time, future material recycling is considered and developed. Both the development of new, high-performance materials and the associated efficient manufacturing processes play a major role here, as well as a sustainable recycling economy that enables the economic recovery of valuable materials.

One major point is the role of defects for the reliability and functionality of upcoming devices and the integration of processes and materials into prototypes and test vehicles.

Fraunhofer THM is a research partner for industry within the framework of industrial contracts and publicly funded projects in the production, application, and recycling of semiconductor and energy materials.

thm.fraunhofer.de

X-Ray Diffraction Analysis of Battery Test Cells at Fraunhofer THM in Freiberg © Daniel Karmann / Fraunhofer IISB

Friedrich-Alexander-Universität Erlangen-Nürnberg (FAU)

Chair of Electron Devices (LEB)

The Fraunhofer IISB and the Chair of Electron Devices (German abbreviation: LEB) of the FAU Erlangen-Nürnberg are both headed by Prof. Jörg Schulze.

Within the framework of a cooperation agreement, the two institutions not only jointly operate the University's cleanroom facility and other laboratories, but also work closely together with regard to teaching and research.

The cooperation of the Chair of Electron Devices and the Fraunhofer IISB makes it possible to cover the entire chain of topics from basic research to the transfer to industry.

For many years now, the vocational training as a microtechnologist has been offered jointly by the IISB and the Chair of Electron Devices. Also, employees of the IISB assist in courses and internships at the university.

leb.tf.fau.de

Chair of Power Electronics (LEE)

The Chair of Power Electronics (German abbreviation: LEE) of the FAU Erlangen-Nürnberg is headed by Prof. Martin März, also head of the Power Electronic Systems Division, at the IISB.

It conducts research on current topics in the field of power electronics for electric power supply. Besides stationary decentralized electrical power systems, the addressed application fields also include the power grids in vehicles, ships, railways, and airplanes.

The LEE is part of the Energie Campus Nürnberg (EnCN) in the Fürther Straße in Nuremberg, and the first chair grown out of the EnCN.

lee.tf.fau.de

Technische Universität Bergakademie Freiberg (TUBAF)

Institute of Applied Physics (IAP)

The Institute of Applied Physics of the TU Bergakademie Freiberg is headed by Prof. Johannes Heitmann, also head of the Energy Materials and UWBG Semiconductor Technology Division and head of the Technology Center High Performance Materials THM in Freiberg.

The THM has been conducting joint research with the TU Bergakademie Freiberg for more than 15 years, and with the Institute of Applied Physics (IAP) for 8 years, complementing each other's competencies and sharing resources in the field of electronic device fabrication, characterization, and material processing.

Main activities of the IAP are the development and evaluation of new materials and processes, like thin film dielectrics and contact material formation for nitride semiconductor and photovoltaic devices, synthesis and characterization of semiconductor nanostructures, and the defect characterization of semiconductor materials and its impact on and the reliability of microelectronic and photovoltaic devices.

tu-freiberg.de/fakultaet2/angph

University of Bayreuth

Bavarian Center for Battery Technology (BayBatt) / Chair of Electronics for Electrical Energy Storage (LEEE)

The Bavarian Center for Battery Technology (BayBatt) at the University of Bayreuth is a research center that bundles interdisciplinary fundamental research, the development of innovative battery technologies, and technology transfer to the industry. With the BayBatt, an expertise center is being established that provides know-how and research to meet the increasing demand for storage technologies, e.g., to ensure grid stability as the share of renewable energies grows.

The core topics of the BayBatt are the safety and sustainability of batteries and their components, the intelligent use of the storage medium, and economic efficiency. The entire spectrum of battery technology is considered, from the molecular basis to the structuring of electrodes and cell development. Specific focus is on the battery cells and systems, and the use of batteries in connected energy storage systems.

Within BayBatt, Fraunhofer IISB cooperates closely with the Chair of Electronics for Electrical Energy Storage (LEEE), led by Prof. Vincent Lorentz, at the University of Bayreuth. Prof. Vincent Lorentz is also head of the Intelligent Energy Systems Department at Fraunhofer IISB.

The main focus of the chair's research is on solutions for the electronic monitoring and control of electrical energy storage systems such as batteries, supercaps, and fuel cells, which are used in mobile and stationary applications. For example, the foxBMS® battery management system platform emerged from an initiative of Fraunhofer IISB in 2015. It is being further developed in BayBatt and enables research and validation of safer, more robust and reliable system architectures.

electronics.uni-bayreuth.de

»Red Place« at the Faculty of Engineering of the Friedrich-Alexander-Universität Erlangen-Nürnberg (FAU) © David Hartfiel

Academic Teaching

University Lectures Held by IISB Researchers

Lecturer	Lecture
Dr. Bernd Eckardt	Electrical Energy Storage Systems
Dr. Andreas Erdmann	Optical Lithography
Dr. Tobias Erlbacher	Power Semiconductor Devices
Prof. Dr. Marc Hainke	Medical Product Development
	Medical Technology Materials
	Materials Engineering
	Engineering Mechanics I
	Engineering Mechanics II
	Basics of Construction
	Construction & Development
	Construction & CAD
	Fluid Mechanics & Thermodynamics
Prof. Dr. Johannes Heitmann	Physics for Scientists III
	Semiconductor Chemistry
	Fundamental Physics for Engineering
	Physics for Engineers
	Materials Analysis
	Nanoelectronic Devices II
	Functional Nanomaterials
	Semiconductor Chemistry
Dr. Michael Jank	Flexible Electronics
	Nanoelectronics
Dr. Jürgen Lorenz	Process and Device Simulation

Lecturer	Lecture
Prof. Dr. Vincent Lorentz	Digital Circuit Technology
	Analog Circuit Technology
	Electrotechnical Fundamentals of Electrochemical Energy Storage Systems
	Battery System Technology II
Prof. Dr. Martin März	Power Electronics (Basics)
	Power Electronics in the Vehicle and Powertrain
	Power Electronics for Decentral Energy Systems
	Thermal Management in Power Electronics
Prof. Dr. Schulze	Bipolar Technology
	Semiconductor Devices
	Quantum Electronics
	Technology of Integrated Circuits

IISB's scientific staff holds academic lectures and supervises a multitude of final theses.

µe-bauhaus erlangen-nürnberg

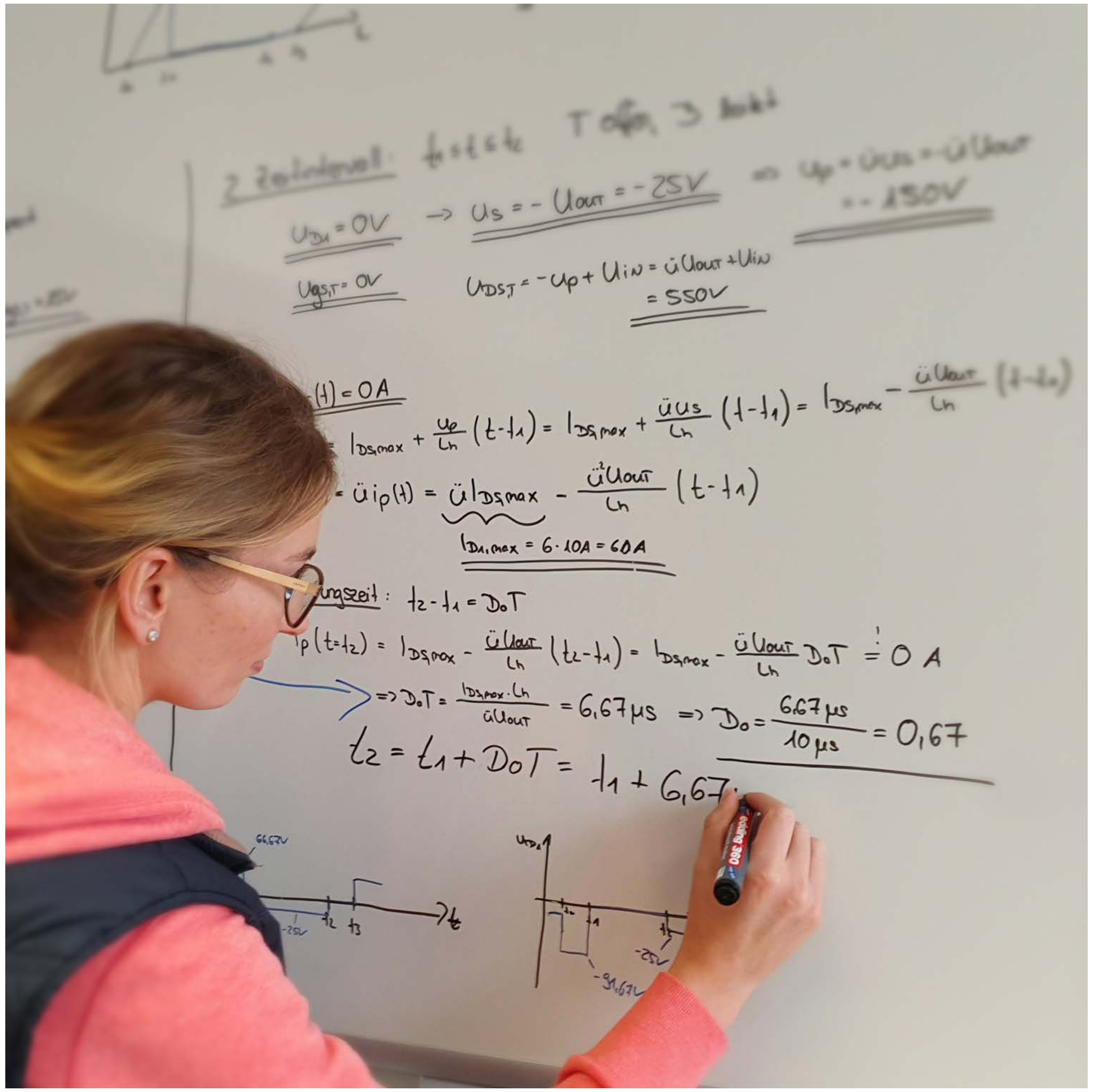
The Technical-Academic Master Forge

The µe-bauhaus erlangen-nürnberg transfers the teaching concept of the famous Bauhaus Weimar-Dessau-Berlin to the idea of a »Bauhaus of Microelectronics« within the Chair of Electron Devices (LEB) and Fraunhofer IISB.

This includes the self-understanding that »teachers« and »learners« work together and jointly plan and realize extensive ideas and designs. The indispensable basis of this creative work is the thorough technical training of students in laboratories and at trial and work stations, which enables them to learn and work independently in teams in a creative manner.

At the µe-bauhaus, the theoretical study of natural sciences and electrical engineering and information technology runs parallel to practical training along the process chain, starting with the design of devices, their development and production up to validation, trial and testing.

iisb.fraunhofer.de/bauhaus



Highly Skilled and Dedicated Professionals Are Vital Not Only for Us as an Institute, but Also for the German and European Research Society and Industry. This Makes It All the More Important to Provide Students and Apprentices with a Profound Theoretical Education without Losing Sight of Practical Applicability © LEEI Melanie Lavery

The Fraunhofer-Gesellschaft

Fraunhofer

The Fraunhofer-Gesellschaft, based in Germany, is a leading applied research organization. It plays a crucial role in the innovation process by prioritizing research in key future technologies and transferring its research findings to industry in order to strengthen Germany as an economic hub as well as for the benefit of society.

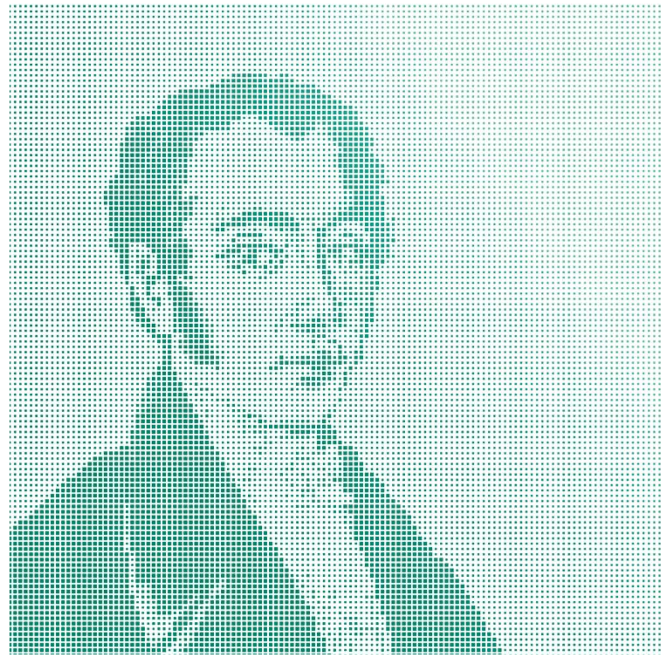
As an important customer group, small- and medium-sized companies in particular tap into Fraunhofer's expertise and resources to develop new technologies and maintain their competitiveness. For years, Fraunhofer has been one of the most active patent applicants in Germany and Europe. The research organization is therefore developing an extensive, international patent portfolio in various technology sectors, primarily as a basis for transferring technology through research projects, spin-offs and licensing. In this way, Fraunhofer experts support industry partners from ideation to market launch, and Fraunhofer's interdisciplinary and international collaboration in specific market environments addresses social objectives in important technology areas.

Fraunhofer also promotes research into key technologies that are vital for society as a whole by applying specific, interdisciplinary and international collaboration geared to the needs of the market. Examples include technologies for the energy transition, cybersecurity and underlying models for generative artificial intelligence.

Fraunhofer is an attractive and established party for public-private partnerships and also makes a significant contribution to strengthening Germany as a hub for innovation and ensuring its viability in the future. Its activities create jobs in Germany, boost investment effects in the private sector and increase the social acceptance of new technology.

International collaboration projects with excellent research partners and companies across the globe ensure that the Fraunhofer-Gesellschaft remains in direct contact with the most prominent scientific communities and economic areas.

Founded in 1949, the Fraunhofer-Gesellschaft currently operates 76 institutes and research units throughout Germany. Its nearly 32,000 employees, predominantly scientists and engineers, work with an annual business volume of 3.4 billion euros; 3.0 billion euros of this stems from contract research, which is divided into three funding pillars. Fraunhofer generates a share of this from industry and license-fee



Joseph von Fraunhofer © Anja Grabinger / Fraunhofer IISB

revenue to a sum of 836 million euros. This high proportion of industrial revenue is Fraunhofer's unique selling point in the German research landscape. The importance of direct collaboration with industry and the private sector that this requires ensures a constant push for innovation in the economy, while at the same time strengthening German and European competitiveness.

Another share of contract research revenue comes from publicly funded research projects. The final share is base funding that is supplied by the German federal and state governments and enables our institutes to develop solutions now that will become relevant to the private sector and society in a few years.

Highly motivated employees are the most important factor in Fraunhofer’s success. The research organization therefore creates opportunities for independent, creative and goal-driven work. Fraunhofer fosters professional and personal development in order to provide career opportunities for its employees in the private sector and society at large.

The Fraunhofer-Gesellschaft is a recognized nonprofit named after the Munich scholar Joseph von Fraunhofer (1787–1826), who enjoyed equal success as a scientist, inventor and entrepreneur.

fraunhofer.de

FMD 3D Showroom © FMD

The Research Fab Microelectronics Germany (FMD)

FMD as a "One-Stop Shop" for Micro and Nanoelectronics

The Fraunhofer IISB is one of the 13 institutes that since 2017 have been cooperating in the Research Fab Microelectronics Germany (FMD for its acronym in German). Across locations and technologies, the FMD collectively addresses current and future challenges in electronic research, providing crucial developmental impulses for tomorrow's technology. Around 4,600 employees from all 13 institutes bring together their expertise in the research and development of micro and nano systems.

The FMD bundles the expertise of 11 institutes from the Fraunhofer Group for Microelectronics with that of the Ferdinand-Braun-Institut, Leibniz-Institut für Höchstfrequenztechnik (FBH), as well as the Leibniz Institute for Innovative Microelectronics (IHP) under one virtual roof. Hence, the FMD constitutes a central point of contact for all micro and nanoelectronics related issues in Germany and Europe.

Improving Sustainability in Digitalization via Microelectronic Research and Development for Information and Communication Technology

The FMD and the Federal Ministry of Education and Research (BMBF for its acronym in German) took a further step towards the implementation of the German government's climate protection program with the funding project Green ICT @ FMD launched in autumn 2022. Within the Green ICT @ FMD project, all participating institutes are setting-up a cross-location competence center for sustainable Information and Communication Technology (ICT) under the coordination of the FMD business office. This competence center provides a centralized approach to green ICT-specific issues as well as a comprehensive range of cross-technology ICT solutions.

Promoting New Hardware Solutions for Next Generation Computing

Currently, a large number of fundamental research projects are being carried out in Germany on quantum and neuromorphic computing. Nevertheless, there are still insufficient opportunities for the development and application-oriented hardware testing that is required for highly complex computing technologies, as well as for the rapid implementation of the results into prototypes and small series. This is precisely what the Research Fab Microelectronics Germany - Module Quantum and Neuromorphic Computing (FMD-QNC) project — launched on December 1, 2022 — aims to address. Within the scope of the FMD-QNC project, researchers and companies should be supported in developing customized microelectronics and scalable manufacturing as well as integration processes for new information technologies.

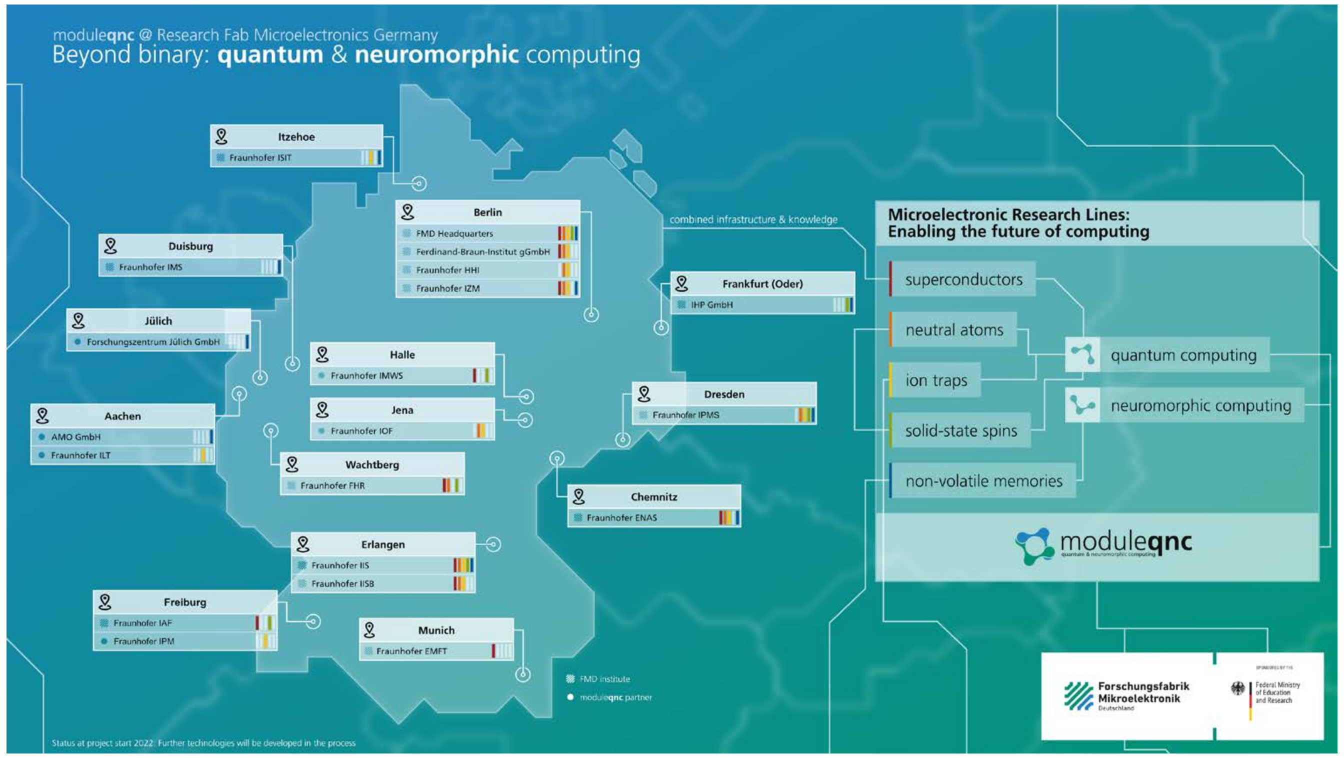
EU Chips Act: FMD Pilot Line for Advanced Heterogeneous System Integration

Over the coming years, the Research Fab Microelectronics Germany intends to build the most comprehensive and advanced pilot line dedicated to chip integration for innovative, robust and trustworthy heterogeneous systems as a contribution to the EU Chips Act. This pilot line comprises an unprecedented range of component technologies and materials that will enable state-of-the-art system design, interconnection and assembly technologies, along with characterization, testing, reliability, and security assessment. Moreover, this pilot line seeks to promote the innovative potential of the whole industrial spectrum in Europe.

FMD Showroom: fmd-insight.de/showroom

Green ICT Space: greenict.de/en/startups

FMD-QNC: module-qnc.de/en



Project Module Quantum and Neuromorphic Computing Promotes New Hardware Solutions for Next Generation Computing
© FMD

Ensuring Skilled Workers, Attracting Young Talent, Supporting Start-ups and SMEs

Along with the range of technological solutions, various cooperation opportunities, and the coordination of large collaborative projects, the FMD also runs special formats and programs for students, young professionals, start-ups, SMEs and research groups. For instance, the first Green ICT Award was presented in 2023. As part of the Green ICT @ FMD competence center, the award is granted to young talents writing their bachelor's and master's theses on resource-saving information and communication technology.

forschungsfabrik-mikroelektronik.de

Fraunhofer IISB – The SiC Specialists Within the FMD

Within the FMD, the IISB has a unique selling point with its integrated, certified production line for the processing of individual SiC-based prototype devices in an industry-compliant environment.

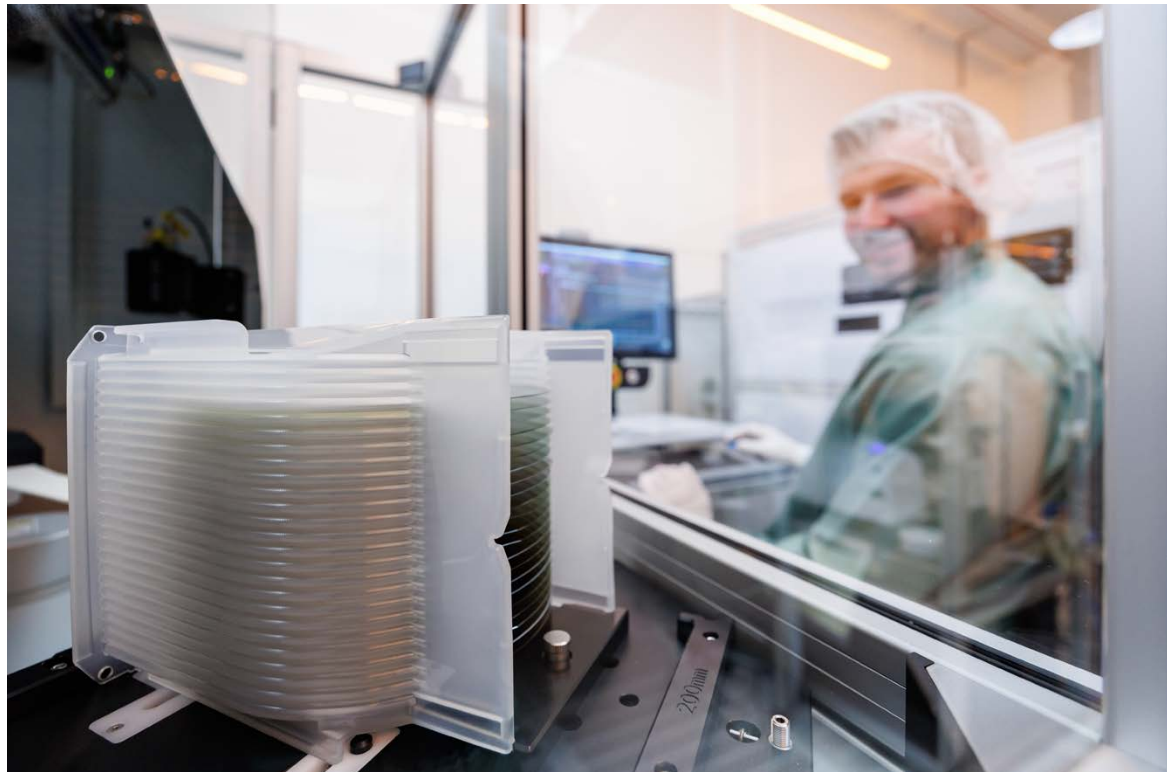
In the front-end area for wafer sizes of mainly 150 mm, all necessary process steps can be performed at Fraunhofer IISB, such as epitaxy, ICP dry etching, growth of silicon dioxide, aluminum implantation at elevated temperatures, activation anneal, and metallization. Usually, vertical devices are manufactured in SiC for power electronics. Therefore, the processing of the backside of the SiC wafers is of critical importance. The FMD investments enables the bonding and debonding of already finally processed wafers at the front side, the thin grinding of wafers at the backside, and the reduction of contact resistance at the backside by means of advanced metallization and laser silicidation.

New integration technologies and innovative assembly and system concepts for prototyping and the production of future power modules are available in the backend area. This makes it possible, for example, to realize particularly complex and compact structures, heavily stressed (special) applications with sometimes small quantities or durable high-temperature power electronic modules.

Extensive, complementary methods are available along the process chain for quality control. The most important of these are a fast, high-resolution X-ray topography system for the analysis of the structural properties of crystals, wafers, and partially processed wafers, and a combined surface inspection photoluminescence device for the analysis of the near-surface material properties of SiC along the process chain. The SiC metrology is supplemented by special measuring stations, which are adapted to the specific, sometimes extreme conditions of power electronics, such as an extra-high voltage measuring station as well as special lifetime and reliability test laboratories.

For the research on new semiconductor materials with large band gaps, crystals of these materials are needed, which then have to be further processed into wafers in order to evaluate the potential in the FMD for power electronics or for other applications such as in quantum technology. Since the new crystal materials, such as GaN, AlN, Ga_2O_3 or diamond, are usually crystals with smaller diameters (50 mm or smaller), Fraunhofer IISB operates a special substrate and wafer laboratory to produce wafers from such crystals. The quality of the wafers used to manufacture the devices is tested using various analytical methods, including the determination of their epitaxial suitability and the production of special test structures.

iisb.fraunhofer.de/sic-services



Within the FMD, the IISB Specializes in Highly Efficient Wide and Ultrawide Bandgap Power Electronics
© Daniel Karmann / FraunhoferIISB

IISB Science Stars

Dr. Jürgen Lorenz, Head of the Simulation Department (now "Modeling and Artificial Intelligence") Since the Foundation of the IISB in 1985, Was Honored With the Fraunhofer Thaler. © Elisabeth Iglhaut / Fraunhofer IISB

Fraunhofer Thaler for Dr. Jürgen Lorenz

On the occasion of his retirement, Dr. Jürgen Lorenz - Head of the Simulation Department, now "Modeling and Artificial Intelligence", since the institute was founded in 1985 - received the Fraunhofer Thaler.

The Fraunhofer Thaler is awarded by the Executive Board of the Fraunhofer-Gesellschaft in recognition of outstanding contribution to the Fraunhofer-Gesellschaft.

Prof. Jörg Schulze, Director of Fraunhofer IISB, presented the award on October 12, 2023 at the IISB's annual conference, which was held under the motto "40 Years of Simulation at IISB".

Dr. Jürgen Lorenz has been highly committed to electronics research in the Fraunhofer-Gesellschaft and in Europe. He very successfully advanced the development and application of numerical simulations of semiconductor processes and devices for micro- and nanoelectronics and was an acknowledged expert in various international committees, such as the "International Technology Roadmap for Semiconductors" (ITRS).

Dr. Lorenz was active in more than 40 European projects with extraordinary commitment and contributed significantly to Fraunhofer IISB's reputation as an excellent project partner. In particular, he initiated and coordinated a total of 9 central European joint projects and networks for the development and application of programs for the simulation of semiconductor processes and components over many years.

We would like to congratulate our colleague on this honor and wish him all the best for his retirement!

Prof. Jörg Schulze (right), Director of Fraunhofer IISB, Presents the Fraunhofer Thaler and the Certificate to Dr. Jürgen Lorenz (left) © Elisabeth Iglhaut / Fraunhofer IISB

Applied Photonics Award 2023 for Valeriia Sedova

Valeriia Sedova, PhD student in the lithography group at Fraunhofer IISB, was honored with the Applied Photonics Award 2023 for the best master thesis.

In her thesis titled "Modeling of Thick Photoresist for Grayscale Lithography Application", Valeriia addresses a critical challenge in the fabrication of micro-optical components: the lack of a well-established model for thick photoresists in grayscale lithography. Her work focuses on developing a special method for producing the components with improved precision and efficiency.

At the same time, her research lays the foundation for the integration of deep-learning techniques into the manufacturing process. With their help, predictions can be made about individual structural shapes, optimizing the accuracy of the product.

Valeriia's research realizes an important step towards faster and more cost-effective production of micro-optical components for a variety of application areas, e.g., telecommunications or medical imaging.

The thesis was supervised by Andreas Erdmann, group manager for lithography and optics at Fraunhofer IISB and lecturer at FAU Erlangen-Nürnberg.

The Applied Photonics Award is the Fraunhofer IOF's "Young Researchers Award for Innovative Theses" and honors particularly relevant research in the field of applied photonics.

Valeriia Sedova, PhD Student in the Lithography Group at Fraunhofer IISB, with the Applied Photonics Award 2023 © Fraunhofer IOF

Best Industry Paper Prize of PEMD 2023 for Simon Querfelder

Simon Quergfelder, member of the Medium Voltage Electronics group at IISB, was awarded the "Best Industry Paper Prize" at the "13th International Conference on Power Electronics, Machines and Drives (PEMD 2023)".

The winning paper is entitled "Analytical Loss Model of a Three-Level WBG NPC Inverter Comprising Reverse Conduction, Dead Time, Modulation Schemes and Switching Energy Analysis".

Co-authors are Prof. Martin März, Head of IISB's Power Electronic Systems Division and the Chair of Power Electronics LEE of the Friedrich-Alexander-Universität Erlangen-Nürnberg, and Dr. Thomas Heckel, Head of the Medium Voltage Electronics Group in the Vehicle Electronics Department of Fraunhofer IISB.

Simon Quergfelder worked on the derivation of analytical equations for the switching and conduction losses of a three-point inverter with wide-bandgap switching devices for different modulation methods. A focus was on the analysis of the switching processes, which differ from those in conventional two-point inverters and lead to different switching energies. The resulting equations can be used for fast and accurate determination of the semiconductor losses for designing and analyzing inverters.

Simon Quergfelder, Researcher within the Medium Voltage Electronics Group at the IISB, Was Awarded The "Best Industry Paper Prize" of PEMD 2023 © IET / pemd.theiet.org

25 Years of GMM User Group "Deposition and Etch Processing"

With a delicious cake in the form of a processed wafer and great community spirit, the participants celebrated the 25th workshop of the GMM User Group "Deposition and Etch Processing" at Fraunhofer IISB in Erlangen.

The organizers of the workshop are delighted and grateful that so many familiar and new faces from the semiconductor scene are contributing today to the wide-bandgap semiconductor technology and, in particular, to new standard processes for deposition and etching.

On the festive occasion, Dr. Werner Robl from Infineon Technologies and Dr. Georg Roeder from Fraunhofer IISB were honored with uniquely processed jubilee wafers for their commitment to keeping the GMM User Group "Deposition and Etch Processing" running since its first meeting in 1999.

In the future, Dr. Mirko Vogt, Manager Chemical Vapor Deposition at Infineon Technologies and Dr. Susanne Oertel, Head of the Front End department at Fraunhofer IISB, will take over the organizational activities of this GMM User Group.

The annual workshops of the group are an open forum for discussion in the fields of physical vapor deposition (PVD), plasma-enhanced chemical vapor deposition (PECVD), electrochemical deposition (ECD) and in general deposition processes and plasma etching.

The GMM workshops enable a direct exchange of knowledge between manufacturers of semiconductor devices, equipment manufacturers and research institutes.

To the next 25 years!

IISB Science Stars

From left to right: Dr. Georg Roeder, Member of IISB's Data Analytics Group, Dr. Susanne Oertel, Head of the Front End Department at Fraunhofer IISB, and Dr. Mirko Vogt, Manager Chemical Vapor Deposition at Infineon Technologies
© Elisabeth Iglhaut / Fraunhofer IISB

Community of the 25th Workshop of the GMM User Group "Deposition and Etch Processing" at Fraunhofer IISB in Erlangen
© Elisabeth Iglhaut / Fraunhofer IISB

IISB Science Stars

Fraunhofer President Prof. Holger Hanselka Visits Fraunhofer IISB

Prof. Holger Hanselka is the new President of the Fraunhofer-Gesellschaft since August 2023. His dialog tour took him to five Fraunhofer sites. There, he primarily sought an open exchange with employees and managers, but also met regional representatives from research, business and politics on the sidelines. He also learned about the institutes' research highlights.

On October 17, Prof. Hanselka was a guest at Fraunhofer IISB. He visited laboratories and workshops and had numerous discussions with colleagues about the institute's range of topics - from next-generation wide-bandgap semiconductor materials to silicon carbide device processing technology and electric aviation. This led to inspiring discussions about the future of semiconductor technology and power electronics at the IISB and at Fraunhofer as a whole.

Prof. Hanselka, whose own Fraunhofer roots lie in electromobility, said after his visit: "I was particularly fascinated by how we are now moving from electric driving to electric flying and the relevance of power electronics in this context."

At the "mikroelektronik-bauhaus erlangen-nürnberg", Prof. Hanselka also spoke to trainees and young master craftsmen and women about the needs of young technical and scientific talents. With his µe-bauhaus erlangen-nürnberg, Institute Director Prof. Jörg Schulze has established a triad of teaching, laboratory practice and R&D in semiconductor technology, transforming the classic Bauhaus concept.

Institute Director Prof. Jörg Schulze (left) and the New Fraunhofer President Prof. Holger Hanselka (right)
© Elisabeth Iglhaut / Fraunhofer IISB

From Right to Left: Dr. Bernd Eckardt, Head of Vehicle Electronics Department, Fraunhofer President Prof. Holger Hanselka and Florian Hilpert, Head of the Aircraft Power Electronics Group, Talk about Electric Drives at the Test Center for Electric Vehicles of Fraunhofer IISB
© Elisabeth Iglhaut / Fraunhofer IISB

Honoring of the Volunteer IHK Examiners

Stephanie Natzer and Martin Heilmann from Fraunhofer IISB Were Honored by the Nuremberg Chamber of Industry and Commerce for Middle Franconia for Their Commitment as Voluntary Examiners
© Oliver Dürrbeck / IHK Nürnberg für Mittelfranken

On September 14, 2023, the Nuremberg Chamber of Industry and Commerce for Middle Franconia (IHK) honored more than 300 examiners who have been volunteering for 10 or 20 years to ensure the quality of professional examinations.

Among them were Stephanie Natzer and Martin Heilmann from Fraunhofer IISB, who have been assisting with the final examinations for microtechnologists since 2000.

The President of the Nuremberg Chamber of Industry and Commerce for Middle Franconia, Dr. Armin Zitzmann, took the opportunity to personally express his sincere thanks to the honorees.

Their commitment in carrying out the examinations is invaluable for the region and the local business community.

New Apprentices at the IISB

In September 2023, the IISB once again welcomed new trainees in the fields of microtechnology, information technology and office management.

As a kick-off to three eventful onboarding days, Institute Director Jörg Schulze took the opportunity to personally introduce his institute to the apprentices. The new colleagues had the chance to take a close look at their future working environment. They also got to know each other and Erlangen's most beautiful sides during a sunny scavenger hunt through the town center.

Fraunhofer IISB is not only looking for apprentices, but also offers exciting positions and career opportunities for all entry levels.

At the Fraunhofer IISB Onboarding Event, the New Apprentices Also Explored the Inner City of Erlangen
© Linus Wegmann / Fraunhofer IISB

IISB Science Stars

Team EVOLONIC and the Erlangen Fire Department are Testing Automatically Flying Drone and AI Image Recognition

The student team EVOLONIC of FAU Erlangen-Nuremberg, based at Fraunhofer IISB, presented its latest long-range drone for early forest fire detection at the Erlangen fire brigade headquarters on August 9, 2023. Numerous representatives from politics, regional fire departments, Bavarian forestry companies, television and the press followed the invitation.

With the presentation of the "Night Fury 4" drone, Evolonic and the Erlangen fire department officially launched the joint testing phase for the entire system comprising the aircraft, camera and sensor module and web application.

With the help of an automatically flying drone and AI-supported image and sensor analysis, the system detects potential forest fires at an early stage and provides the firefighters with all the information they need in real time to tackle fires quickly and in a precise manner.

The collaboration between Evolonic and the fire department focuses in particular on the long-term stability and reliability of the technology and software. In addition, the operational forces gain their first practical experience of working with the system and are involved constructively in the development process.

The event was moderated by Adrian Sauer, Evolonic team leader and member of the Aviation Electronics Group at Fraunhofer IISB, and Tobias Raczok, responsible for networking and communication at Evolonic.

Guest speakers were the Bavarian State Minister of the Interior Joachim Herrmann, Prof. Martin Maerz, Head of the Power Electronic Systems Division at IISB and holder of the Chair of Power Electronics at FAU Erlangen-Nuremberg, and the Mayor of Erlangen Florian Janik. On behalf of the Erlangen fire department, Friedhelm Weidinger, Head of Office and Head of Department 1 "Administration" and Birgit Süssner, Head of Department 5 "Respiratory Protection and CBRN Matters" spoke about the new challenges in firefighting and the effects of climate change on the condition of the forests.

https://evolonic.de

Team EVOLONIC Presents Its Latest Long-Range Drone for Early Forest Fire Detection to Joachim Herrmann, Bavarian State Minister of the Interior, at the Erlangen Fire Brigade Headquarters
© Elisabeth Iglhaut / Fraunhofer IISB

Microelectronics Innovation Award for X-Ray Topography Measurement and Defect Quantification

The Förderkreis für die Mikroelektronik e.V. awarded the Hans-Georg-Waeber Innovation Prize 2023 on October 25. This innovation prize honors research work, development, teaching and technology transfer in the field of microelectronics.

This year, the prize was split and went to Dr. Korbinian Reiser, Infineon Technologies, and the team of Dr. Christian Kranert, Dr. Christian Reimann, both IISB, and Dr. Michael Hippler, Rigaku Europe SE.

The team from the IISB and Rigaku Europe SE received the award for the development of a new X-ray topography tool for the rapid non-destructive analysis of material defects in various semiconductor materials, which can improve quality control and yield in the industrial production of semiconductor devices.

The innovative technology could revolutionize the non-destructive testing of wafers and form the basis for a global quality standard.

https://www.iisb.fraunhofer.de/xrt

At the Center of Expertise for X-Ray Topography in Erlangen, the Winners of the Hans-Georg-Waeber Innovation Award 2023 (from Left) Dr. Michael Hippler, Riggaku Europe SE, Dr. Christian Reimann and Dr. Christian Kranert, Both Fraunhofer IISB, Present Their Prize Certificates © Elisabeth Iglhaut / Fraunhofer IISB

IISB Science Stars

ZEISS Award for Talents in Photomask Industry for Sean D'Silva from the IISB Lithography Group

Sean D'Silva, PhD student in the lithography group at Fraunhofer IISB, received the ZEISS Award for Talents in Photomask Industry for his paper “Predicting resist pattern collapse in EUV lithography using machine learning”.

www.iisb.fraunhofer.de/lithography

It was selected as the best student paper at the 38th European Mask and Lithography Conference in Dresden.

In the paper, Sean and his co-authors R. Arava, A. Erdmann, T. Mülders, and H.-J. Stock employ machine learning to predict the dependence of the probability for resist pattern collaps on resist material properties, feature density, and profile shape.

Sean D'Silva from the Lithography Group at the IISB Received the ZEISS Award for Talents in Photomask Industry © Elisabeth Iglhaut / Fraunhofer IISB

Fraunhofer IISB at PCIM Europe 2023 in Nuremberg

This is the place where representatives from research and industry come together, and where trends and developments are presented to the public for the first time.

At the PCIM Europe 2023, Fraunhofer IISB once again showcased the broad spectrum of its activities – from wide- and ultra-wide-bandgap semiconductor materials and devices to high performance power modules for extreme demands and intelligent, reliable power electronic systems for aviation and electromobility.

The visitors got to talk to the IISB's experts to gain first-hand insights into the institute's research and development activities and took the unique opportunity to view the wide range of exhibits.

As always, it was a great pleasure to see many new and familiar faces at PCIM Europe and Fraunhofer IISB would like to thank its guests at the booth for the inspiring conversations.

See you in 2024!

The Colleagues from Fraunhofer IISB, Who Prepared and Supervised the IISB's Booth at PCIM 2023, Welcomed Many Visitors for Inspiring Discussions at the Leading Power Electronics Fair in Europe © Elisabeth Iglhaut / Fraunhofer IISB

Pretzfeld - The Real Silicon Valley?

There are rumors that even Microsoft co-founder Bill Gates once visited Pretzfeld: He wanted to get back to the roots of semiconductors.

And these are located in the small market town of Pretzfeld in the Franconian Switzerland, north of Nuremberg.

After the Second World War, the physicists Walter Schottky and Eberhard Spenke conducted research in Pretzfeld into the new semiconductor material silicon. Siemens, which had recently relocated to the nearby town of Erlangen, established a semiconductor laboratory in the Pretzfeld castle. Here, for the first time, it was possible to produce high-purity and perfect crystals from silicon.

In addition to many other innovations for power electronics, the Pretzfeld laboratory team developed the "Siemens Process" for the production of ultra-pure silicon. This process is still the basis for microelectronics and photovoltaics worldwide.

Historically speaking, the first Silicon Valley is in Franconia, even if most people think of the IT industry in California when they hear this name.

To honor the achievements of the silicon pioneers, Fraunhofer IISB and the local community of Pretzfeld are presenting historically unique exhibits from the early days in the display window of the local Sparkasse bank.

From Left to Right: Dominik Trautner (Head of Sparkasse Pretzfeld), Dr. Martin Schottky (Grandson of Walter Schottky), Steffen Lipfert (1st Mayor of Pretzfeld), Sieglinde Hack (Former Employee of Siemens Laboratories), Dr. Jochen Friedrich (Head of the Materials Department at Fraunhofer IISB) and Prof. Georg Müller (Former Head of the Crystal Growth Department at Fraunhofer IISB) Officially Opened the Exhibition in Pretzfeld on June 26, 2023 © Thomas Richter / Fraunhofer IISB

Fraunhofer IISB Awards for Research and Development

This years Fraunhofer IISB Awards for Research and Development are all about high-performance power electronics for e-mobility:

The R&D Group Award goes to a five-person team from the Vehicle Electronics department for their elaborate development, commissioning and characterization of a 1 MW SiC high-performance traction inverter. In order to achieve this, Maximilian Hofmann, group manager Drives and Mechatronics, together with colleagues André Müller, Alexander Benner and Stefan Arenz collaborated with Hubert Rauh, group manager Advanced Power Modules. Now, the 1 MW SiC inverter has been integrated into a vehicle by Porsche AG to drive laps on a test track.

The other lucky recipient of an IISB R&D Award is Florian Hilpert, newly appointed business unit developer for power electronic systems and group manager Aviation Electronics. During the last year, he has greatly advanced the field of aviation power electronics at the IISB. Driven by his enthusiasm for electric flying, Florian opened up access to seven projects of the European Union Clean Aviation Programme: PROJECT NEWBORN, AMBER, HyPoTraDe, TheMa4HERA project, HERA project, HECATE and CONCERTO Project.

The IISB R&D Awards are given by the directorate to our scientists for outstanding achievements. Institute Director Jörg Schulze presents the prizes annually at our End-of-year meeting before the Christmas vacations.

Prof. Jörg Schulze (Right), Director of Fraunhofer IISB, Presents the Fraunhofer IISB R&D Group Award 2024 to (from Left) Dr. Hubert Rauh, Group Manager Advanced Power Modules, Dr. Maximilian Hofmann, Group Manager Drives and Mechatronics, and Alexander Benner and André Müller, Both Members of the Drives and Mechatronics Group © Elisabeth Iglhaut / Fraunhofer IISB

Award-Winning DC Technology for the Energiewende

Fraunhofer IISB congratulates Richter R&W Steuerungstechnik GmbH on receiving the 2023 Future Prize of the Chamber of Crafts (HWK) for Upper Franconia in the category "Energy Transition in the Skilled Crafts"!

The HWK's Future Prize honors outstanding achievements by regional craft businesses that are significantly above the industry average. The company from Ahorntal, which specializes in control, measurement and regulation technology, impressed the award jury with its Intelligent Energy Node (IEK). At the award ceremony at Rosenau Castle in Rödental, Bernd Zeilmann, Managing Director of R&W Steuerungstechnik and Senior Master of the Bayreuth Electrical Guild, particularly emphasized the importance of in-house training of skilled workers and close cooperation between science, industry and the craft trades.

R&W Steuerungstechnik managed the complex development process right up to the market-ready product together with the Chair of Measuring and Control Technology at the University of Bayreuth and the Fraunhofer IISB in Erlangen. The collaboration between the three project partners resulted in a modular intelligent energy system comprising various modules for the conversion, supply, storage and output of self-generated energy as well as backup power functionality: the Intelligent Energy Node (IEK). The power electronics for the DC grid integrated in the IEK, which are not available on the market, were developed by the DC Grids Group at Fraunhofer IISB under the direction of Bernd Wunder.

When crafts, industry and science pull together, sustainable added value is created in the high-tech sector!

At the Presentation of the Future Prize: (From Left to Right) Joachim Hausner, Chairman of the Board of VR Bank Bamberg-Forchheim eG, Prof. Dr.-Ing. Gerhard Fischerauer, Faculty of Engineering and Chair of Measuring and Control Technology at the University of Bayreuth, Bernd Wunder, Group Leader DC Grids at Fraunhofer IISB in Erlangen, Bernd Zeilmann, Managing Director of Richter R&W Steuerungstechnik GmbH, Laudator Prof. Dr.-Ing. Tobias Plessing - Faculty of Engineering at Hof University of Applied Sciences / Director of the Institute for Hydrogen and Energy Technology (iwe), Dipl.-Ing. (FH) Matthias Graßmann, President of the Chamber of Crafts for Upper Franconia. © HWK

Bayerischer Halbleiter-Kongress 2023

The Bavarian Semiconductor Congress 2023

The Bavarian Semiconductor Congress 2023 on Mai 22, 2023 in Munich was an absolutely beneficial meeting for Fraunhofer IISB and the (not only) Bavarian semiconductor community.

We would like to thank Minister of State Hubert Aiwanger (Bavarian State Ministry of Economic Affairs, Regional Development and Energy), the Bayern Innovativ initiative, and the Bavarian Chips Alliance for the invitation.

With the Bavarian Semiconductor Congress, a trend-setting event format is being established for our high-tech industry and research landscape in order to jointly find answers to the global changes in microelectronics.

The positive atmosphere, the comprehensive lecture program, the great guests and the quality of the discussions inspired us and we are already looking forward to the next Bavarian Semiconductor Congress!

stmwi.bayern.de/mediathek/videos/video/52642/

bayern-innovativ.de/bavarian-chips-alliance

bayern-innovativ.de

Prof. Jörg Schulze during His Presentation at the 2nd Bavarian Semiconductor Congress 2023 © Thomas Richter / Fraunhofer IISB

IISB Science Stars

We Are All Science Stars!

Staff Members of Fraunhofer IISB During the Long Night of Science 2023 © Elisabeth Iglhaut / Fraunhofer IISB

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