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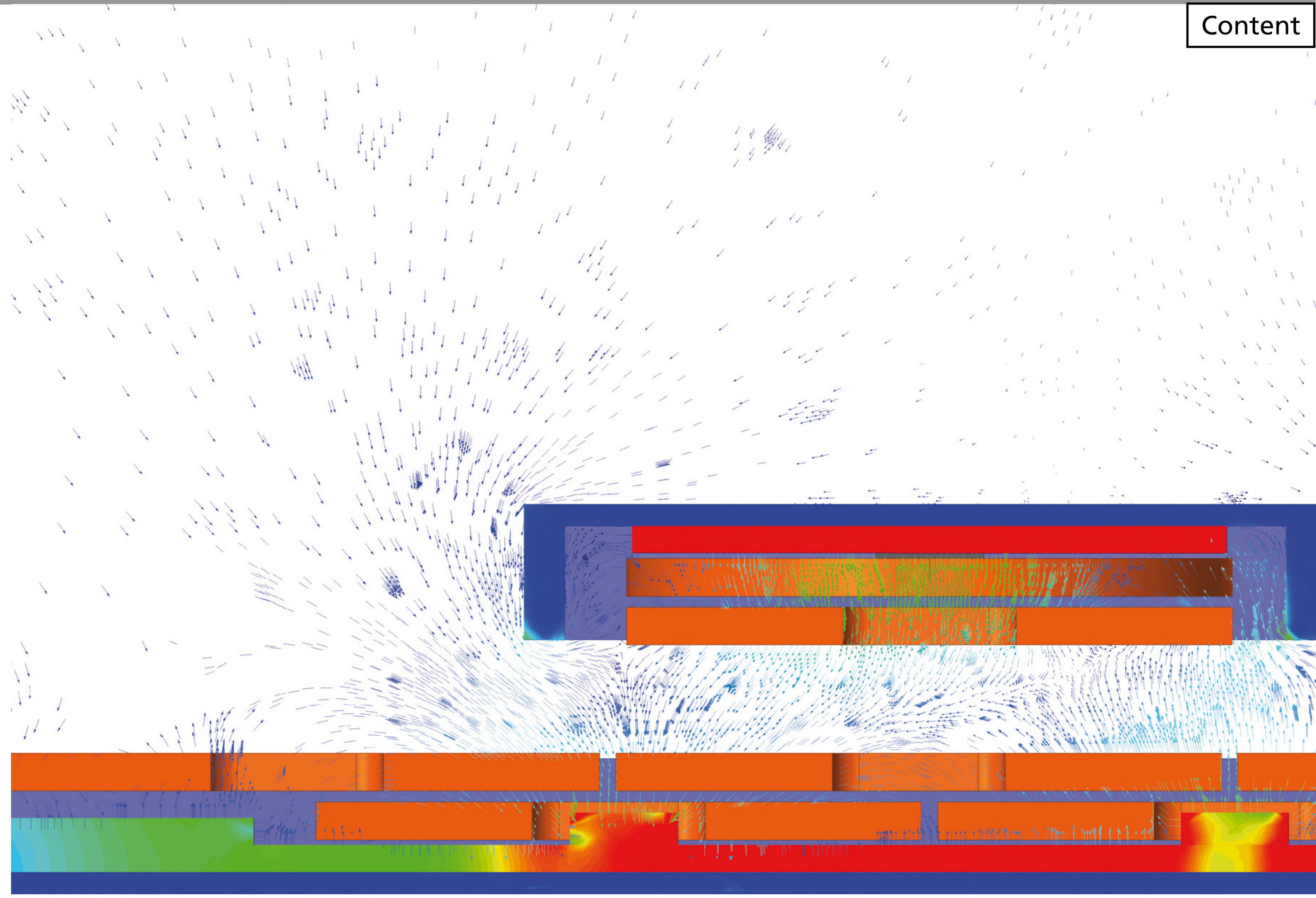
IISB

FRAUNHOFER INSTITUTE FOR INTEGRATED SYSTEMS AND DEVICE TECHNOLOGY IISB

Content

Annual Report 2013

Fraunhofer Institute for Integrated Systems and Device Technology IISB



ANNUAL REPORT 2013

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Cover Photo:
Numerical simulation of the magnetic field in a coil arrangement for inductive charging of electric vehicles.

ACHIEVEMENTS AND RESULTS
ANNUAL REPORT 2013

Content

FRAUNHOFER INSTITUTE FOR

INTEGRATED SYSTEMS AND DEVICE TECHNOLOGY IISB

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PREFACE

In 2013, the research activities of Fraunhofer IISB were strongly influenced by the major topic of “energy”. For the institute, this is most obviously reflected by SEEDs, our large Bavarian energy research project, which was started last year together with partners from Fraunhofer and industry.

SEEDs aims for a sustainable energy supply and infrastructure under the special boundary conditions of medium-sized industrial environments, such as power peaks, grid interferences, and large amounts of secondary forms of energy such as cooling, heating, and processing gases. Within the framework of SEEDs, IISB has extended its activities in energy research from power electronics to the interfaces between electrical energy and non-electrical forms of energy. The institute itself is now used as a demonstration platform for energy research.

SEEDs – which also refers to a germ cell – also stands for the strategic development of the institute, which received a new organizational structure at the beginning of 2014 that reflects our development in the last years. IISB covers the whole value chain of power electronics from materials to systems.

Among many highlights, wide-band-gap-based devices have garnered significant attention with successful projects for new silicon carbide devices or benchmark-type power converters using gallium nitride devices.

I would like to thank all colleagues at the institute for their successful work in the past year. My gratitude also goes to our partners at the Friedrich-Alexander University of Erlangen-Nuremberg and in industry. I would also like to thank our funding authorities, especially the Bavarian Ministry of Economic Affairs and Media, Energy and Technology, and the German Federal Ministry of Education and Research (BMBF) for their support.

Erlangen, April 2014

Lothar Frey

Prof. Dr. Lothar Frey

1 *Prof. Dr. rer. nat. Lothar Frey, Director of Fraunhofer IISB. Image: Matthias Heyde / Fraunhofer-Gesellschaft*

2 *Fraunhofer IISB: Demonstration platform for energy project SEEDs.*

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PROFILE OF THE INSTITUTE

Brief Portrait

The Fraunhofer Institute for Integrated Systems and Device Technology IISB conducts applied research and development in the field of electronic systems for application in, e.g., electric mobility or energy technology. In this connection, the IISB extensively covers the complete value chain from basic materials to entire power electronic systems.

With its two business areas, semiconductors and power electronics, the institute provides innovation and solutions in materials development, semiconductor technology and manufacturing, devices and modules, vehicle power electronics, energy electronics, and energy supply systems. This is supplemented by broad activities in reliability, simulation, characterization, and metrology.

The headquarters of the IISB is located in Erlangen. The institute has two branches in Nuremberg and one in Freiberg. As one of the 67 institutes of the Fraunhofer-Gesellschaft, the IISB does contract research for industry and public authorities. Moreover, it closely cooperates with the University of Erlangen-Nuremberg and is a member of the "Energie Campus Nürnberg" (EnCN). The IISB has about 200 employees plus numerous students working as research assistants. The institute is equipped with high-class laboratories, such as a test center for electric cars and an application center for DC grid technology. Together with the University, it operates 1500 m² of cleanroom area for semiconductor technology on silicon and silicon carbide.

The IISB is a close partner for national and international industry. It's main objective is to provide excellent research to its customers and to set technological benchmarks as one of the leading research institutions in electronic systems.

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1 *Building of the Fraunhofer IISB with test center for electric vehicles, cleanroom, and new laboratory building; behind: cleanroom laboratory and building of the Chair of Electron Devices of the University of Erlangen-Nuremberg. Image: Kurt Fuchs / Fraunhofer IISB*

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PROFILE OF THE INSTITUTE

Organization and Fields of Activity

Materials
Together with its industrial partners, the IISB develops equipment and processes for the production of crystalline bulk and layer materials for electronics. This comprises silicon, wide-band-gap semiconductors (e.g., silicon carbide, gallium nitride), materials for optical applications, detectors, and energy technology.

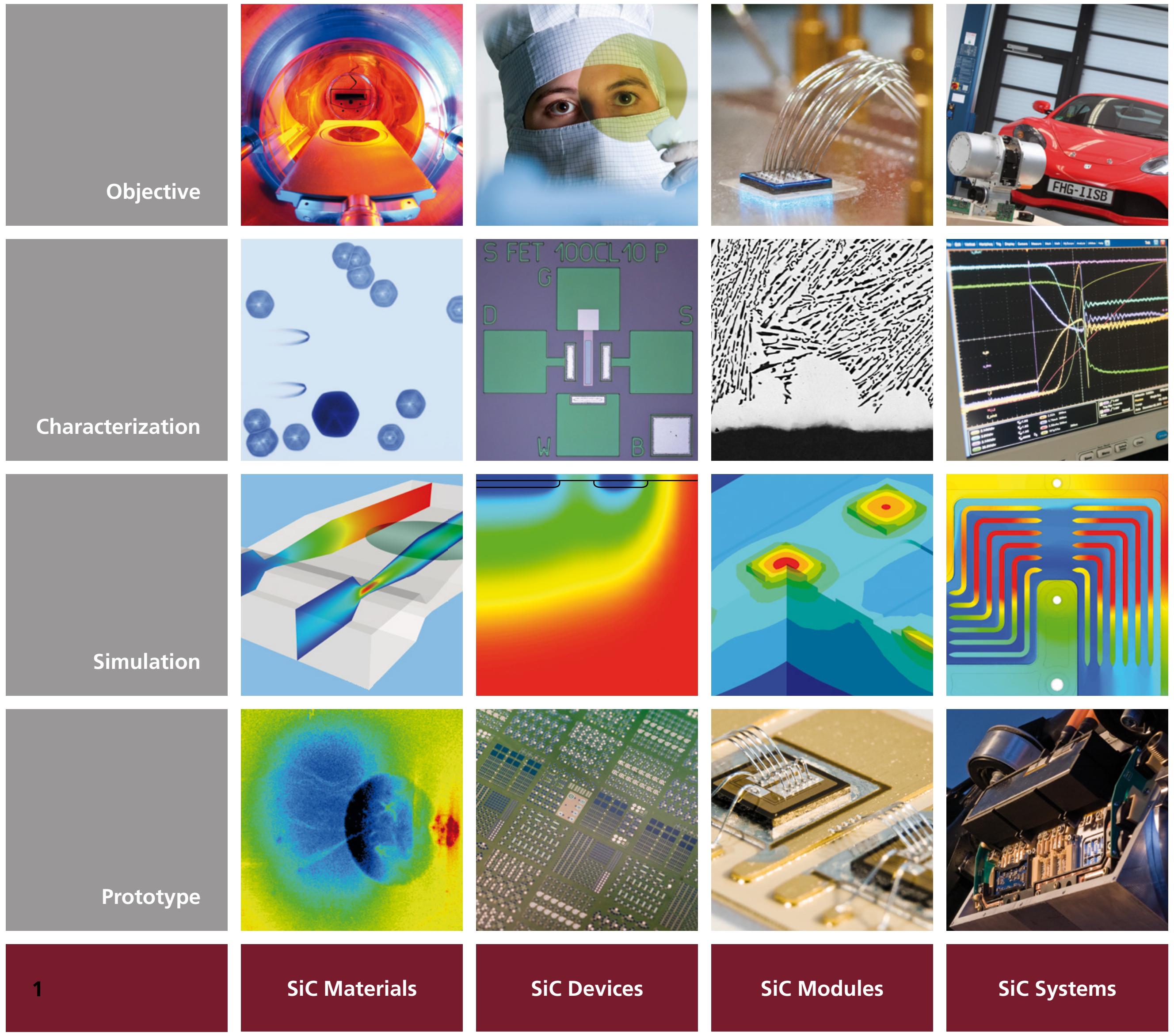
Technology and Manufacturing
The IISB operates extensive semiconductor technology lines, cleanroom infrastructure, and metrology on silicon and silicon carbide for the development of custom-tailored processes and prototype devices in power electronics and microelectronics. Furthermore, the IISB works on nanotechniques, particle and thin-film systems. Manufacturing aspects like process and quality control, equipment optimization, automation, and efficiency are also considered.

Simulation
The research activities of the IISB and its customers are supported by extensive competencies in simulation, modeling, and software development in the fields of, e.g., process and device simulation in semiconductor technology, crystal growth simulation, or thermal simulation for designing power electronic systems.

Devices and Reliability
The institute develops customer-specific active and passive electron devices on silicon and silicon carbide for application in power electronics, microelectronics, and sensors. In addition, new methods and materials for packaging, cooling, lifetime and failure analysis, and reliability play an important role.

Vehicle Electronics
Efficient, compact, and robust power electronic systems for all kind of vehicles are in the focus of the IISB. This comprises electric drives, battery systems, and charging infrastructure of electric cars. Benchmark values for energy efficiency and power density are regularly set for the work of the IISB. Further fields of application are shipping and aviation.

Energy Electronics and Systems
Power electronic systems are indispensable for realizing modern energy supply and the transition to predominantly regenerative energy sources. The developments of the IISB contribute to this on all levels of the power grid by, e.g., electronic components for HV DC transport, local DC micro grids or the integration of electrical storages and regenerative sources into the power grid. Another field of activity is the coupling of electric and non-electric energy and the development of the necessary interfaces for implementing a sustainable energy infrastructure, especially for industry-size environments.



1 *Extensive SiC R&D activities at IISB as an example for the institute's value chain from materials to power electronic systems.*

PROFILE OF THE INSTITUTE

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Headquarters and Locations

Fraunhofer IISB Erlangen
Schottkystrasse 10, 91058 Erlangen

The headquarters of Fraunhofer IISB in Erlangen are located in close neighborhood to the University of Erlangen-Nuremberg. About 7000 m² of laboratories and office area allow research and development on a broad range of power electronics, semiconductor technology, and materials development. A test center for electric cars and extensive cleanroom area for semiconductor technology on silicon and silicon carbide, which is partly operated together with the Chair of Electron Devices of the University, are part of the available infrastructure.

Fraunhofer IISB Nuremberg-South
Landgrabenstrasse 94, 90443 Nuremberg

In Nuremberg-South, 800 m² of office and lab area are available. Research activities are focused on packaging and power electronic systems for industrial application and energy technology.

Fraunhofer IISB Nuremberg-EnCN
Fürther Strasse 250, "Auf AEG", 90429 Nuremberg

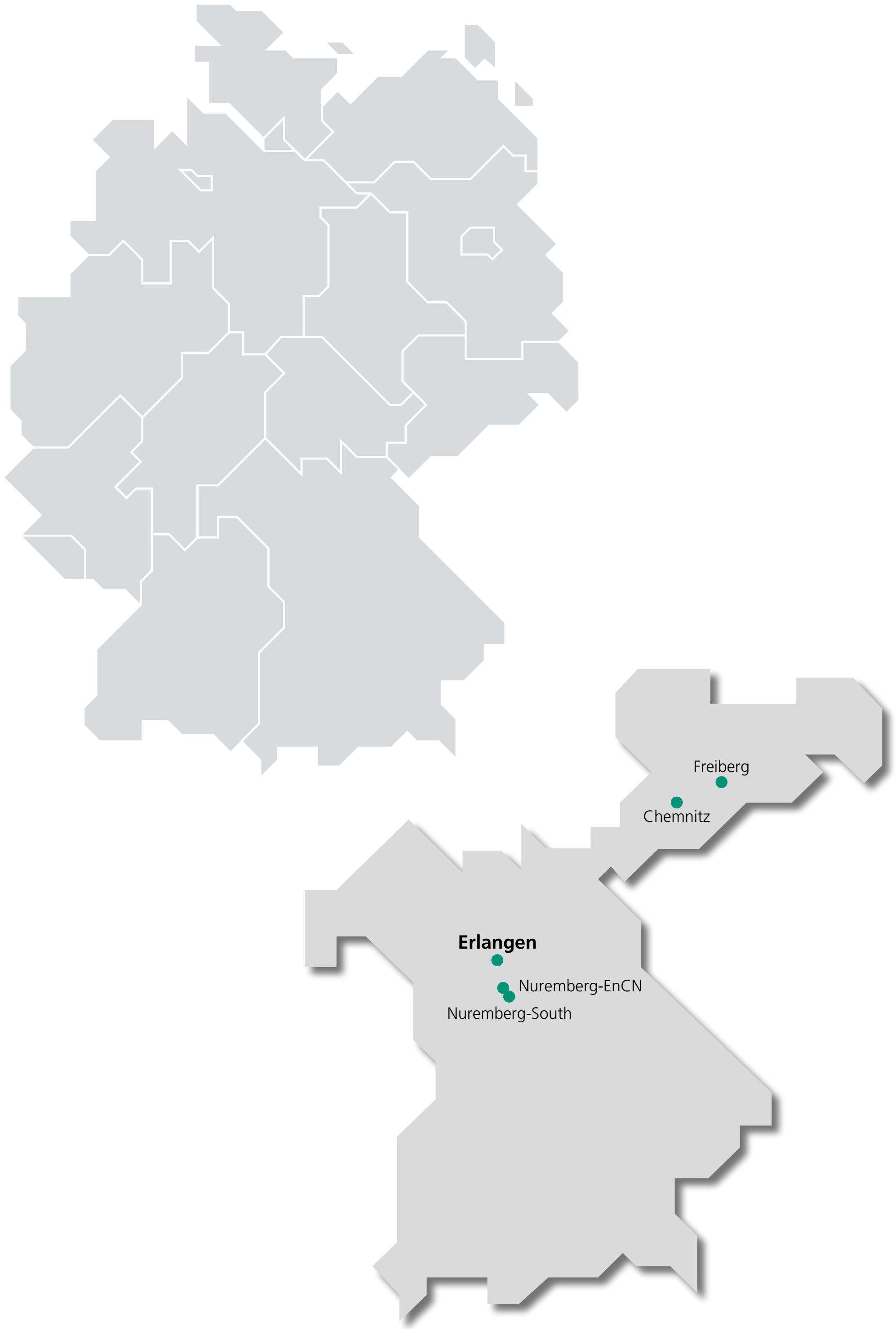
As a member of the "Energie Campus Nürnberg" (www.encn.de), the IISB operates a 450 m² branch lab on megawatt power electronics for energy supply in the joint EnCN building in Nuremberg.

Technology Center for Semiconductor Materials THM Freiberg
Am St.-Niclas-Schacht 13, 09599 Freiberg

The THM is a joint department of Fraunhofer IISB and Fraunhofer ISE. It supports industry in technologies for the production of innovative semiconductor materials to be used in microelectronics, optoelectronics, and photovoltaics. The IISB part of the THM comprises 650 m².

Laboratory Chemnitz
Reichenhainer Strasse 29a, 09126 Chemnitz

In the year 2013, a new laboratory for the application of power electronics was opened in Chemnitz. The laboratory has now a total area of 160 m².



1 *In addition to its headquarters in Erlangen, Fraunhofer IISB has two branch labs in Nuremberg and one in Freiberg. A laboratory for power electronics was opened in Chemnitz.*

Content

Cooperation

Within its research activities, Fraunhofer IISB pursues cooperation with numerous national and international partners in joint projects and associations, inter alia:

- Since its foundation, the IISB has been closely cooperating with the University of Erlangen-Nuremberg. The institute is directed by the head of the Chair of Electron Devices of the University. The joint operation of infrastructure as well as the exchange in education and training create extensive synergies.
- The IISB is partner of the excellence projects at the University of Erlangen-Nuremberg (www.eam.uni-erlangen.de, www.aot.uni-erlangen.de/saot/).
- The IISB is a member of the "Energie Campus Nürnberg" (www.encn.de).
- The IISB is a close partner of the "Förderkreis für die Mikroelektronik e.V." (www.foerderkreis-mikroelektronik.de).
- The IISB is coordinator of the joint Bavarian energy research project SEEDs (www.energy-seeds.org).
- The IISB is coordinator of the Bavarian Research Cooperation for Electric Mobility (FORELMO, www.forelmo.de).
- The IISB is coordinator of the Fraunhofer Innovation Cluster "Electronics for Sustainable Energy Use".
- The IISB closely cooperates with industry and research associations, such as the European Center for Power Electronics, the Bavarian Clusters for Power Electronics and Mechtronics & Automation, the German Crystal Association DGKK e.V., or the International Technology Roadmap for Semiconductors (ITRS)
- The IISB is coordinator and partner, respectively, of numerous joint European research projects.
- Together with the Federal Ministry for Education and Research (BMBF), the IISB initiated and operates the joint student program of BMBF and Fraunhofer for electric mobility, DRIVE-E (www.drive-e.org).

Within the Fraunhofer-Gesellschaft, the Fraunhofer IISB is member of the following institute groups and alliances:

- Fraunhofer Group for Microelectronics (www.mikroelektronik.fraunhofer.de)
- Fraunhofer Energy Alliance (www.energie.fraunhofer.de)
- Fraunhofer Battery Alliance (www.batterien.fraunhofer.de)
- Fraunhofer Nanotechnology Alliance (www.nano.fraunhofer.de)

History

The Fraunhofer Institute for Integrated Systems and Device Technology IISB in Erlangen is an important center of applied R&D for electronic systems, power electronics, semiconductor technology, and materials development in Europe, Germany, and the Nuremberg Metropolitan Region. It was founded in 1985 as the electron devices department AIS-B of the Fraunhofer Working Group for Integrated Circuits. In 1993, it turned into a Fraunhofer institute (IIS-B), but was still formally linked to its sibling 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 his retirement in 2008, the IISB was headed by Prof. Heiner Ryssel. Since 2008 Prof. Lothar Frey has been director of the IISB. From the beginning, the institute has been closely cooperating with the University of Erlangen-Nuremberg.

1 *Welcome to Fraunhofer IISB!*

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The Chair of Electron Devices, University of Erlangen-Nuremberg

The Fraunhofer IISB and the Chair of Electron Devices (German abbreviation: LEB) of the University of Erlangen-Nuremberg are both headed by Prof. Lothar Frey. Within the framework of a cooperation agreement, the two institutions not only jointly operate the University's cleanroom hall 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 allows to cover the entire chain of topics from basic research to the transfer to industry. For many years, the vocational training as a "microtechnologist" has been offered jointly by IISB and the Chair of Electron Devices. Employees of IISB assist in courses and internships at the University.

The following staff members of Fraunhofer IISB regularly give lectures at the University of Erlangen-Nuremberg:

Dr. Andreas Erdmann
Optical Lithography: Technology, Physical Effects, and Modeling

Dr. Tobias Erlbacher
Semiconductor Power Devices

Dr. Michael Jank
Nanoelectronics,
Introduction to Printable Electronics

Dr. Jürgen Lorenz
Process and Device Simulation

Prof. Dr. Martin März
Automotive Electronics,
Architecture and Systems Technology for Electric Mobility

Prof. Dr. Lothar Pfitzner
Semiconductor Equipment Technics

Priv.-Doz. Dr. Peter Pichler
Reliability and Failure Analysis of Integrated Circuits

Prof. Dr. Heiner Ryssel
Cleanroom Technology

1 *Chair of Electron Devices of the University of Erlangen-Nuremberg: main building and cleanroom laboratory. Image: Chair of Electron Devices (LEB)*

Content

Advisory Board (December 2013)

IISB is consulted by an Advisory Board, whose members come from industry and research:

Dr. Reinhard Ploß (Chairman of the Advisory Board)
Infineon Technologies AG

Thomas Harder
European Center for Power Electronics (ECPE)

Dr. Stefan Kampmann
Robert Bosch GmbH

MinR Dr. Ulrich Katenkamp
Federal Ministry of Education and Research (BMBF)

Markus Lötzsch
Nuremberg Chamber of Commerce and Industry

Prof. Dr. Marion Merklein
Dean of the Faculty of Engineering Sciences of the University of Erlangen-Nuremberg

Dr. Andreas Mühe
Siltronic AG

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Bayern Kapital GmbH

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REPRESENTATIVE FIGURES

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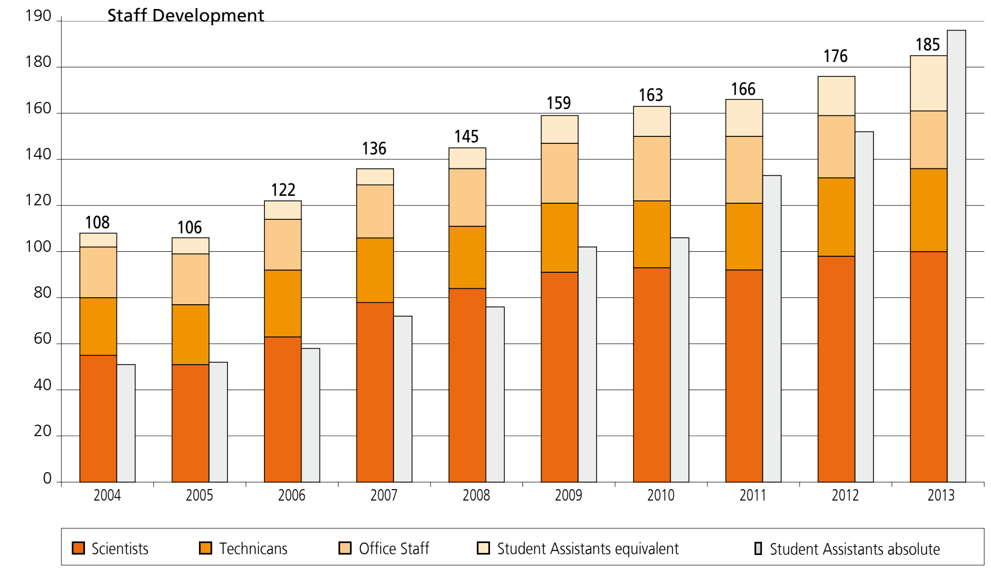
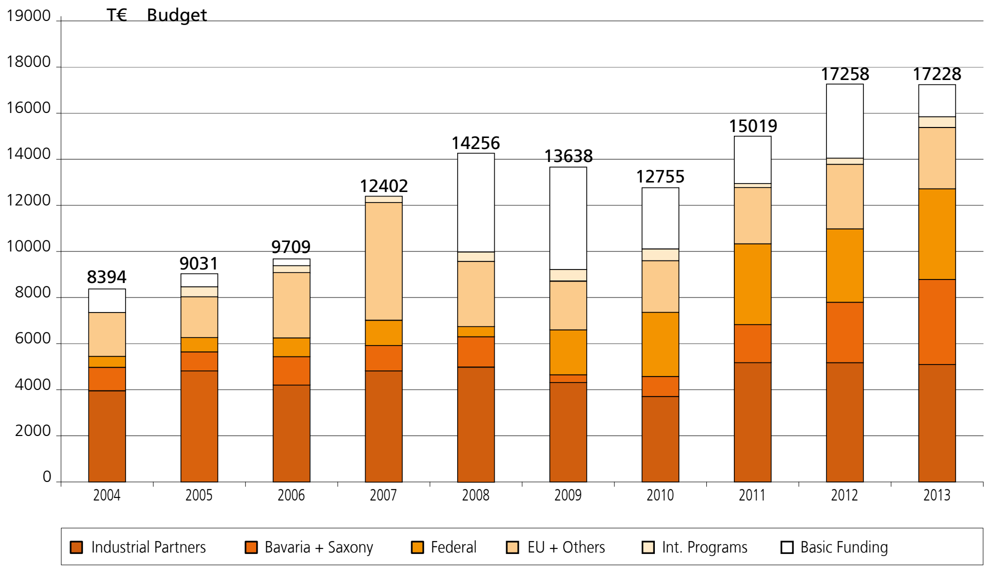
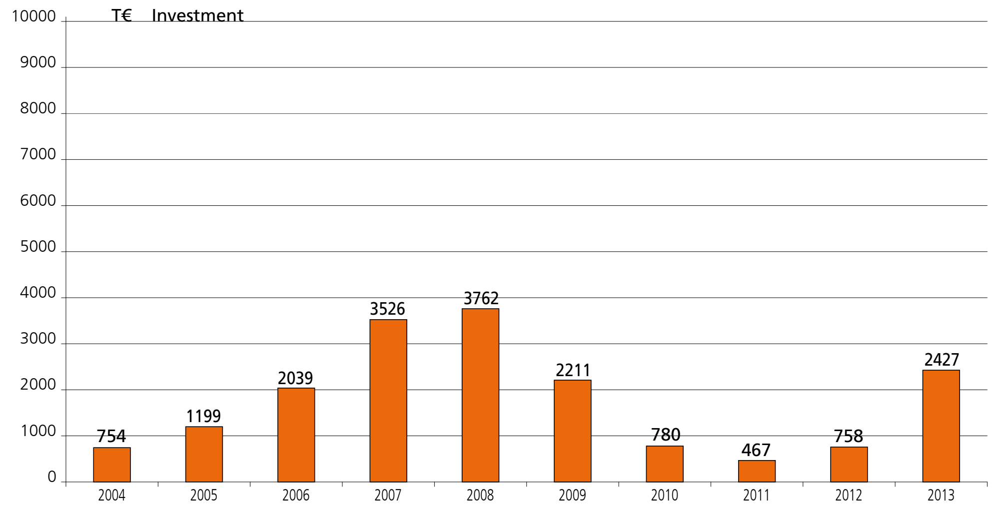
Staff Development, Budget, and Investments



1 *Staff development*
2004 - 2013.



2 *Operating budget according to financing domains*
2004 - 2013.



3 *Capital investment (without basic equipment and special funds)*
2004 - 2013.

Content

The Fraunhofer-Gesellschaft

Research of practical utility lies at the heart of all activities pursued by the Fraunhofer-Gesellschaft. Founded in 1949, the research organization undertakes applied research that drives economic development and serves the wider benefit of society. Its services are solicited by customers and contractual partners in industry, the service sector and public administration.

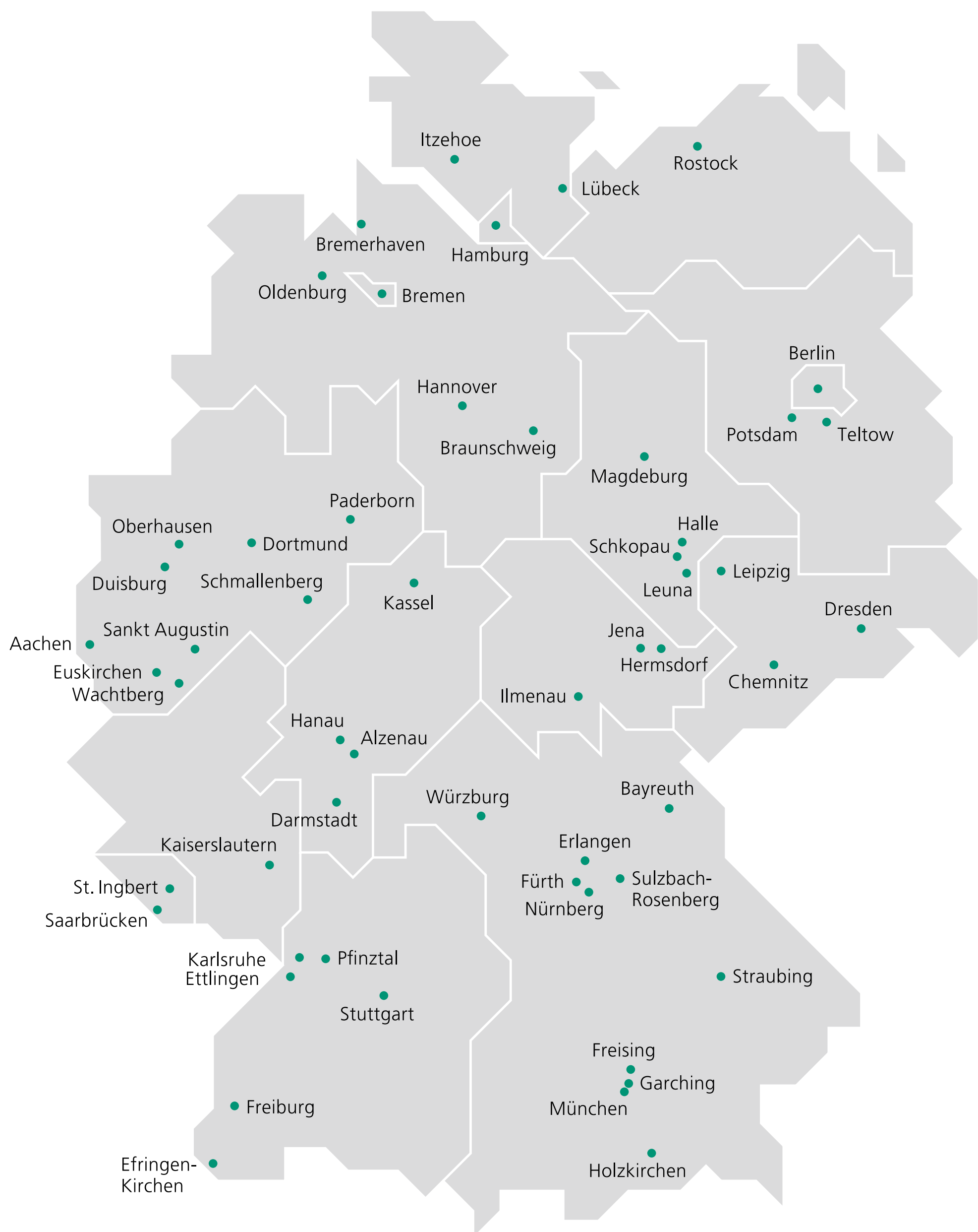
At present, the Fraunhofer-Gesellschaft maintains 67 institutes and independent research units. The majority of the more than 23,000 staff are qualified scientists and engineers, who work with an annual research budget of 2 billion euros. Of this sum, more than 1.7 billion euros is generated through contract research. More than 70 percent of the Fraunhofer-Gesellschaft's contract research revenue is derived from contracts with industry and from publicly financed research projects. Almost 30 percent is contributed by the German federal and Länder governments in the form of base funding, enabling the institutes to work ahead on solutions to problems that will not become acutely relevant to industry and society until five or ten years from now.

Affiliated international research centers and representative offices provide contact with the regions of greatest importance to present and future scientific progress and economic development.

With its clearly defined mission of application-oriented research and its focus on key technologies of relevance to the future, the Fraunhofer-Gesellschaft plays a prominent role in the German and European innovation process. Applied research has a knock-on effect that extends beyond the direct benefits perceived by the customer: Through their research and development work, the Fraunhofer Institutes help to reinforce the competitive strength of the economy in their local region, and throughout Germany and Europe. They do so by promoting innovation, strengthening the technological base, improving the acceptance of new technologies, and helping to train the urgently needed future generation of scientists and engineers.

As an employer, the Fraunhofer-Gesellschaft offers its staff the opportunity to develop the professional and personal skills that will allow them to take up positions of responsibility within their institute, at universities, in industry and in society. Students who choose to work on projects at the Fraunhofer Institutes have excellent prospects of starting and developing a career in industry by virtue of the practical training and experience they have acquired.

The Fraunhofer-Gesellschaft is a recognized non-profit organization that takes its name from Joseph von Fraunhofer (1787–1826), the illustrious Munich researcher, inventor and entrepreneur.



1 *Locations of the Fraunhofer-Gesellschaft in Germany*

TECHNOLOGY SIMULATION

Content

Focal Areas of Research and Development, Trends, and Potentials

The simulation of semiconductor fabrication processes, devices, and circuits strongly contributes to the reduction of development costs in micro- and nano-electronics. Among others, this has been confirmed in the International Technology Roadmap for Semiconductors (ITRS). The Technology Simulation department contributes to this with the development of physical models and programs for the simulation and optimization of semiconductor fabrication processes and equipment. Furthermore, it supports the development of processes, lithography masks, devices, circuits and systems by providing and applying simulation and optimization tools.

While process and device simulation has meanwhile become largely established in industry as an indispensable tool for the development and optimization of highly scaled devices ("More Moore"), the area of "More than Moore", which consists of fields such as power electronics, photovoltaics, and microsystems technology, offers a large variety of additional applications. On the other hand, these new fields of application in particular often require the combination of heterogeneous competencies, because thermal, mechanical, optical, and chemical effects also occur in addition to electronic effects. This gives rise to an additional demand for research.

The Technology Simulation department responded to this demand by extending its activities to the "More than Moore" sector. Our solid expertise gained in the field of "More Moore", for instance regarding tailored numerical methods for model implementation, also provides a sound basis for the development and application of simulation in other fields such as "More than Moore". This is comparable to research and development for industrial production itself: The application of advanced technologies from "More Moore" also leads to improved and more cost-effective products in the "More than Moore" sector. In consequence, the department utilizes "More Moore" results in the "More than Moore" area as well.

Four projects that started or finished in 2013 are good examples for current activities of the department: In the EC FP7 project CoLiSA.MMP (Computational Lithography for Directed Self-Assembly: Materials, Models and Processes), started in November 2013 and coordinated by IISB, a consortium of research institutes, universities and a material supplier, develops new materials, processes and especially simulation software for the most promising options of lithography for sizes below 20 nm. The EC FP7 project ATEMOX (Advanced Technology Modeling for Extra-Functionality Devices), completed in November 2013, was based on earlier projects on physical process models for aggressively scaled devices. Coordinated by IISB, a consortium of research institutes, universities, equipment SMEs, STMicroelectronics and the software house Synopsys, they worked on the development and implementation of models for leakage currents and technologies for advanced low-power electronics, smart power applications, CMOS image sensors, and CMOS derivatives. The department also started work on two other EC projects in 2013 that is also based on preceding modeling work for aggressively scaled devices and extends this to "More than Moore" applications: ATHENIS_3D (Automotive Tested High Voltage and Embedded Non-Volatile Integrated System on Chip Platform employing 3D Integration), started in November 2013 and coordinated by ams, and MSP (Multi-Sensor-Platform for Smart Building Management), started in September 2013 and coordinated by the Material Center Leoben. MSP aims to integrate sensing functions and their implementation via a corresponding Multi Project Wafer Service. As an example for activities of the department in the area of power electronics, electromagnetic field simulation of wiring is presented in a separate article below.

The department will continue its approach to performing focused work on physical models and algorithms in order to develop the necessary skills and tools on the one hand and to transfer these results to applications in industry on the other hand. Here, a close and trustful cooperation based on sharing work according to the individual competencies and requirements of the partners has been a key element of the success achieved for many years. The overall mission is to extend the well-established and well-proven contributions that simulation offers for aggressively scaled devices in the "More Moore" area to the more diverse requirements and applications in "More than Moore" and to power electronics in general as well.

1 *Dr. Jürgen Lorenz, head of the department. Image: Kurt Fuchs / Fraunhofer IISB*

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Content

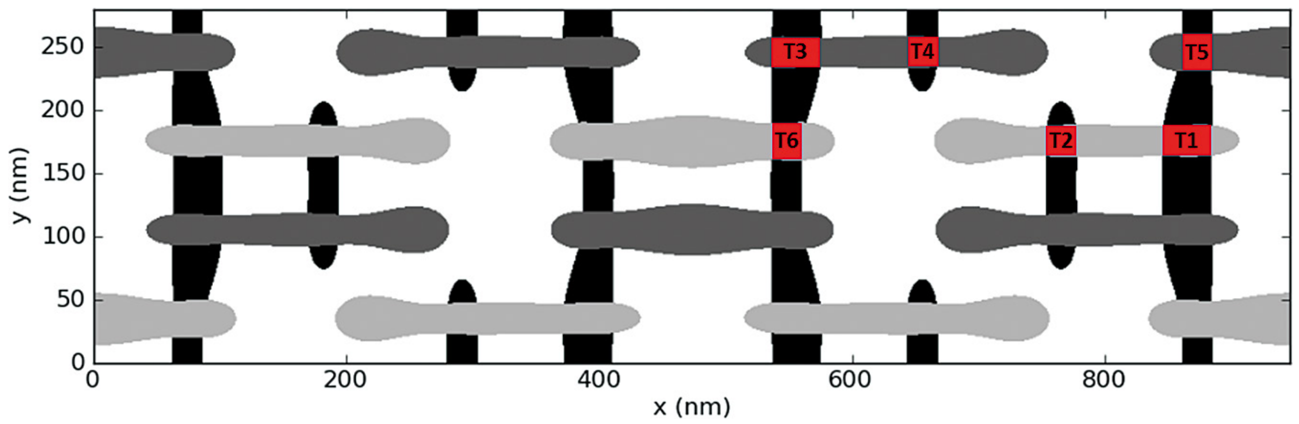
Impact of Process Variability on Devices and Circuits

Process variations belong to the most critical challenges for the further development of advanced nanoelectronic devices and circuits. They not only critically affect devices with the smallest feature sizes but also various "More than Moore" devices with relaxed feature sizes, e.g. in the analog or high voltage area. In order to meet this challenge, the sources of variability must be identified, their size must be quantified, and their impact on devices and circuits assessed and compared to the specifications of the products: For example, if the threshold voltage of a device varies too much, this would cause the circuit and the overall product to malfunction and must consequently be avoided. The SUPERTHEME project (Circuit Stability Under Process Variability and Electro-Thermal-Mechanical Coupling - see www.supertheme.eu) coordinated by IISB addresses this challenge.

The impact of process variations on device and circuit performance cannot be studied mainly through experiments, both due to the lack of capabilities to sufficiently control them and due to the very high complexity and effort which would be needed. In contrast, simulation tools which employ sufficiently accurate physical models and are well calibrated to match and reproduce the "nominal" process (which means a fabrication process without variations) can be efficiently used to assess the impact of assumed variations on the fabricated devices and circuits. In order to enable this, suitable tools for equipment, process, device and circuit simulation must be available and must be integrated. Furthermore, process variations must be characterized at their source, e.g. in homogeneities in process equipment or statistical effects which result from the granularity of matter.

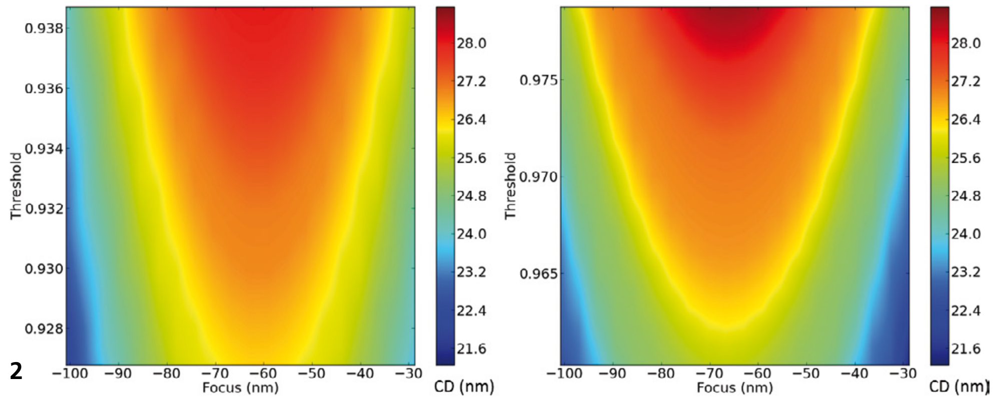
SUPERTHEME is funded by the EC from its FP7 program and is carried out by a consortium consisting of Fraunhofer IISB and IIS / EAS, the semiconductor company ams, the equipment companies ASML, Excico, HQD and IBS, the software house GSS, Glasgow University, and TU Vienna.

A hierarchical simulation approach is being employed which allows the impact of process variations to be simulated from their source (largely at the equipment level) through the sequence of process steps needed for device and circuit manufacturing up to the performance and reliability of the device and circuits. Within SUPERTHEME, IISB focuses on the extension and integration of programs for lithography and topography simulation to enable the efficient treatment of process variations, and on the extraction of process-aware compact models. As an example, the impact of focus and illumination dose variations in "Litho-Freeze-Litho-Etch" double patterning (LFLE) is shown[1]: Double patterning is one of the favorite options to enable the production of devices with smaller feature sizes, because it allows feature sizes to be shrunk by 50% in principle. For this purpose, LFLE sequentially employs two masks instead of one to print adjacent features. The SRAM cell layout shown in Fig. 1 is used to demonstrate a penalty resulting from this: Transistors in neighboring lines of smallest pitch, such as T2 and T4, are generated with different masks and are therefore subject to statistically independent variations of focus and dose in the exposure step. Fig. 2 shows the resulting feature sizes as color codes. Fig. 3 shows the resulting channel length for transistor T2. Fig. 4 shows the "read signal nose margin" as a performance indicator of the SRAM cell. Compared with the nominal value, minimum ("Min") and maximum ("Max") values of focus (F) or dose (D) strongly change this value, even if the same variations are used for all transistors. Statistically independent variations (not shown here) lead to even worse results.



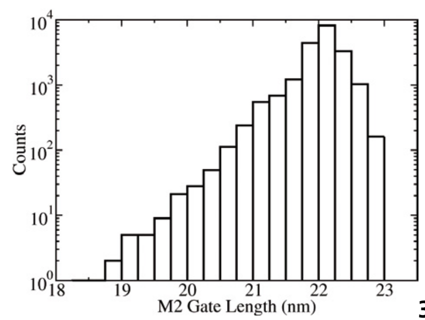
1

1 Lithography simulation of an SRAM cell with 20 nm SOI MOSFETS: Transistors of the inner flip-flop part T1, T2, T3, T4; access transistors T5 and T6.



2

2 Gate lengths (colors) for two transistors T2 (left) and T4 (right) generated with the second lengths and the first exposure step, respectively.



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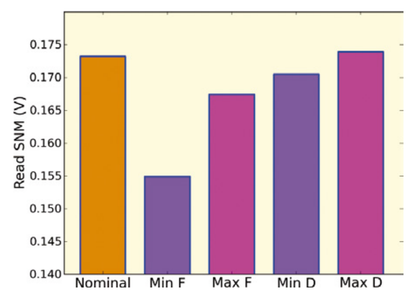

4

3 Channel length for transistor T2 subject to variations of focus and dose.

4 Read SNM of SRAM cell in case of correlated variations for the different transistors.

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[1] P. Evanschitzky, A. Burenkov, J. Lorenz, in : Proc. SISPAD 2013, 105-108 (2013)

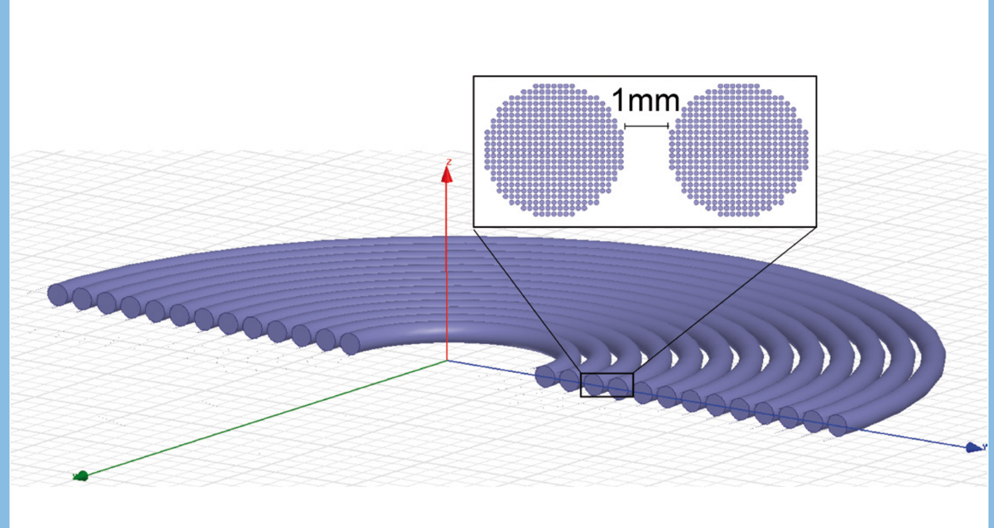
Content

Simulation of the Influence of Contacts on the Current Distribution in Litz Wires

In most power electronic systems for high frequency applications, litz wires are used. Due to the special structure – several hundreds of strands are isolated from each other – the skin effect in these wires is reduced significantly. Especially in transformers for consumer electronic or coils for inductive power transfer, litz wires yield a higher efficiency and reduction of losses in the entire system. With the help of FEM (finite element method) simulations and the reduction to rotationally symmetric models (2.5D), the electric and magnetic behavior of a system can be predicted and optimized. Due to the increase in computational resources in the last few years, the resolution of even very complex geometries has become feasible, and the results tend to be increasingly reliable. Nevertheless, the accuracy of loss calculations in coils with stranded conductors depends on the frequency. For high frequencies, simulation sufficiently matches measurement; however, below 500 kHz there is a large difference of more than 50%. In the following, we describe a new methodology which allows us to improve this accuracy.

In state-of-the-art simulations, the coils (Fig. 2) are reduced to 2.5D models (Fig. 1), and a homogenous current distribution is assumed. "Homogeneous" here means that each strand carries the same current. Based on this initial condition, a frequency-dependent current distribution and the losses are calculated. For our new method, we enhanced the common model by a 3D simulation of the connector. In this soldered area, all strands are electrically connected, while outside this area, all strands are isolated from each other. The results show the influence of the skin effect inside the connector on the current distribution of the entire system. This inhomogeneous current distribution is used as initial condition for the standard 2.5D simulation of the coils. An additional new factor in simulations of litz wires is the consideration of the twist of the strands inside the wire. All litz wires have a twisting of strands that prevents the formation of large loops. In our new simulation method, this twisting is realized by interchanging the current values and averaging these results.

To verify these simulation results, several coils with 420 x 0.1mm and 240 x 0.1 litz wires were measured. The curves for the new method show the same behavior when the frequencies start to increase at around 10 kHz and allow us to capture the trends well that are observed in the experiments (Fig. 4). To identify the potential of the connector for loss generation, an ordinary soldered connector of a coil system was replaced by a round connection terminal, where the strands were located circularly in one layer. In such a connection, the skin effect was reduced and consequently the resistance factor decreased up to 10% in the range between 30 – 300 kHz (Fig. 3). Using the new methods significantly reduced the difference between simulation and measured losses. Moreover, the identification of the connector as the origin of the inhomogeneous current distribution leading to high losses allows us to derive guidelines for connector designs and to build more efficient electrical systems.



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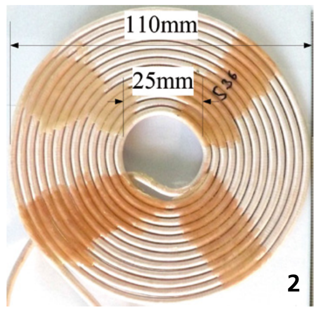
1 Simulation model of the experimental coil with exact resolution of the strands.



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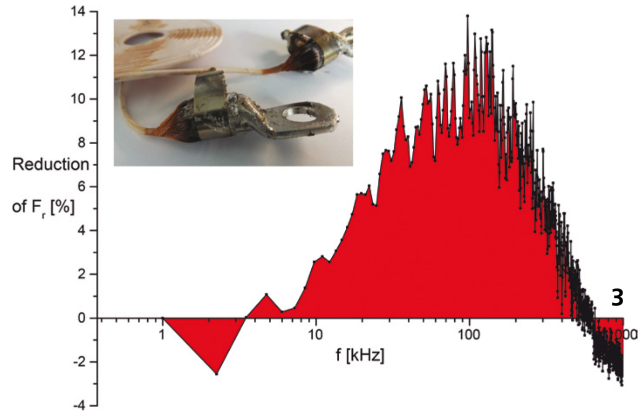
2 Experimental coil with 13 windings of a 420 x 0.1 mm litz wire.



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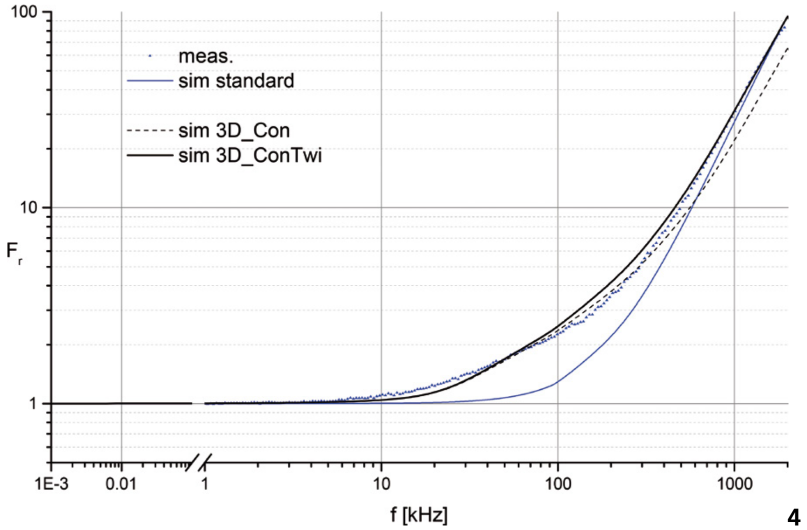
3 Reduction (in %) of F_r (=R(f) / R(0)) by using the circular connector (small picture) instead of standard connecting by soldering.



4

4 Comparison of measurements (blue dots) with the results of the standard (blue curves) and the new (black curves) simulation methods. For simulation "sim3D_Con" the influence of the connector is included and in "sim3D_ConTwi" additionally the twisting. F_r.Fr is plotted vs. the frequency for the N=13 420 x 0.1 mm litz wire system.

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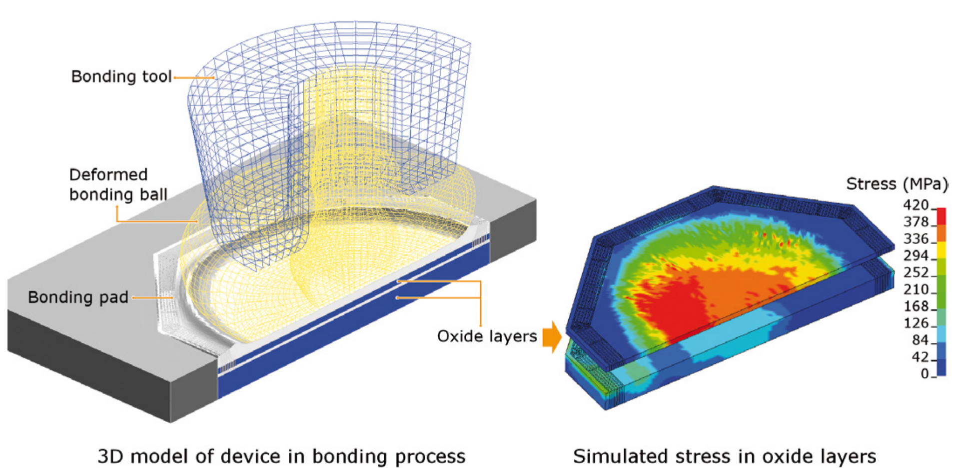

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Content

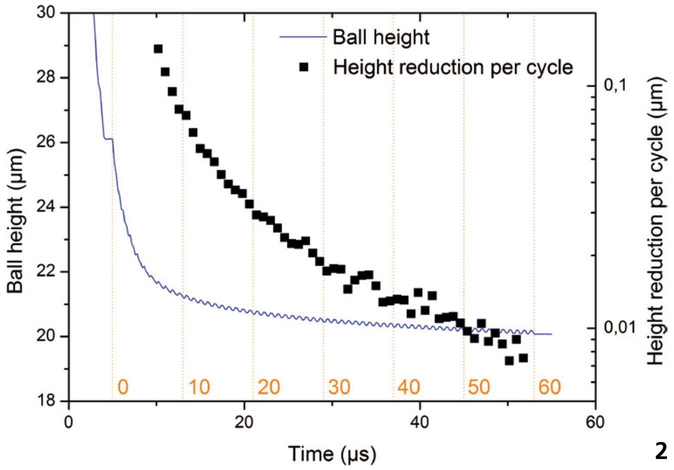
Simulation of Wire Bonding: Yield and Reliability

Wire bonding continues to be the dominant form of interconnection technology used for interfacing chips and their packages. It is an ultrasonic welding process that joins wires to devices by applying pressure and ultrasonic side-to-side motion. Wire bonding has implications for the yield and reliability of semiconductor devices. First of all, the process itself induces stresses into a device and the device must therefore withstand the peak stresses involved. Secondly, the use of wire bonds in power electronic applications can limit their lifetime through bond failure during the many cycles of thermal expansion and contraction that devices undergo during operation. To assess both issues, thermo-mechanical models were developed at IISB and applied to current topics in this area.

For the realisation of a new battery management chip in the FP7 project ESTRELIA, high voltage isolation was needed. This required the use of thick oxide layers below bonding pads, which needed to be investigated for the likelihood of cracks forming during the wire bonding process. For this purpose, a dynamic 3D model of the bond formation process was created and simulated (Fig. 1). To better predict the amount of stress induced into the structure, ultrasonic effects were taken into account. This included the effects of ultrasonic softening as well as a high number of ultrasonic motion cycles, which had not been simulated for a ball bonding process before. Dynamic friction was also incorporated to simulate the forming bond. Previous models published in the literature had simulated none or only a low number of ultrasonic cycles (up to 9). The thermo-mechanical model we developed simulated a total of 60 cycles, revealing the height evolution of the squashed ball during the bonding process (Fig. 2). It showed an initial rapid squashing of the ball, which saturated during the ultrasonic agitation in agreement with published experimental data. The ultrasonic motion was also found to be the dominant effect for the amount of stress induced into the isolation layers. This stress was evaluated by an improved failure prediction theory which takes the combined effects of perpendicular tensile and compressive principle stresses into account. Its application revealed that the thick isolation layer is not expected to be ruptured by the bonding process, which opens the path to new isolation variants.

The use of wire bonds in power electronic modules exposes bond interfaces to a great many cycles of heating and cooling. The resultant thermal expansion differs across the materials, with the aluminium (forming the wires and bond pads) featuring a significantly higher coefficient of thermal expansion than the underlying semiconductor material. This creates stress which results in plastic deformation of the aluminium near the junction between the bonded wires and the bonding pads. Accumulating with each thermal cycle, the plastic deformation finally causes the wire to be lifted off the bonding pad. Colleagues at the IISB's Devices and Reliability department recently discovered that a reduction in the diameter of the bond wires resulted in significantly improved reliability performance. To understand this, a thermo-mechanical simulation model of a power electronic module was created and simulated. The simulation results for a temperature cycle shown in Figure 3 indicate that thicker wires (a) have a considerably higher degree of deformation than smaller wires (b), which supports the results of the experiments.

1 *3D model of a device undergoing wire bonding (left). Here a bonding tool (blue wireframe) is shown squashing a gold ball (yellow wireframe) against the bonding pad. The resultant stress in the oxide layers of the device can be seen (right).*



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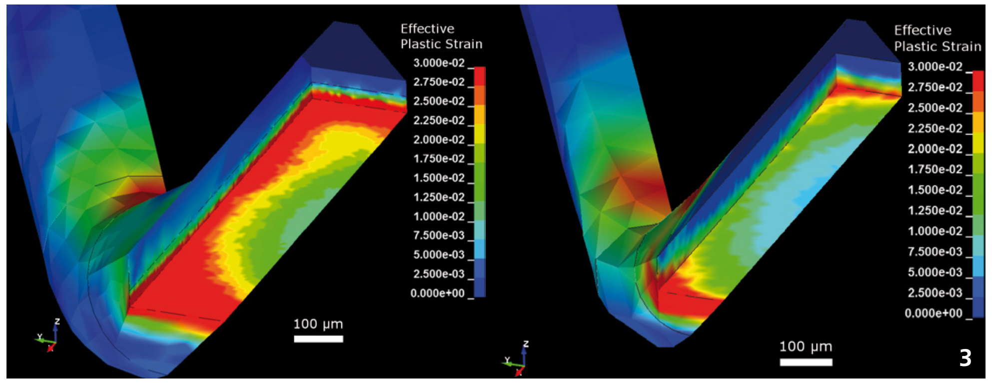
2 *Evolution of the squashed ball height vs 60 side-to-side motions indicated in orange along the 'x' axis. This shows an initially rapid rate of squashing followed by the height beginning to stabilise.*



3

3 *Plastic deformation under bonded wires for a large (375 µm) diameter bond wire (a) and a small (125 µm) diameter bond wire (b) resulting from thermal expansion during a thermal cycle.*

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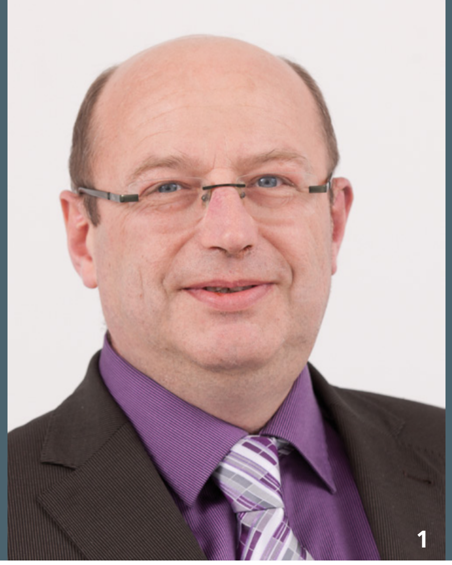
CRYSTAL GROWTH



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Content

Focal Areas of Research and Development, Trends, and Potentials

The research focus of the Crystal Growth department is on clarifying – in close collaboration with our industrial partners – how the material properties of bulk crystals, as well as those of thin epitaxial or other functional layers, correlate with their respective conditions of production. This basic understanding of the correlation between material quality and growth conditions is of utmost importance for any kind of improvement in the bulk crystal growth and layer deposition techniques used in industry. The global focus points towards the achievement of larger crystal dimensions, less harmful crystal defects, more uniform electrical and structural properties, processing and development of new materials. The strategy adopted by IISB together with its branch in Freiberg, the Fraunhofer Technology Centre for Semiconductor Materials (THM), is the optimization of the crystal growth processes through a combination of thorough experimental process analysis, tailored characterization techniques and numerical modeling. For that purpose, IISB and THM provide a well-suited infrastructure, consisting of R&D-type furnaces and epitaxial reactors, state-of-the-art metrology tools as well as powerful and user-friendly simulation programs. These programs are especially suitable for heat and mass transport calculations in high-temperature equipment with a complex geometry. In 2013, the Crystal Growth department of Fraunhofer IISB had already consolidated its position as a worldwide-acknowledged center of competence in the field of crystal growth.

In the field of crystallization of solar silicon, IISB, together with its subsidiary in Freiberg, the Fraunhofer Technology Centre for Semiconductor Materials (THM), and its partners from industry and academia, have their main focus on reducing detrimental dislocation clusters. The reduction of these crystal defects is considered to be an important step to further increase the quality of directionally solidified silicon ingots. The investigations of IISB and THM have contributed to the development of so-called high-performance multi material. This material is characterized by a large number of small grains which nucleate at the beginning of the solidification process, resulting in ingots with fewer dislocation clusters compared to conventional material.

In the field of wide-band-gap semiconductors, we were able to double the growth rate during the growth of 4H SiC epitaxial layers by using HCl as an additional precursor gas. This offers of the potential of significantly reducing the costs for processing SiC power devices with high blocking voltages. Furthermore, a defect luminescence scanner (DLS) was put into operation, which provides a rapid, contactless detection of recombination-active defects on up to 6-inch SiC epitaxial wafers. The DLS especially allows the detection of harmful basal plane dislocations and stacking faults. In the field of GaN, we have demonstrated the first thick GaN layers grown by the HVPE technique, using a novel approach to improve the efficiency of the conversion of the precursors into GaN. Furthermore, we could identify small angle boundaries consisting of dislocation walls as a major origin for cracks in thick GaN crystals by using our high-resolution analytic tools.

At our subsidiary THM in Freiberg, we began, in close collaboration with the TU Bergakademie Freiberg, to work on the development of materials which have a high application potential for future energy conversion and storage systems. In particular, we were able to synthesize pyroelectric materials as well as cathode materials for batteries for the first time in our lab, and we started to correlate the properties of such functional layers with the conditions of their synthesis.

Several invited talks at international conferences as well as the participation in different national and international expert panels in the field of crystal growth underline the reputation and recognition of the Crystal Growth department. Further elements of the networking process were the events organized by IISB. Moreover, the Crystal Growth department works closely together with different research institutions and maintains not only national but also international cooperation with industry.

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1 *Defect Luminescence Scanner for silicon carbide.*

Content

Defect Luminescence Scanner for Quality Assurance of the Silicon Carbide Device Technology

Silicon carbide (SiC) is the ideal material for energy-efficient power electronic devices due to its outstanding material properties such as a wide band gap, high electric breakdown field, and high thermal conductivity. Within the last years, the material quality of SiC substrates and epilayers has been greatly improved. However, material defects such as so-called dislocations and stacking faults can still limit the device performance and production yield.

Therefore, it is of great importance for the ongoing material development as well as for device production to effectively monitor and identify these defects in the SiC material along the device production chain – from substrate to epilayer and to device.

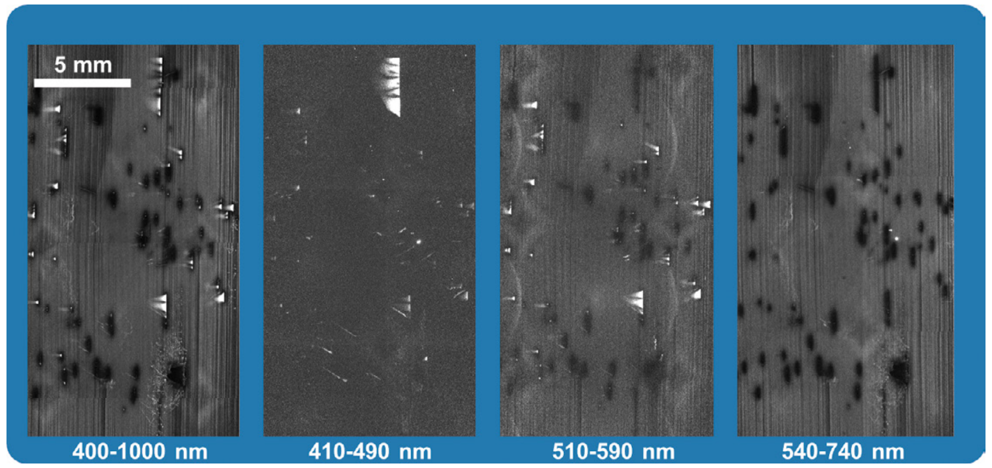
For inline monitoring and identification of these defects, the basic characterization method needs to be non-destructive, non-contact as well as fast and reliable. Since the current characterization methods are either destructive or too slow, Fraunhofer IISB and its industrial partner Intego GmbH are developing a new measuring instrument. It is based on photoluminescence (PL) with high spatial resolution, which is a fast and non-contact technique. This defect luminescence scanner (Fig. 1) is designed to detect relevant defects at or below the surface and identify them by their specific “spectral fingerprints”.

The scanner operates with a UV laser at 325 nm wavelength. The PL signal is detected by a highly sensitive EMCCD camera that allows fast image recording at a high signal-to-noise ratio. Bandpass filters can be inserted in front of the camera to analyze the PL wavelength of defects and hence identify them (Fig. 2).

Automatic defect analysis and statistics are included as well. The defect luminescence scanner is designed for fast mapping of SiC wafers up to 150 mm in diameter. A 100 mm wafer can be fully scanned and analyzed within less than 15 min.

In industrial production processes, the defect luminescence scanner will thus be able to rate each wafer and device individually with respect to material defects and accompany the entire device processing inline. The goal is to judge the material quality of each individual SiC device and to improve the reliability of these devices up to “zero defect tolerance”.

In addition, the defect luminescence scanner will provide new insights into the relationships between technology parameters and material quality, which will accelerate material and technology development.



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2 *Details of high resolution full-wafer defect scans. The measured state-of-art SiC epiwafer has different defect types which emit in characteristic wavelength ranges. E.g. the bright triangular defects are so-called ingrown stacking faults, which could lead to failures of devices during operation.*

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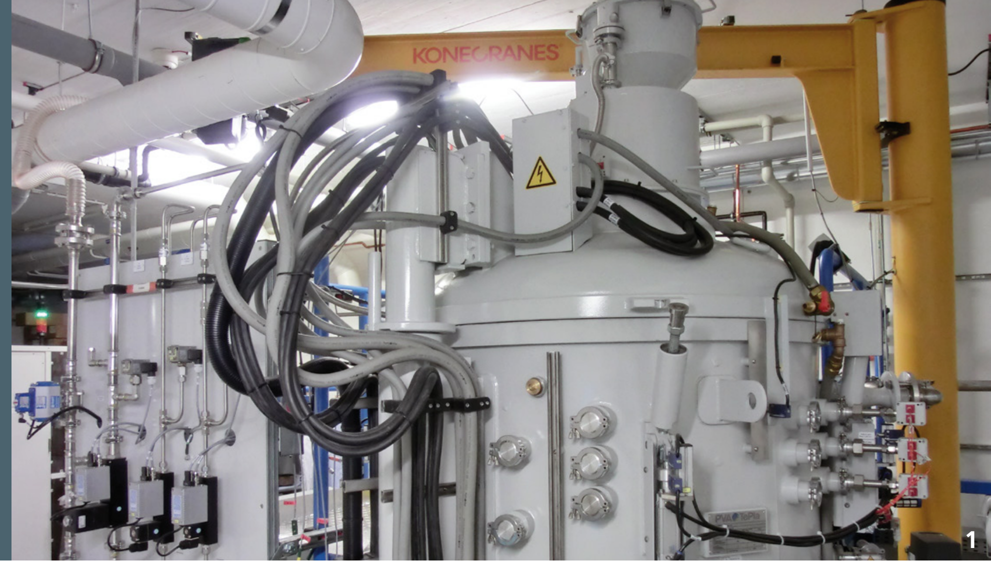
CRYSTAL GROWTH



Directional Solidification of N-type Low-defect Silicon for PV Applications

N-type silicon is the favorite primary material for the production of high-efficiency silicon solar cells. However, the market share of n-type silicon solar cells is rather small in comparison to the widely used p-type cells, which are boron-doped. The n-type material is mostly produced nowadays with the expensive Czochralski technique. The resulting wafer material is mono-crystalline and nearly defect-free.

One principal challenge for the production process of n-type silicon wafer material is the less suitable incorporation behavior of phosphorus in the silicon crystal during the crystallization process, which results in a more inhomogeneous dopant as well as resistivity distribution over crystal length. For an optimized solar cell production, the resistivity range has to be very small. Otherwise, the wafer yield per crystallization run is reduced and the wafer costs are increased.

One approach to reducing the costs for high-quality n-type silicon crystals is their production with low-cost directional solidification techniques. However, the crystals which are solidified by controlled heat extraction in a crucible under standard process conditions exhibit a multi-crystalline structure with a huge amount of crystal defects, which reduces the electrical performance of the solar cell.

In the HENSiproject, a special R&D furnace was installed at Fraunhofer IISB which was used to grow defect-reduced multi-crystalline silicon ingots of 220 x 220 mm² with a height of 130 – 220 mm. The furnace is equipped to control important growth parameters such as initial nucleation, phase boundary shape or growth velocity. Furthermore, a recharging unit is placed on top of the furnace (see Fig.1), which allows the addition of new silicon raw material during the crystallization process.

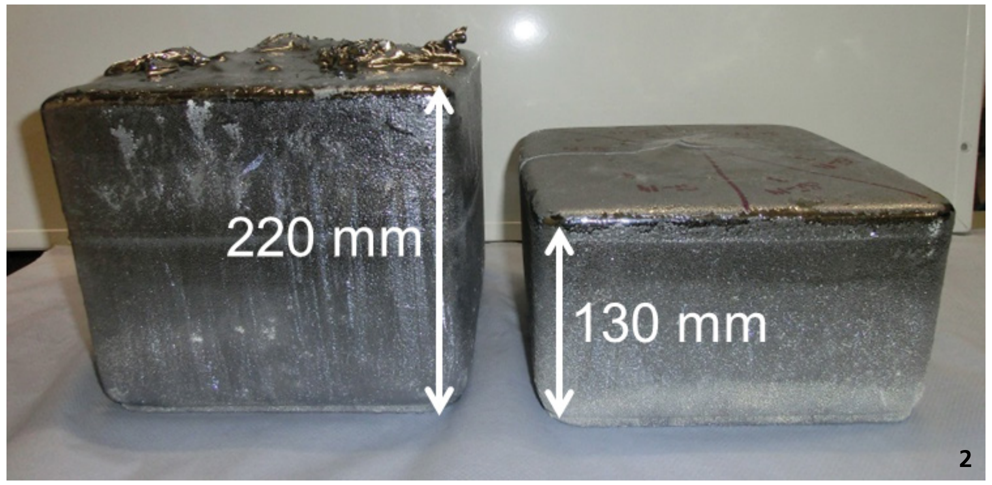
Firstly, with this newly developed furnace it is possible to grow high-quality, multi-crystalline material. Secondly, this has the advantage of growing higher ingots within a crucible with equal dimensions. Simultaneously, the recharging of new feedstock before or during the crystallization process allows a better control of the dopant and resistivity distribution over crystal height. Depending on the recharging procedure, a smaller resistivity gradient or, in the best case, a constant resistivity profile over crystal height can be achieved.

Content

The HENSi project is financed by the Federal Ministry for the Environment, Nature Conservation, Building and Nuclear Safety.

In Fig.2 two silicon ingots grown at Fraunhofer IISB are shown. By using the recharging process, the crystal height could be increased by 70 % from 130 mm to 220 mm.

1 *R&D furnace at Fraunhofer IISB with recharging unit on top.*



2 *Directionally solidified silicon ingots produced at IISB with and without recharging process.*

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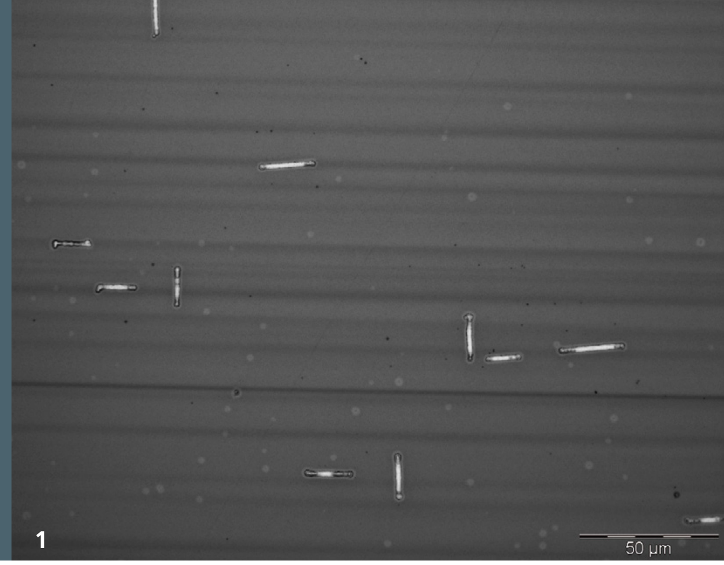
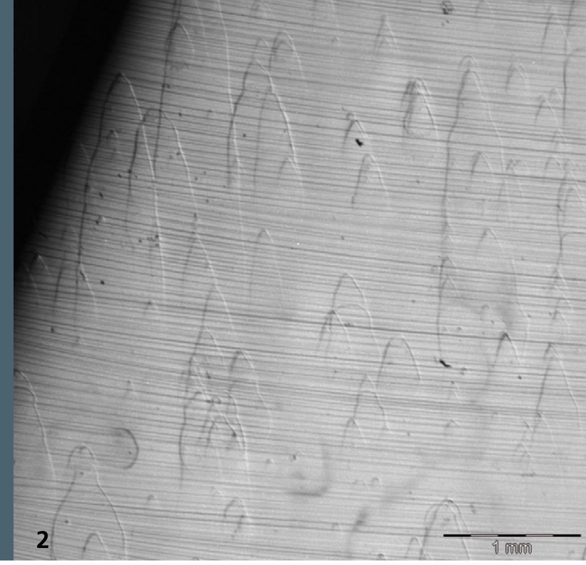




Content

Evaluation of Characterization Techniques for Heavily Doped Czochralski Silicon

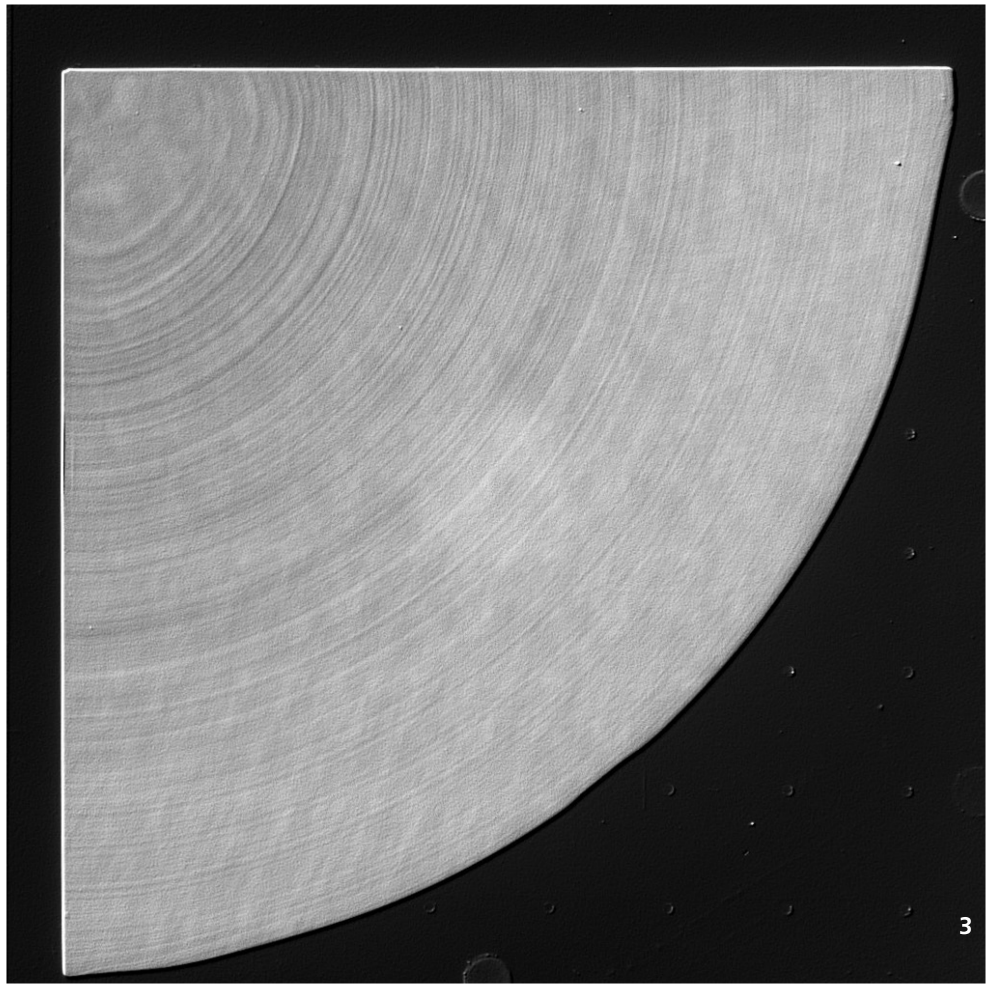
Heavily doped Czochralski silicon is used as a substrate material for high-power devices based on Power MOS technology. To exploit the energy-saving potential and to increase the device performance, it is necessary to reduce the resistance by increasing the dopant level. In this target range of about 1 – 5 mΩcm, most of the standard characterization methods to evaluate the crystal growth process fail because of the huge number of free charge carriers and the resulting changed recombination mechanics. Several crystal-related parameters are crucial to understanding and enhancing the crystal growing process.

To evaluate the thermal conditions of the crystal growth process, knowledge of the solid-liquid interface is essential. In normally doped silicon, the lateral photo voltage scanning method (LPS) can be used. This method does not work for heavily doped material. In addition to the time-consuming method of wet etching, we use the in-house method of photoluminescence imaging (PL).

The measurement of one wafer or one cross section can be realized in seconds. A PL measurement of a CZ wafer is shown in Fig. 3. Here striations can be revealed in a non-destructive manner. The shape of the solid-liquid interface can be determined in the form of horizontal lines of measured horizontal cross sections.

Crystal defects determine the properties of the material. Because of their small size, the detection is not trivial. An established method to detect dislocations and stacking faults in normally doped silicon is the usage of defect-selective etching solutions. In heavily doped silicon, these special etching solutions are not selective enough. Thus we use the technique of copper decoration with a subsequent defect-selective etching to detect stacking faults (Fig. 1). Modified etching recipes can be used to create flow pattern defects (FPD), see Fig. 2. A special kind of these defects are related to the occurrence of agglomerates of vacancies, called crystal-originated particles (COPs).

The results shown originate from the Power On Si project, supported by the European Union and the German state of Saxony.



1 *Stacking faults in heavily doped silicon after copper decoration and subsequent defect selective wet etching.*

2 *Flow pattern defects after wet etching*

3 *PL imaging of a quarter of a heavily doped Si wafer.*

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SEMICONDUCTOR MANUFACTURING EQUIPMENT AND METHODS

Content

Focal Areas of Research and Development, Trends, and Potentials

The core competence of the Semiconductor Manufacturing Equipment and Methods department is the multidisciplinary research and development for manufacturers of equipment, materials, and semiconductor devices. The decisive factor for this is the expertise in process development, metrology, analytics, software, simulation, and device integration combined to develop tailor-made solutions together with customers.

This approach requires a wide-ranging expertise which manifests itself in competence in regard to equipment, advanced process control, manufacturing science, productivity, contamination control and yield control aspects as well as materials, in terms of utilities and means of production. Experts from the fields of electrical engineering, materials science, mechanical engineering, physics, computer science, and chemistry work together on the issues that will sustainably influence efficiency in the construction of manufacturing equipment, the production of materials for manufacturing, and IC manufacturing itself.

The scope of developments ranges from lead research for novel processes and measurement methods to the application of new research results in cooperation with corporate industrial partners and to the assessment and optimization of equipment in an industry-compliant environment. The IISB analysis laboratory for micro- and nanotechnology with various chemical, physical-chemical and physical test methods is essential for a conclusive and comprehensible assessment.

Preliminary research in the reporting period includes, for example, the optimization of UV-based measurement of very thin layers under vacuum conditions, or the development of a novel approach for optical nanotopography measurements on reflecting surfaces. On the side of application-oriented research, IISB successfully finalized the EU project "SEAL" which aimed at developing and evaluating innovative process and metrology equipment in a European network of 36 equipment suppliers, device manufacturers, and research institutions. The new project "SEA-4KET" builds on the proven principles established in previous European SEA programs and takes them to the new field of assessing equipment for key enabling technologies: SEA4KET concentrates on process and metrology systems for important enablers of future technologies: 450 mm wafer equipment, SiC material and 3D processing. To support the collaboration of semiconductor stakeholders in Germany, a BMBF-funded study on the development of common issues of semiconductor manufacturers and their suppliers was successfully finished: Feedback from more than 60 experts and 12 workshops was evaluated, three urgent topics were identified (equipment, automation and data-driven productivity enhancement), and collaboration was started.

Two working groups at Fraunhofer IISB are contributing their expertise in advanced process control, manufacturing science, productivity, contamination control and yield control aspects to the ENIAC project "EPPL", which aims to combine research, development and innovation to demonstrate the market readiness of power semiconductor devices fabricated in leading European 300 mm pilot lines.

Successfully completed collaborations such as "SEAL", as well as ongoing projects such as "EPPL", "SEA4KETL", "MSP", "Enable450" or "Bridge45" make very high demands – especially in the European context – on the knowledge and communication skills of the researchers involved: Automated process control, integrated and virtual metrology, environment-, energy- and resource-optimized manufacturing, yield optimization, predictive maintenance, throughput optimization, device integration, 450 mm processes and devices, as well as the simulation of manufacturing equipment and components are just some of the challenges that can only be met successfully in a multidisciplinary approach. Research projects of this kind as well as bilateral development projects with industrial partners confirm the broad approach of the department, which is well-positioned for the future due to its variety of topics.

The described research activities are complemented by the involvement in national and international committees and panels: Staff members of the department are active in several committees and sections of the "VDI / VDE-Fachgesellschaft GMM" and take leadership roles in the development of SEMI standards and the ITRS, the International Technology Roadmap for Semiconductors.

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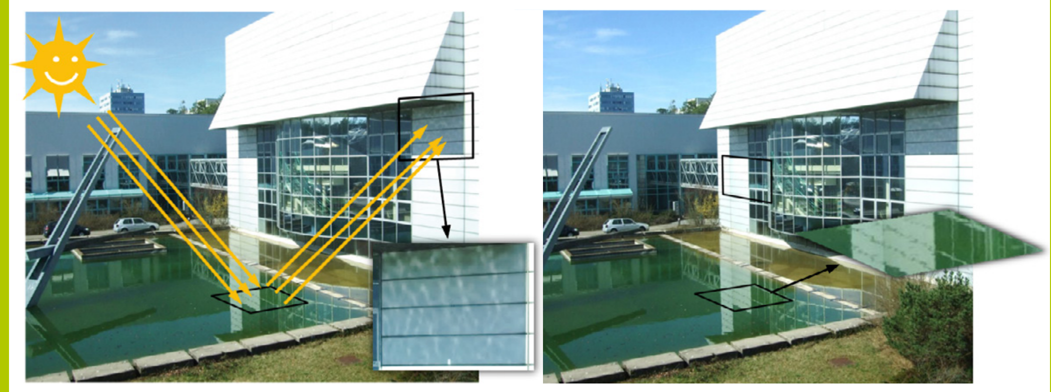
SEMICONDUCTOR MANUFACTURING EQUIPMENT AND METHODS



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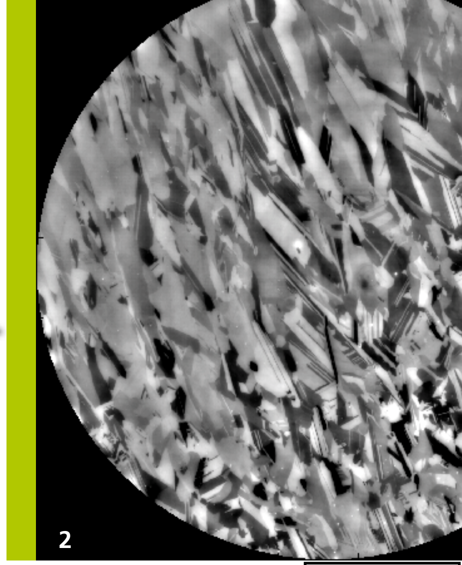

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Content

A Novel Optical Method for 3D Inspection of Wafer Surfaces

To meet increasing demands in semiconductor manufacturing, the surface of a semiconductor wafer needs to be extremely flat – comparable to an increase in height of several centimeters over a length of one kilometer. To measure those wafer topographies, conventional 3D microscopes cannot be used since their field of view is far too small. Over several years, Fraunhofer IISB developed a novel optical method with a field of view in the size of the wafer diameter (300 mm) – covering the whole development chain from early research and the patented idea to the first prototype. Currently, a product-ready tool for the semiconductor market is being engineered in cooperation with E+H Metrology.

With decreasing feature sizes in semiconductor manufacturing, a high flatness of the wafer is required for many essential processes, e.g. processes where the depth of focus is involved, such as EUV lithography. An important quality parameter to be investigated is the wafer nanotopography, which is defined as the height deviation of the surface within a spatial wavelength range of 0.2 mm to 20 mm (SEMI standard M43). Accordingly, to measure nanotopography, there are high demands for metrology, namely a lateral resolution better than 200 µm (about the diameter of a human hair) and a vertical resolution in the lower nanometer range. Moreover, a large measuring field, ideally in the size of the wafer under test, is beneficial. Interferometers with 300 mm full-field nanotopography measurement capability are available. However, due to the interferometric nature, these tools require expensive optics and are prone to external vibrations. Other state-of-the-art tools only measure the wafer at discrete points or use scanning or mapping to obtain a full 300 mm wafermap. These tools, however, require sophisticated stitching algorithms to merge the single measurements, and the measuring of nanotopography with high throughput turns out to be challenging. In search of a simple, highly sensitive, robust and non-interferometric way to measure the topography of a specular wafer surface, the following example is given: Instead of a wafer's surface, the specular surface of a lake is considered, as shown in Fig. 1, posing the question of how to determine the lake's topography. One possibility is illustrated on the left: An intensity image can be seen on the wall of the cleanroom building. It is the so-called "Makyoh" (Japanese for "magic mirror") image of (a part of) the lake. It is generated by collimated light – in this case coming from the sun – that falls on the lake's surface. Due to the lake's topography (e.g. small waves), the reflected rays are deflected and thus not perfectly parallel any more. An intensity image with brighter and darker regions is thereby generated on the wall. This simple principle has long been known and used in the semiconductor industry for qualitative inspection of wafer surfaces. Research on the "Makyoh" method has been done for several years at Fraunhofer IISB. It is highly sensitive to the smallest height changes. However, this method is only of a qualitative nature – a direct 3D reconstruction of the topography is not possible. There is a second approach to obtaining information on the lake's topography, shown in Fig. 1 on the right. This is the principle of deflectometry. This is the obvious but non-trivial method how the human eye, and thus the human brain, perceives the topography of specular surfaces. It works as follows: The mirror image of the background, reflected by the lake, is watched. This image – in this case for example the front of the cleanroom building – is distorted compared to the real image because of the non-planar surface of the lake. This distortion depends on the local slopes of the lake's surface. The method is not unambiguous without further ado, but can be made quantitative.

The new method that has been invented for the inspection of wafer surfaces is a combination of the above-mentioned principles. The directed illumination known from "Makyoh" sensors is retained, whereas the deflectometric principle is used for the quantification of data. A special optical system was designed that allows for both projection of an optical pattern and imaging of the wafer surface. Like deflectometry, it is a slope-measuring method. However, since the slope is the gradient of the actual surface (topography), the topography can be derived by numerical integration of the gradient field.

A prototype tool with a measuring field of ø 300 mm was built, enabling "one shot" measurement ability for standard 300 mm wafers. The setup is composed of 300 mm field-of-view optics and a light structuring unit using LED illumination. It features an overall lateral resolution of approx. 100 µm, in other words about 7 million measuring points per wafer. The software enables full 3D reconstruction of the topography, including powerful filtering algorithms. Compared to state-of-the-art techniques that allow the measurement of nanotopography, the new technique is rather simple, despite the large measuring field. A major benefit is also the high robustness against external vibrations. Due to the slope measuring, there is no direct sensitivity to constant changes in height during the measurement. A measurement performed by the prototype is shown in Fig. 2. The prototype is currently being developed further in cooperation with E+H Metrology – a German tool manufacturer – considering different applications in semiconductor industry. Apart from semiconductor materials, the inspection of specular reflecting surfaces in general is a potential application – such as polished metal surfaces, mirrors, lenses, optical flats, hard disks or even the surfaces of liquids.

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1 *Two methods to perceive the topography of a lake's specular surface: "Makyoh" method (left) and deflectometry (right).*

2 *Topography map of a polycrystalline silicon surface. Differences in height according to the crystallographic orientation of the silicon grains can be seen and were generated by polishing and subsequent anisotropic etching.*

SEMICONDUCTOR MANUFACTURING EQUIPMENT AND METHODS

Analysis Laboratory for Micro- and Nanotechnology – Challenges and Opportunities

The Analysis Laboratory for Micro- and Nanotechnology at the Fraunhofer Institute for Integrated Systems and Device Technology carries out analytical services in the fields of physical, physico-chemical, and chemical analysis for micro- and nanotechnology.

Solutions for characterizing wafers, processes, media, materials, and equipment in respect to their contamination behavior, for determining contamination sources, and for certifying cleanroom suitability are provided. The characterization methods include the analysis of organic, inorganic and particulate contamination. Furthermore, services for the assessment of sensors or other electronic systems under various atmospheric conditions – even evaluations in harmful atmospheres – are offered. With its expertise in the area of material and trace analysis in combination with sophisticated preparation techniques, the Analysis Laboratory at Fraunhofer IISB is an acknowledged partner in the micro- and nanoelectronics industry.

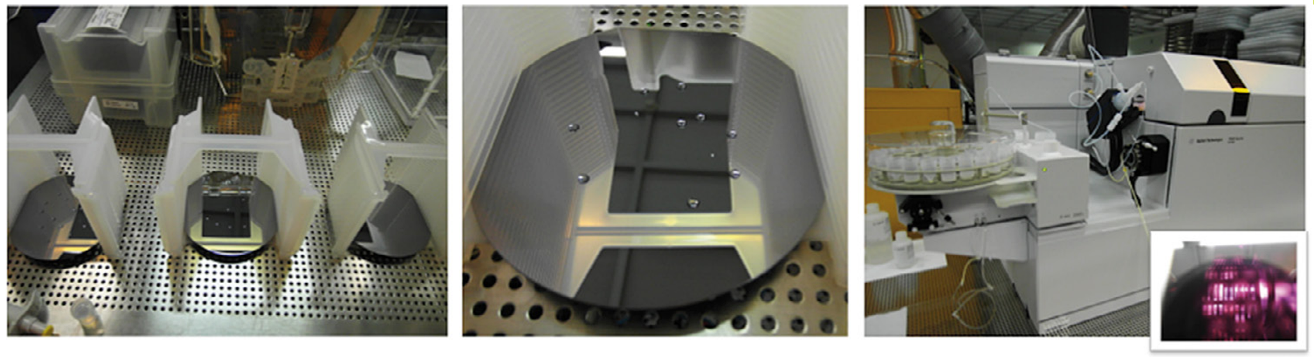
With feature sizes shrinking, thinner layers, new materials, 3D integration and more complex designs, contamination control is a constant challenge and a prerequisite for a continuous quality control and achieving high yields in the manufacturing processes. Within several R&D projects and internal programs, the Analysis Laboratory at Fraunhofer IISB is developing or adapting analytical methods and sample preparation methods to provide emerging solutions for their partners. “More Moore” as well as “More than Moore” applications are being addressed.

For “More Moore” applications, the major challenges are the low detection limits and the sample preparation of 450 mm wafers. The Analysis Laboratory at Fraunhofer IISB uses state-of-the-art analytical systems, such as Inductively Coupled Plasma Mass Spectrometry (ICP-MS) and Gas Chromatography Mass Spectrometry (GC-MS) to fulfill the detection limit requirements. The sample preparation capabilities, in particular vapor phase decomposition and thermo desorption, are being extended towards the preparation of 450 mm wafers.

The challenges for analytical services for “More than Moore” applications are more versatile. New organic compounds are being used for wafer bonding applications. The impact of these organic compounds, particularly the outgassing effects, on front-end processes has to be explored in the cleanroom and in mini-environments, e.g. wafer boxes such as Front Opening Unified Pods (FOUPs). Investigations on yield impact have to be accomplished, cleaning procedures for wafers and wafer boxes (FOUPs) have to be developed, and the efficiency of these cleaning procedures has to be examined. The Analytical Laboratory offers monitoring of the cleanroom and mini-environments by GCMS and provides efficient solutions to perform these kinds of characterization, e.g. active sampling with multiple sample tubes. In addition, offline characterizations of organic compounds under various laboratory conditions are performed. In the area of 3D integration, electronic systems, e.g. sensor systems, were developed and have to be evaluated regarding their functionality and behavior in different environments, including harmful conditions. IISB offers different laboratory set-ups to provide test beds and correlation measurements for their partners.

On the one hand, noble metals have been introduced in the process chain of silicon-based technologiesfor power device applications, and on the other hand, SiC is becoming more and more important as a substrate material. Specific sample preparations and analytical methods using ICP-MS for noble metals, e.g. Ag, Au, Pd, were developed and tested with the preparation and analysis of defined contaminated samples. Nearly 100% recovery rates for the tested elements and concentrations could be achieved. For the contamination analysis of SiC, the sample preparation was adapted to the specific requirements of this substrate material.

By facing the challenges in “More Moore” as well as “More than Moore” applications, the Analysis Laboratory for Micro- and Nanotechnology at the Fraunhofer IISB has developed and adapted the analytical services required to be a reliable partner for the industry now and in the future.



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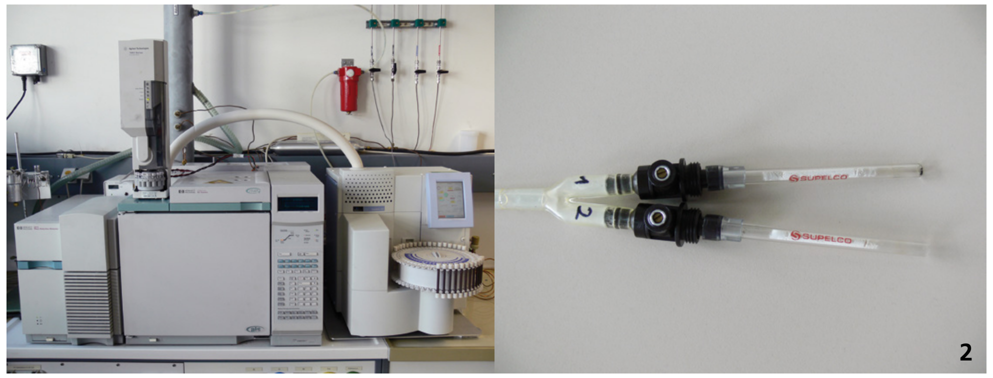
1 *Preparation of intentionally contaminated samples.*



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2 *ICPMS at Fraunhofer IISB facility.*

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Content

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Focal Areas of Research and Development, Trends, and Potentials

Technology stands above all for research and development in the field of electronic devices on a micro- as well on a nano-dimensional scale. In addition, to focus more on facility services for customers, the service sector was re-organized in a separate organization unit which is called π-Fab. The purpose of π-Fab is the fabrication of custom-tailored prototype electron devices. Furthermore, from nano-technology to printable macro-electronics, the Technology department is your contact for the realization and characterization of single-process steps and devices up to prototypes. Based on comprehensive cleanroom facilities, silicon, as well as silicon-carbide processing, forms the backbone of the technology. Examples for current activities are high-resolution nano-imprints on a large scale, fabrication of advanced integrated power devices, or low-temperature depositions of inorganic materials by printing techniques. The heterogeneous integration of various technologies is currently acquiring more and more importance.

For this purpose, IISB and the Chair of Electron Devices of the University of Erlangen-Nuremberg operate joint cleanroom facilities of 1000 m^2 (primarily class 10), provided with CMOS-compatible equipment. This allows the implementation of the most important process steps on silicon wafers with diameters of up to 200 mm and SiC wafers up to 150 mm. An industrial CMOS process transferred to IISB and adapted for research and development purposes is used as a reference and basis for the development of advanced process technologies.

The main activities focus on the fields of power semiconductors and silicon-carbide electronics. IISB has increased its commitment in these fields by implementing new equipment and processes to meet special requirements necessary for Si and SiC power device processing. This above all concerns the etching and refilling of deep trenches and high-temperature processing of SiC. A smart-power IGBT technology with integrated trench isolation has been successfully implemented. This all allows the department to strengthen its competence in manufacturing smart-power or high-voltage devices. By now, IISB has developed its resources and expertise to the point where it can perform nearly all manufacturing steps on SiC substrates. The devices currently under development include Schottky diodes and pindiodes in the voltage range above 1 kV as well as MOSFET devices such as vertical or lateral DMOS.

For the development of novel process steps in the field of dielectrics and metallization, IISB operates advanced sputter and chemical vapor deposition tools on the basis of ALD that are used for the deposition of high-k and metallic layers. Adaptation of the process to the particular chemistry of the precursor, deposition of a multiplicity of precursors, and the characterization of the deposited layers are the main tasks of the department. Special activities are focused on ion implantation technologies. At IISB, implantation tools with acceleration voltages ranging from a few eV up to several MeV are available. Special implantations for CMOS as well as for power semiconductors have been established (for example, commercial tools have been modified to be able to implant several wafer diameters and manifold elements at elevated temperatures).

Physical and electrical characterization of process steps and device structures is of the utmost importance for the manufacturing of semiconductor devices. Important steps in this respect are the determination of topography, doping profile, and further physical and chemical parameters as well as SEM & TEM investigations, energy-dispersive X-ray analysis, and AFM surface characterization of layers. The specific competence of the department consists of the combination of several methods for failure analysis during the processing of semiconductor devices, or the tracing of causes of failure. The spectrum for electrical characterization has been further increased (e.g. lifetime measurements and high voltage measurements).

Another focal area of the department's work is the processing of structures in the range of a few nanometers as well as the repair and analysis of prototypes of electronic devices by means of focused ion beam (FIB) techniques and electron beams. In addition to that, UV nano-imprint lithography, a cost-effective fabrication technique that allows the transfer of nano-sized features to photoresist without the use of advanced optical lithography, by applying small rigid stamps, and, most importantly, by applying large-area (up to 150 mm) flexible stamps as well, is now well-established at the Technology department.

The focus of the department's activities in the field of printable electronics is on the investigation and development of manufacturing methods for solution processing of inorganic thin films for electronics, especially printable electronics. A special emphasis is placed on the interaction of processing with the resulting electrical properties for specific applications. Based on inks with semiconducting, conducting, and insulating nanoparticles or the respective molecular precursors, thin-film transistors (TFTs) comprising printed features are created. The properties of functional thin films made by means of liquid processing are also analyzed in detail.

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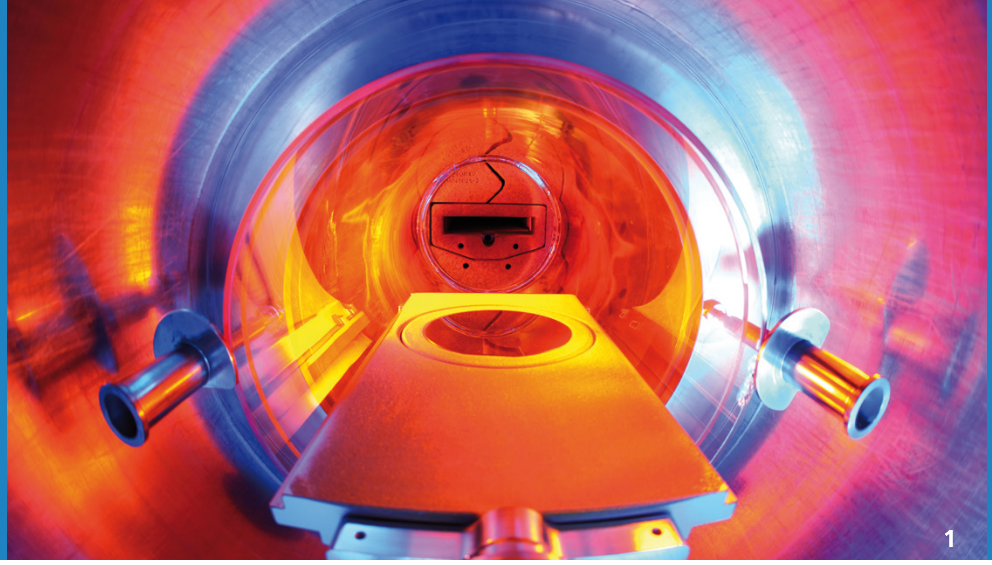
1 *Dr. Anton Bauer, head of the department. Image: Kurt Fuchs / Fraunhofer IISB*



Content

Customized SiC Devices, Prototyping and Fabrication

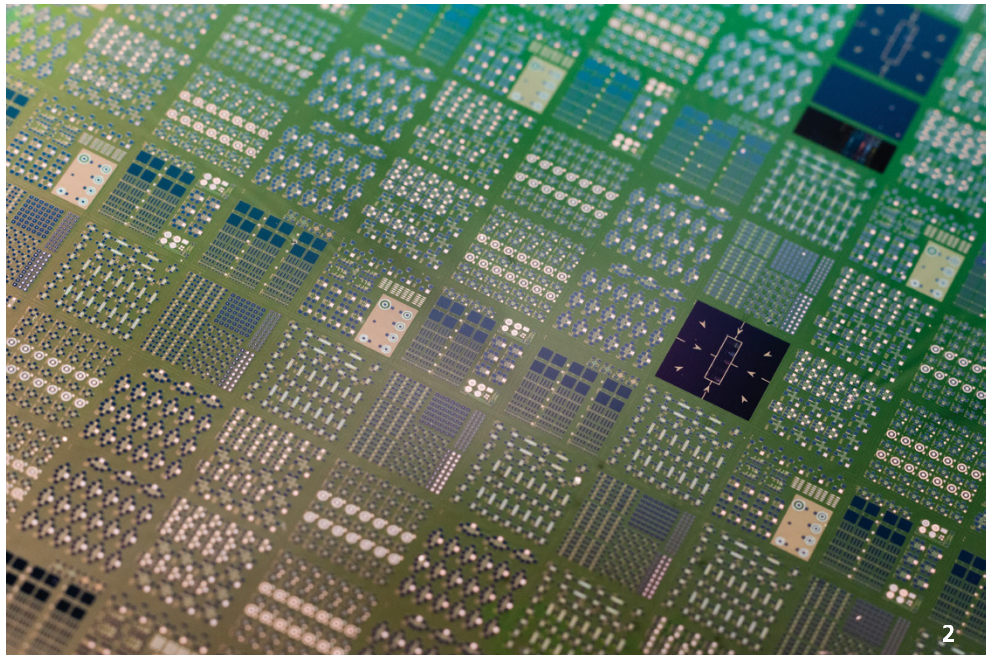
Due to its wide band gap, silicon carbide (SiC) shows excellent physical properties that predestines it for applications in power electronics. SiC-based devices are significantly more energy-efficient than silicon-based solutions at given voltage classes. A further benefit of SiC is its higher thermal conductivity compared to Si. This allows operation at elevated temperatures and thus higher current densities or lower expenses in cooling components. All in all, transmission losses and losses in devices can be greatly reduced by replacing Si with SiC power devices. Systems with SiC devices are expected to have losses between 1 – 3% compared to 5 – 10% when using Si devices. This can dramatically reduce CO_2 emissions, since losses of electric energy carry a very high environmental price tag due to the inefficiency of the electricity generation, which is currently only about 30% efficient.

On the π–Fab platform, the Technology department develops and fabricates SiC prototype devices and supports customers with its expertise in electron device and materials development in order to promote the commercialization of SiC-based solutions. The SiC device prototyping and fabrication is based on a 0.8 µm silicon CMOS line. Specific equipment (epitaxy, high-temperature oxidation and annealing, metal contact formation) has been integrated in the line, and existing equipment (implantation, dry etching, metallization) has been adapted in order to meet the particular requirements of SiC processing. In this way, the key processing steps (epitaxy, implantation, annealing, oxidation, trench formation, passivation, dicing) could be optimized.

Now, these measures allow nearly every request for the prototyping of customized SiC power devices to be fulfilled. In addition, research and development activities such as growing defect-reduced epitaxial layers, increasing MOSFET channel mobility by advanced N2O oxidation, channel engineering with ion implantation, and junction termination for high-voltage applications have been intensified. Our objective is to provide a one-stop solution for the development and the prototype fabrication of SiC devices. Benefits for customers are all-in-one solutions, a short time-to-market for their devices, and competitive fabrication costs even at small volumes.

However, device fabrication is only one part of the Fraunhofer IISB work on SiC power devices. Activities in material characterization, device simulation, laser dicing, joining technologies, test and reliability measurements, dynamic characterization, and integration of SiC power modules in converter systems round off the competencies of IISB for SiC.

1 View into horizontal hot-wall reactor for SiC homoepitaxy during wafer loading. Image: Kurt Fuchs / Fraunhofer IISB



2 Top view of a 4H-SiC wafer with various types of electron devices: n- and p-channel MOSFETs, MOS-gated Hall bars, JFETs, PiN diodes, lateral IGBTs, test patterns.

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TECHNOLOGY

Content

Prototype Fabrication of Customized Electron Devices

Based on more than 25 years of experience in microelectronics research and development, IISB has extended its activities to industry-oriented low-volume prototype fabrication. The focus will be on custom-specific power devices, CMOS devices, sensors, MEMS and passives. The new services are offered and performed under the name π-Fab. In addition to the fabrication of custom-tailored prototype electron devices, π-Fab offers process steps or process modules, such as lithography, oxidation, CVD, ion implantation, annealing, or dry and wet etching.

Particular emphasis will be on aspects such as process stability, process and delivery reliability as well as customer satisfaction. Several measures have been taken in order to meet increased requirements on the process line. On the one hand, all π-Fab processes are carried out in accordance with a quality management system (QMS) according to EN ISO 9001. The QMS and certification is due to be completed by the end of 2014. On the other hand, the sophisticated and fully equipped silicon CMOS line was supplemented with new and state-of-the-art process equipment, such as a medium-current ion implanter, a stepper or a dry etcher. Legacy equipment (e.g. furnaces or wet chemistry benches) has been either replaced by new equipment or overhauled.

The cleanroom is operated together with the Chair of Electron Devices of the University of Erlangen-Nuremberg and provides a total cleanroom area of 1000 m². The process line is based on a 0.8 µm CMOS technology.

A unique feature of π-Fab appreciated by customers is the comparatively high flexibility with regard to wafer material and wafer size. Silicon wafers with diameters of 150 mm and 200 mm are handled by default. In addition to silicon technology, special attention has been given to silicon carbide (SiC) device processing on 100 mm and 150 mm wafers. π-Fab provides additional equipment for performing dedicated SiC process steps, such as the growth of epitaxial layers, the growth of silicon dioxide with low interface state density, implantation of aluminum at elevated temperatures, implant activation annealing at temperatures of up to 1900 °C, or the alloying of ohmic contacts.

1 *View of the cleanroom. Image: Kurt Fuchs / Fraunhofer IISB*

2 *Horizontal furnace for thermal wafer processing. Image: Kurt Fuchs / Fraunhofer IISB*

3 *Wafer handling station of OptimaMDx medium current implanter. Image: Kurt Fuchs / Fraunhofer IISB*

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Content

π-Fab: Fabrication of Competitive Semiconductor Devices in Small Batches

Usually, semiconductor devices are commercially fabricated in large quantities. Especially in the power semiconductor sector, customers can only choose from a small number of variants for their particular applications, and there is no viable option for limited-lot production. Often, system and circuit designers have to use semiconductor devices that barely meet their requirements to compromise with this lack of individualization. Consequently, the full potential of their respective application cannot be exploited. This is particularly true for small and medium-sized enterprises that generate revenues by selling a small amount of systems.

Foundry services where application-specific circuits can be manufactured are an exception to this rule. Nevertheless, the required chips must be compatible to a preset process flow, e.g. CMOS-based smart-power ICs. A foundry can thus cluster different chip designs and operate under the large quantities premise. Still, the fabrication of semiconductor devices custom-built for a particular application is out of the scope of silicon foundries.

When dedicated solutions for power semiconductor devices and detectors are desired, development activities are typically restricted to institute- and university-type cleanrooms. There, the fabrication of semiconductor devices is not based on costly statistical process control, and no permanent quality management is employed. However, this imposes a severe risk to the adherence of delivery dates and the reliability constraints that companies depend on for their own success.

This year, Fraunhofer IISB and the Chair of Electron Devices at the University of Erlangen-Nuremberg have launched the "π-Fab" foundry-type service dedicated to competitive small-volume fabrication of special semiconductor devices. The available process technology allows the fabrication of silicon (up to 200 mm wafer diameter) and silicon carbide devices (up to 150 mm wafer diameter) dedicated to specialized power semiconductor devices and detectors. "π-Fab" process technology is based on CMOS technology with a focus on power semiconductors, but a key benefit is the capability to develop dedicated fabrication processes with a high manufacturability. π-Fab will introduce a quality management system according to ISO 9001 by the end of this year, and critical processes are validated using statistical process control.

As an example, the π-Fab staff has recently finished the process transfer of the front-end processing of silicon drift detectors for a medium-sized German enterprise. These drift detectors are used in spectrometers and handheld measuring equipment for x-ray analysis. By transferring the technology to Erlangen, the wafer diameter in production was successfully increased to 150 mm, resulting in reduced production costs per chip and the possibility of the competitive fabrication of larger sensors with higher resolution. As a result, the world's first commercially available drift detectors capable of resolving x-ray emission from single individual atoms were fabricated.

This example illustrates how application-specific semiconductor devices for small-volume markets can increase revenues and foster the prestige of a company by introducing outstanding products in the market. At the same time, these products fully benefit from quality management and statistical process control, increasing trust in the manufacturing process and the process control measurements. The associated yield increase offers significant cost reduction possibilities in small volume production. Additionally, the outsourcing of fabrication to ISO 9001-compliant suppliers simplifies the customer demands for a universally qualified production chain.

1 *π-Fab cleanroom of University of Erlangen and Fraunhofer IISB in Erlangen, Germany. Image: Kurt Fuchs / Fraunhofer IISB*

2 *Operator with SiC wafer in front of horizontal oxidation furnace in cleanroom environment. Image: Kurt Fuchs / Fraunhofer IISB*

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POWER ELECTRONIC SYSTEMS

Content

Focal Areas of Research and Development, Trends, and Potentials

After 13 years of steady growth and a staff size of about half the institute, the Power Electronics Systems department had reached a size that called for organizational adjustments.

The main objective of this first larger reorganization since 2007 was to make the department, respectively the business field of power electronics, fit for the challenges of the upcoming years. This concerns, for example, the wide field of electrical energy supply, which experienced a great momentum in the course of Germany´s "Energiewende" (turnaround in energy policy). However, issues such as fast switching and EMC have also achieved great application relevance, e.g. by the current availability of SiC and GaN power semiconductor devices.

Several new working groups, such as "DC grid" or "RF-Power Electronics & EMC", were founded to address these emerging fields and to further strengthen our core competencies. Fortunately, the applicant situation in the second half of the year improved so that we could increase our headcount significantly. All organizational planning was closely coordinated to the strategy process in the framework of the institute audit in 2013.

As a result, there have been three departments in the business field of power electronics starting in 2014: "Vehicle Electronics", "Energy Electronics" and "Devices, Modules and Reliability (BMZ)", the last one with a bridge function to the second IISB business field of semiconductor technology. The head of the Vehicle Electronics department will be Dr. Bernd Eckardt, Energy Electronics will be temporary headed by Prof. März, and the BMZ department by Andreas Schletz and Dr. Anton Bauer.

In the last year of the old structure, the department once more achieved an excellent economic result, with an industry contribution well above 30 percent.

The EC project eDAS started in 2013, as well as the BMBF projects EMiLE, InTeLekt and HHK, the project SEEDs funded by the Bavarian Ministry of Economic Affairs and Media, Energy and Technology as well as FSEM II, a Fraunhofer internal research program. The Bavarian Research Cooperation for Electric Mobility (ForELMo), funded by the Bavarian Research Foundation, was able to be launched successfully at the beginning of this year too.

From 4th to 8th March 2013, the fourth "DRIVE-E Academy" took place in Dresden. This summer school is a joint initiative of the Federal Ministry of Education and Research (BMBF) and the Fraunhofer-Gesellschaft. Fifty students interested in e-mobility from all over Germany experienced a week with professional lectures by well-known speakers, excursions, and the award ceremony for the "DRIVE-E Students' Awards".

In spring 2013, our Energy Systems working group headed by Dirk Malipaard moved to our new branchlab in the Energy Campus Nürnberg (EnCN). The EnCN is a research network committed to putting into practice the vision of a sustainable power society based on renewable energy. The work packages of IISB focus on new solutions for megawatt power electronics, the integration of electrical energy storage in a smart power grid, and comfortable wireless energy interfaces to mobile systems such as electric vehicles.

In the summer we organized a very attractive three-month exhibition on e-mobility under the headline "Bewegung Zukunft, e-Mobilität begreifen" (Movement of the Future – Understanding e-mobility) together with the Museum of Industrial Culture in Nuremberg. In October, the "Long Night of the Sciences" took place with a strong commitment of the Power Electronics department and our EcoCar student team.

Apart from all these events, an impressive number of industrial projects could be processed successfully. There were also 21 supervised bachelor and master theses, 14 scientific publications and 26 lectures.

Sincere thanks to all the colleagues in the department for their extraordinary commitment and to all our supporters from industry, politics, Fraunhofer, and the entire institute.

1 *Dr. Martin März, head of department. Image: Kurt Fuchs / Fraunhofer IISB*

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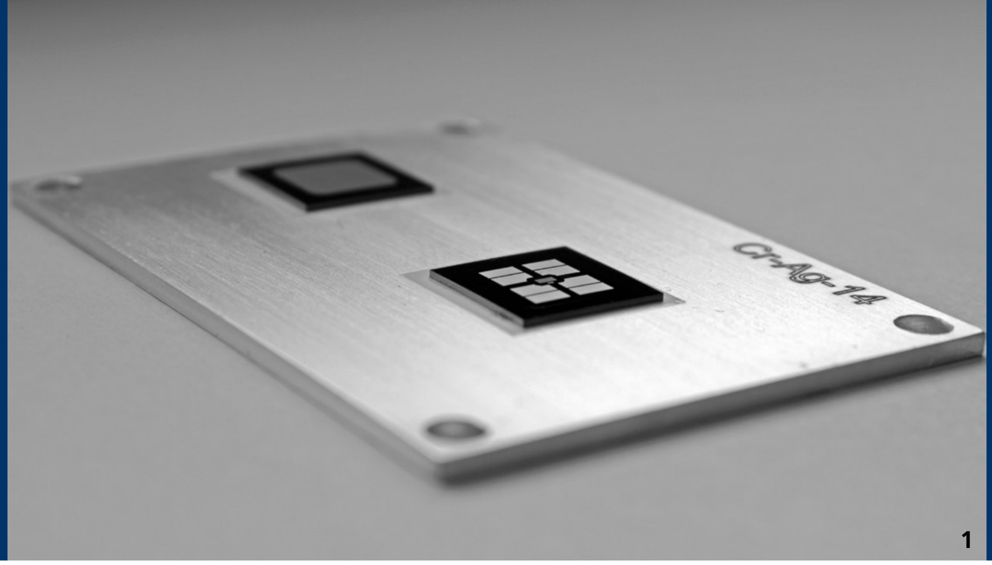
POWER ELECTRONIC SYSTEMS



Content

High-voltage Switching Cell for Modular Multilevel Converters

The ongoing transformation of the public energy supply to a self-sufficient system based on renewable energy sources will speed up significantly in the coming years. This process is directly associated with an increased use of power electronic systems. This affects the whole energy supply chain, from generation through transport and distribution, to consumption. Especially the development of the new modular multilevel topology allows a very efficient and flexible control of the energy flow in the grid. Fraunhofer IISB is working on the development of new power electronic components for modular multilevel converters in energy grip applications. A special focus is on high-voltage direct current systems (HVDC) for efficient energy transmission over long distances. The main goal is to increase the efficiency and lifetime of the system at reduced overall system costs. Recently, several HVDC connections based on this new converter technology have been constructed in the German North Sea for connecting offshore wind farms to the energy grid. Furthermore, the onshore grid development plan describes three HVDC point-to-point connections between the northern and southern regions of Germany. In these application fields, the modular multilevel topology has many system benefits. Therefore, a growing number of realized systems is expected in the next years.

The converters that are constructed today consist of high-voltage power semiconductors in standard packages with isolated base plates that are designed for standard industrial drive inverters or railway traction systems. For applications in the energy grid, a system lifetime of 40 years and more has to be guaranteed. Especially considering that the complete field of power electronics has only existed for 35 years, this is a very challenging constraint.

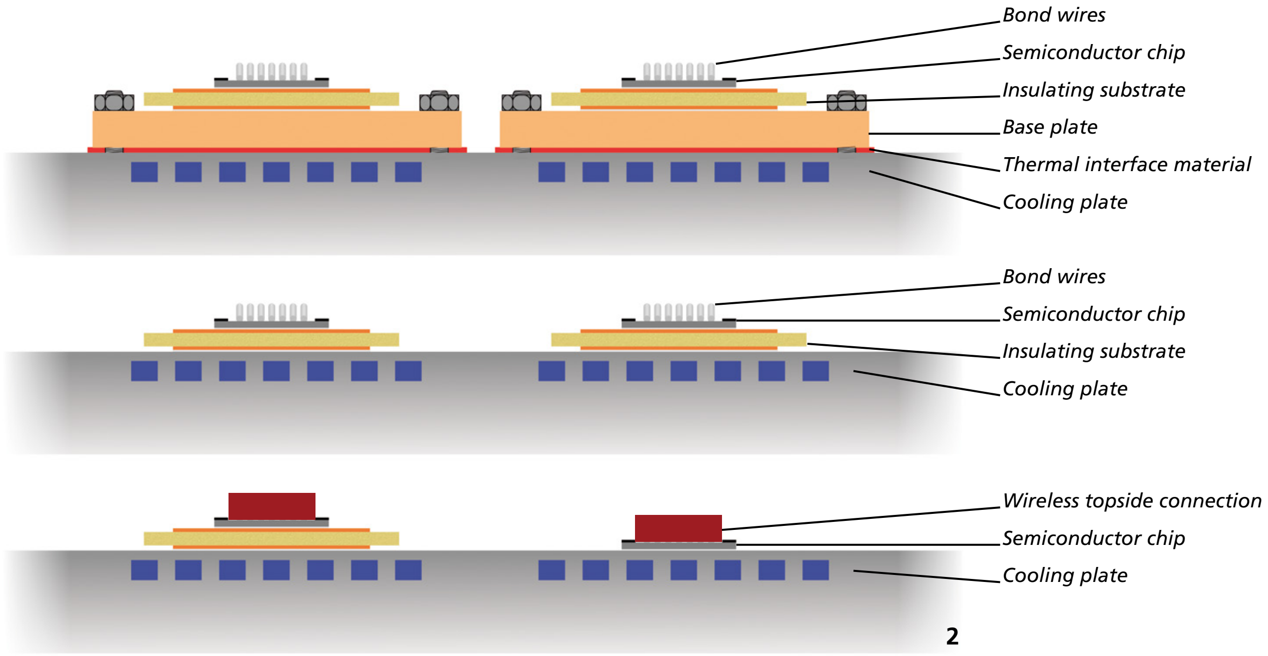
The modular multilevel topology has a couple of special requirements regarding semiconductors. On the other hand, compared to standard converter designs, several additional degrees of freedom are available. To utilize the full potential of the used semiconductor chips, Fraunhofer IISB is developing and qualifying a new module design with a specially adopted joining technology.

The Figure illustrates several aspects of the proposed new design. An application-specific module concept allows an optimization of the thermal design. If the isolation substrates can be mounted directly on the heat sink without screwed base plates with additional thermal interface material, the thermal resistance can be reduced significantly. Furthermore, the single modules of the converter are mounted isolated against each other. Therefore, the electrical potential of all the mechanical parts of one module, including the aluminum liquid coolers, can be chosen freely. Part of the new design is to mount the semiconductor chips of the bottom switch directly onto the heat sink, which removes unnecessary isolation barriers and additionally improves the thermal performance.

Due to the relatively high mismatch of the coefficients of thermal expansions (CTE) between silicon (CTE ~ 2.7 ppm/K) and aluminum (CTE ~ 23 ppm/K), the thermo-mechanical stress on the joining technique and the semiconductor is increased compared to the state-of-the-art assembly. The development of a specialized joining technology for this "high CTE mismatch" environment is one of the main issues of the ongoing research work. In addition to the improvement of the thermal concept, a custom module design can address many other application requirements to achieve cost and performance benefits in the complete system. Based on this work, it is possible to reduce the costs of systems that are essential for the transformation of the electrical energy system to a self-sufficient system based on renewable energy sources.

1 Chips directly soldered on metal plate, test sample for lifetime tests.

2 New design concept for a high voltage switching cell.



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Content

Coupled Electrothermal Battery System Modeling, Simulation and Characterization

In mobile and stationary battery systems, lifetime expectancy is a key parameter for the calculation of monetary effectiveness. It significantly affects the return on investment and therefore is a key parameter for the market breakthrough of the desired battery application. Battery life is influenced by two different factors, namely electrical utilization and environmental conditions. As higher temperatures lead to a faster deterioration of the lithium-ion battery, smart thermal design can not only increase and homogenize battery lifetime but also reduce cooling costs and improve overall efficiency. It is therefore essential to establish an effective thermal design by performing coupled electrothermal modeling and design of the battery cell, battery module, and fully assembled battery pack.

A battery system must be able to estimate its own state, protect itself against failure and degradation, and provide information about its state to other system components, e.g. to a driver's user interface in electric vehicles or to a power utility in stationary applications. To predict valuable information such as the remaining driving distance, the state of charge (SOC) and others, various battery models can be used. Correction and adaption of these models can be done with different filters. The parameters for the models are significantly dependent on temperature. Exact thermal characterization leads to more accurate estimations of SOC and other temperature-dependent estimators.

The foremost aim for the thermal design of a battery system is to minimize temperature gradients while delivering the best cooling performance to dissipate the heat generated during battery operation. Temperature differences between cells inside modules and packs lead to variances in all temperature-dependent processes, which especially lead to unequal aging and self-discharge rates, thus requiring balancing circuits that can be difficult to cool (i.e. passive balancing) or complex and costly to implement (i.e. active balancing).

For electrical modeling of battery cells, equivalent networks are mainly used. Lumped elements of the equivalent networks can be of an electrical nature (e.g. resistors, capacitance, inductor, voltage and current sources) or describe chemical effects, such as diffusion in the active material (e.g. constant phase element). Various methods for the parameterization of the electrical equivalent circuit can be used. In addition to electrochemical impedance spectroscopy (EIS) and a numerical approach using hybrid power pulse characterization (HPPC), other methods such asthe current step response method or the current interrupt method are used.

Optimization methods such as genetic algorithms can be used to minimize parameterization misfits. Thermal modeling can be performed with the help of finite element methods (FEM). A detailed mechanical CAD model of the battery cell is created with CAD software and parameterized with the appropriate thermal parameters, namely thermal conductivity and specific heat capacity. When the complete geometry of the battery cell is considered, detailed boundary conditions can be defined to describe the cooling conditions used. The specific losses are applied to the geometry on the appropriate elements.

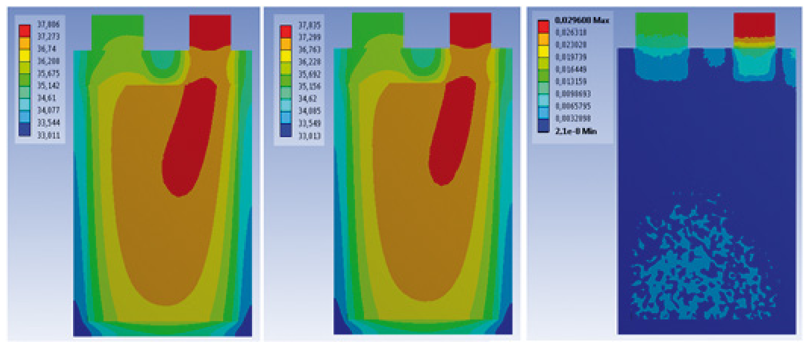
The issue is that FEM simulations are very time-consuming. A solution to this issue is the use of model order reduction (MOR). The aim of MOR is to generate a low-dimensional approximation of the system model. This is stated in the formulas on the right, where dimensions for describing the state and output matrices of the reduced order model are of a lower order than the ones of the system model. This enables a drastic reduction in simulation time: The simulation time ratio in our setup of FEM simulation to reduced model simulation is more than 2 orders of magnitude. With this reduced model, it is possible to make a coupled simulation with the electric model in reasonable time.

System model:

$$E\dot{x} = Ax + Bu$$
$$y = Cx$$

Reduced order model:

$$E_r\dot{z} = A_r z + B_r u$$
$$y = C_r z$$



1

1 *Comparison of FEM and MOR simulations.*

To verify the simulated results, the measurements of thermal radiation by the infrared camera and local surface temperature by the thermocouples were recorded synchronously. They were compared to temperature simulations of a reduced order model. The temperature measurements are in very good agreement with the simulation results and show less than 1.5 °C difference.

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POWER ELECTRONIC SYSTEMS

Faster, More Efficient, and More Compact – Redefined Benchmarks for Power Converters with GaN Power Devices

Excellent results were obtained for the efficiency and power density of electrical power converters with high-performance gallium nitride (GaN) components. The study was conducted at the Fraunhofer IISB in Erlangen, Germany, in collaboration with the Japanese industrial partner Panasonic.

The objective of the study was to explore the potential of GaN components for increasing the efficiency in electronic power systems beyond what is currently possible. The results speak for themselves: An overall efficiency of up to 99.3 % could be determined for a compact converter with hard-switching topology developed at Fraunhofer IISB. Furthermore, a switching frequency of 1 MHz was achieved – depending on the operating point – with the same design. In load tests, a stable operation could be demonstrated with an input power of up to 2.5 kW. With a construction volume of only 0.09 liters, this corresponds to a power density of 28 kW / l.

Last but not least, these excellent results are due to the use of an especially compact and low-inductance layout with an integrated gate driver. As the electrical measurement of such extremely high efficiencies becomes very challenging, all measurements were validated with a calibrated calorimetric setup.

Within the framework of the investigation, designs and setups were implemented in so-called hard-switching converters, and their electrical and thermal performance was characterized. Pilot production components made of the promising semiconductor material gallium nitride (GaN) resulted in the convincing key values presented above. These components, developed and produced by Panasonic, were close-to-production GaN transistors whose mass production is now imminent.

Prof. Dr. Martin März, Head of the department of Power Electronic Systems and Deputy Director of the Fraunhofer IISB explains, "These benchmark figures, in such a compact design, speak for the efficiency of the GaN components of Panasonic as well as for the quality of the converter setup developed at Fraunhofer IISB. Compared to the records published in the recent past, the losses could be considerably reduced. Whereby it should be noted that the enthusiastically advertised efficiency of converters with such high effectiveness is only really meaningful in respect to the achieved power density."

1

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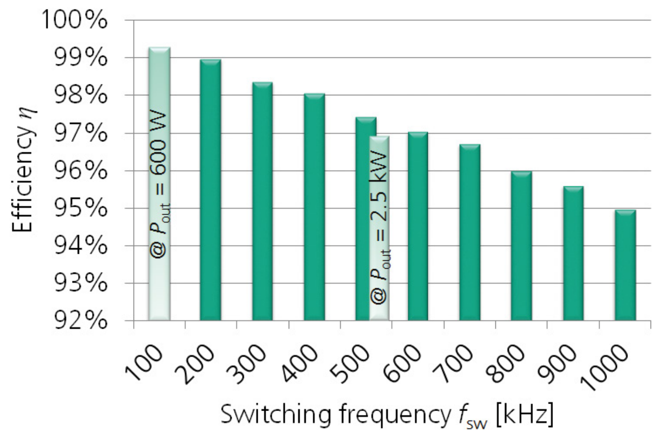
One additional feature makes the GaN devices used in this study particularly convincing for application in a power electronic system: In the past, GaN power transistors from other manufacturers showed a parasitic effect called dynamic on-resistance $R_{ds(on)}$. In contrast, the GaN transistor used in this study shows no dynamic on-resistance. This remains true for device temperatures up to 150 °C, as can be seen in the figure below. Another aspect of these GaN transistors is the very low charge of their body diode compared to silicon counterparts. This device is therefore beneficial for future power electronic applications requiring a soft body diode turn-off such as hard switching bidirectional power stages.

1 *New horizons in efficiency and power density of electrical power converters with high-performance gallium nitride (GaN) components.*



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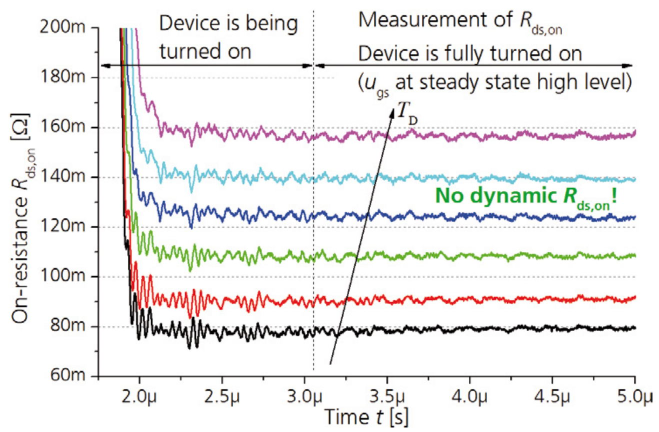
2 *Efficiency results of the GaN DC/DC converter. If not otherwise stated, the output power is 1.5 kW.*



3

3 *On-resistance of the GaN transistor as a function of device temperature TD at 30 °C, 50 °C, 75 °C, 100 °C, 125 °C and 150 °C. The clamped inductive switching test was performed at 10 A while the drain source voltage of 300 V in the off state was applied for 15 s.*

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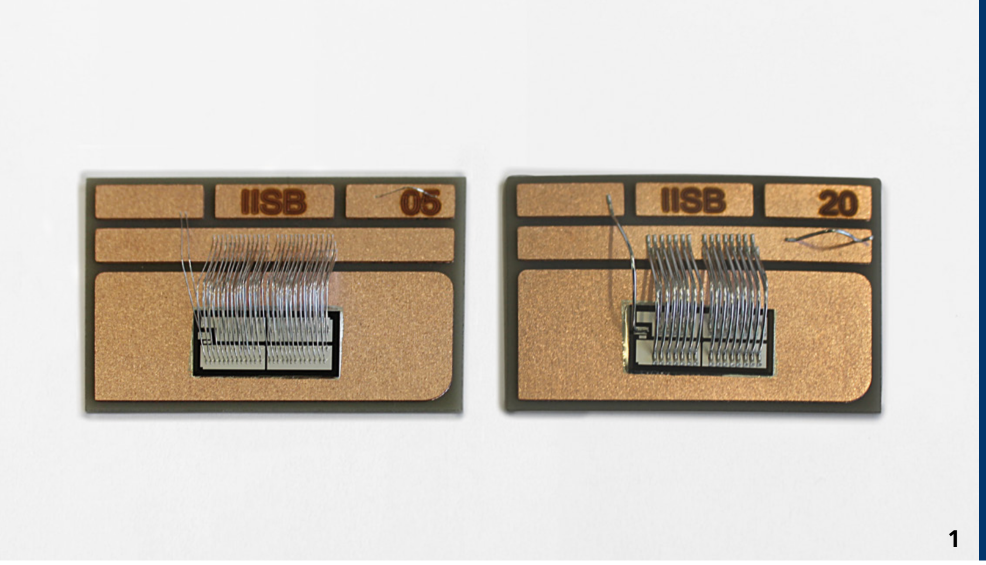

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Content

The Easiest Way to Avoid Bond-Wire Liftoffs

A cause of failure in state-of-the-art power modules is the lift-off of bond-wires from the semiconductor. This can be avoided by using small wires instead of a few large wires. The increase in lifetime is shown by a power cycling test and finite element analysis. A way to process the needed number of small wires is also presented.

The life-limiting factor of power electronic devices is still the aluminum bond wires. Therefore, new wires such as aluminum-copper composites [1] or pure copper wires [2] are in development. The copper-wire bonding process is still not state-of-the-art [3], and all other alternatives to aluminum wires are not mature. The demand for a low-cost and easy-to-apply alternative is still given. Hoa showed in 2009 that the plastic strain in the aluminum can be decreased by smaller wire diameters [4].

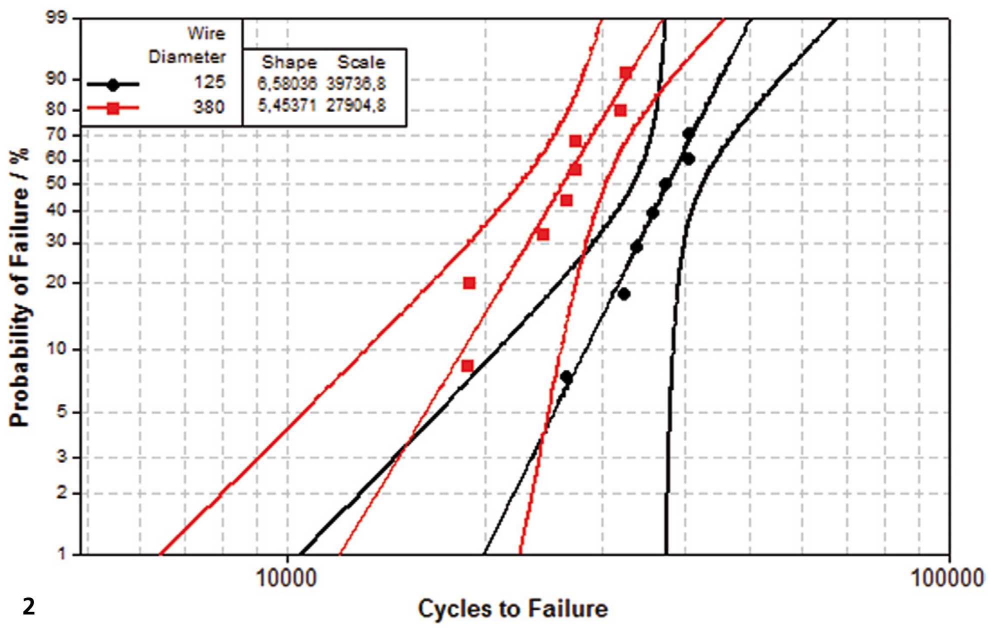
For the experimental setup, 20 samples were built up with SAC305 solder preforms and an Infineon IGBT4, type IGC109T120T6RH on DBC substrates (directly bonded copper). For the top-side connection of the dies, two kinds of aluminum bonding wires were used with a thickness of 125 µm and 380 µm. The results were two groups with ten devices each. No base plate or molding compound was used.

These 20 samples were power cycled with the PCT3 system at Fraunhofer IISB, which is described in [5]. A constant heating current of 89 A was set for all samples, which led to a temperature swing of 130 K. The cycle times t_{on} and t_{off} were set to 15 seconds each and the minimum temperature was 25 °C.

To get the same current through the small wires, we have to add nine times more pieces compared to the ones of 380 µm in diameter. Normally an IGBT is connected with eight thick wires to the substrate, which means that ~80 thin wires are necessary to achieve the same electrical resistance. With 28 wires, the 380 µm wire diameter test group had the edge over the 100 wires with a diameter of 125 µm in terms of electrical resistance.

During the power cycling test, all samples with the thicker wires failed due to bond-wire lift-off. The devices with the thinner wires failed many cycles later because of solder degradation. All 125 µm bonding wires were still in good condition after the test.

It is shown with power cycling tests that the lifetime of power electronic assemblies can be significantly extended with the use of smaller bonding wires. With decreasing wire diameters, the thermo-mechanical stress between the silicon semiconductors and the aluminum also decreases, and therefore the bonding connection stays intact longer. The higher number of bonding wires can be achieved with new bonding machines, which might be able to bond multiple wires simultaneously.



2

1 *Test samples for power cycling test with differend kinds of aluminum bonding wires: 125 µm (left) and 380 µm (right) thickness.*

2 *Probability plot of power cycling test results.*

[1] *R. Schmidt, U. Scheuermann, E. Milke: Al-Clad Cu Wire Bonds Muliply Power Cycling Lifetime of Advanced Power Modules, PCIM Proc., Nuremberg, 2012*

[2] *J. Rudziki, F. Osterwald, M. Becker, R. Eisele: Novel Cu-bond contacts on sintered metal buffer for power module with extended capabilities, PCIM Proc., Nuremberg, 2012*

[3] *Z. Zong: Overview of wire bonding using copper wire or insulated wire, Microelectronics Reliabilty Vol. 51, Issue 1, 2011, p. 4-12*

[4] *L. Hua: Design for reliability of power electronics modules, Microelectronics Reliability 49, Amsterdam, 2009, p. 1253.*

[5] *A. Schletz: Power Cycling: Test and Interpretation, Fraunhofer-Cluster Leistungselektronik*

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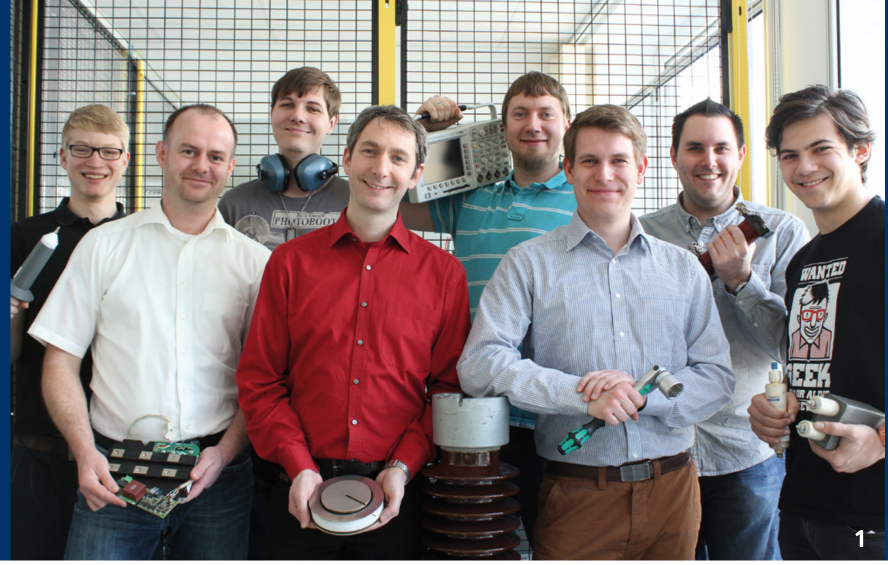
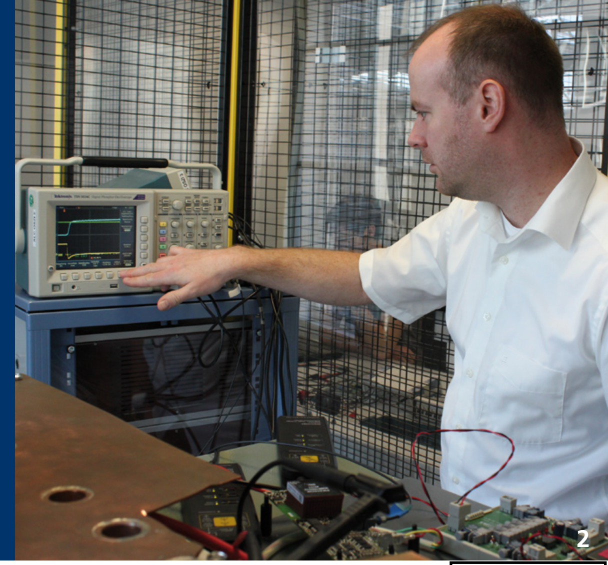
POWER ELECTRONIC SYSTEMS





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Power Electronics Launches an Application Laboratory in Chemnitz

In the year 2013, a new laboratory for the application of power electronics was opened in Chemnitz, Saxony. It is now located on the second floor of the Pegasus Center near the Technical University of Chemnitz and the Smart Systems Campus.

The IISB department of Power Electronic Systems had previously placed members close to the University of Freiberg, Saxony. This is where a part of the application group – formerly known as Industrial Power Electronics – was located. After networking a couple of years, it turned out that Chemnitz would be a better place for working on power electronics.

Moving from Freiberg to Chemnitz was a good choice because the TU Chemnitz has a well-established department of Electrical Engineering with at least three chairs focusing on high voltage and power electronics. Their profiles range from power semiconductors, regenerative energies, e-mobility, through high voltage power generation, conversion, to energy transmission and storage. The young and dynamic students from the university as well as experienced engineers can provide IISB with new ideas and perspectives on these topics. The main intention is to initiate long-term employee retention and to provide interesting application work for students and young engineers close to the Technical University of Chemnitz. With the new laboratory in Chemnitz, the Fraunhofer IISB also offers new job positions for them.

In addition to modern lab equipment to facilitate daily work on industrial projects such as development and troubleshooting, the working environment is oriented to provide a long-term employee satisfaction. Highly motivated, freshly graduated engineers have already finished up to two projects predominantly on their own within half a year after leaving the Chemnitz University of Technology. For more details also refer to "A modular training platform for current sensors" in this annual report. Surrounding infrastructure such as a nursery school and shopping facilities right next to the new laboratory makes all employees benefit from such short distances.

Initially, two people started with 120 square meters for offices, laboratories, test benches and a business plan to recruit more scientists. Since then, the team has expanded steadily, and the application lab now has a total area of 160 square meters.

Many tasks require a lot of help – therefore, seven trainees, nine student assistants and one scientific assistant were employed during the first year. They all did a great job to make the application lab ready for work. A first publication is already in progress together with the Technical University of Chemnitz. As a result of active networking, the receipt of a Ph.D. in Chemnitz was celebrated in the application lab, and hopefully there will be more in the future.

After obtaining furniture, assembling equipment and recruiting new staff, the team was ready to start in March 2013. Fig. 1 shows eight people who are now engaged in projects for industrial partners. They design power electronic components and systems as well as self-made test benches that are needed for a steady workflow. The work now focuses on high-voltage DC transmission, a long-term and important key factor for the change in government energy policy. With renewable energies on the shore of Germany, a technology providing much fewer losses compared to traditional AC transmission is important for the power transmission across our country.

These applications require more than just standard electronic lab equipment. For this reason, two high-voltage cages have been installed. They can be equipped with a test bench for IGBT driver and semiconductor characterization up to 10 kV (Fig. 2). For measurements of small signals at high voltages, modern high-resolution oscilloscopes benefit from fiber-optical probes. In order to react quickly, the lab is equipped to assemble prototypes in SMD technology. The laboratory has a soldering oven for reflow soldering and other tools to fulfill this task. The finished circuit boards can be tested in a climatic chamber. For hot-spot evaluation, thermographic cameras are available.

The core team of this application lab welcomes the decision for Chemnitz, since they were born there. After many years of experience at IISB in Erlangen, Nuremberg and Freiberg, they are now looking forward to prosperous work in Chemnitz. This new lab opens a large variety of business fields and new possibilities for future projects with established industrial partners and new companies in the region.

1 *The current team in Chemnitz.*

2 *Measurements in the high voltage cage.*

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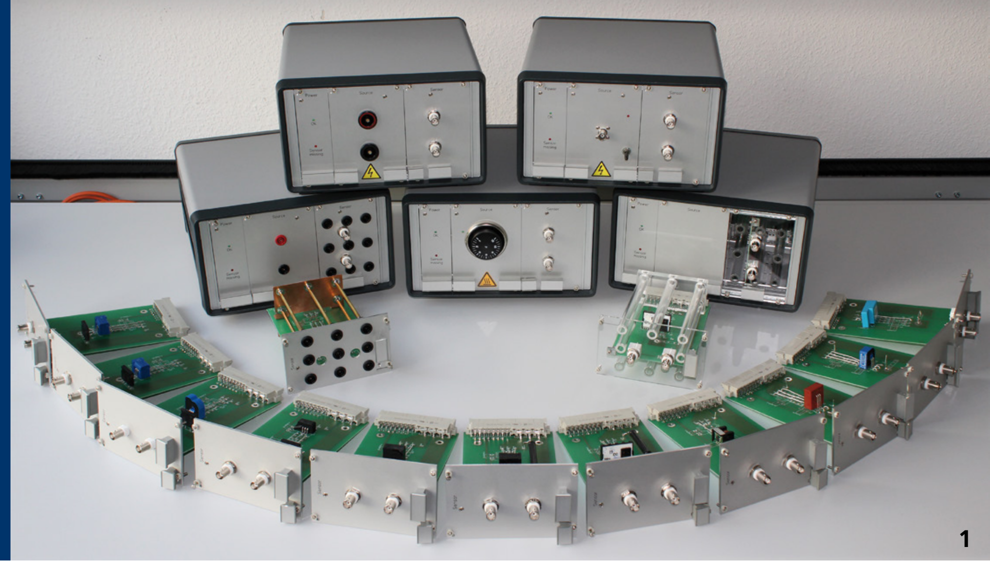

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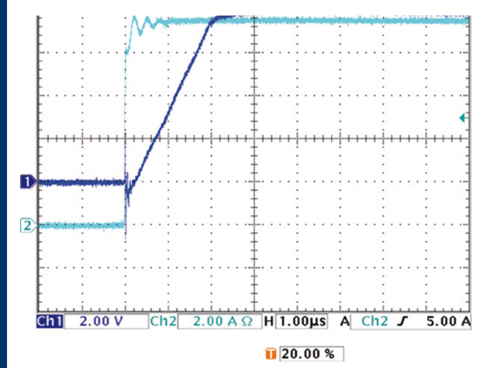

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Content

A Modular Current Sensor Training Platform

The European Center for Power Electronics e.V. (ECPE) was founded in 2003 by eight industrial enterprises. Meanwhile it has become a research network for power electronics in Europe consisting of 70 European universities and research institutes as Competence Centers. Their goal is to promote education, innovation, science, research and technology transfer in the scope of power electronics within Europe. A long partnership between ECPE and Fraunhofer IISB has also resulted in several projects on current sensors. Seminars were held for ECPE, and other developments were done in the past. On behalf of the ECPE, Fraunhofer IISB now created a modular training platform for current sensors.

This consists of several base racks with different experimental setups (Fig. 1). These are to educate and train engineers, technicians and other people in the usage of current sensors. As there is no sensor that is the optimum for all applications, the goal is to provide a technical background to choose the best sensor for a project application. Since the behavior of each sensor differs with the application, they can be compared in the same setup. These behaviors include the response in current or voltage changes, the effects of temperature, overload and properties such as sensitivity, linearity, noise and magnetic offset. These effects can be seen in various applications such as machines, converters and other power electronic systems. The training platform consists of nine different current sources in separate racks to serve different characteristics. The heart of the system consists of one circuit board that can hold eleven different sensors. This allows the sensors to be arbitrary combined with the sources by simply adding a bridge or a resistor on the sensor circuit board.

When a setup is combined with a given sensor, different physical principles and their parasitic effects can be observed. With that knowledge, the user gets to know the pros and cons that go along with different sensor types and their application. This underlines the conclusion that there is no perfect sensor, but in most cases there is a best-fitting one. This gives indications for the next time a sensor is chosen for a specific environment.

Setup number one shows the behavior of different current sensors at steep ascending currents. This gives information about the current sensor's dynamic characteristics. For this, a capacitor bank is loaded with a voltage of up to 600 V. This fairly high voltage is discharged via a spark gap through a resistor and a shunt as a reference. Due to that, the current rises very fast. The step response of the sensor and a reference signal can be investigated with an oscilloscope (Fig. 2).

The second experiment shows the influence of high potential shifts (dU/dt noise) between the primary conductor of the current sensor and its electronics. For that purpose, a charged capacitor is connected to a half bridge with a rectangular switching voltage at its output. The current sensor is connected to that output so that the impact of the voltage changes to the output of the sensor can be seen at the oscilloscope. The maximum sensitivity of the current sensor and possible saturation effects can be investigated with the third experiment. A sinusoidal output current from a transformer is led through a resistor and the sensor. The transfer characteristic with partial saturation can be recorded by an oscilloscope in an x-y operation. Foreign fields caused by currents both inside and outside of the application have an influence on the sensor's behavior. With this setup, the influence of the return path of the current can be investigated. The setup has different paths that can be chosen. Depending on the path, different results can be observed at the output of the sensor.

Strong magnetic fields can disturb the current sensors. To examine this behavior, the user can apply an external field with permanent magnets. The current sensor does not sense a current but the influence of the magnet. The output of the current sensor is measured by a multimeter.

Setup number six is intended to determine errors in the linearity of the sensors. Therefore, a DC current source is applied and measured with the current sensor. The values should not exceed the nominal positive and negative currents. A reference can be measured with a shunt. This experiment consists of a charged capacitor that can be discharged quickly through the current sensor, resulting in a large current pulse. The output of the sensor is measured prior to and after the overload current. These two results can be compared to receive the effects of the overload on the sensor. To degauss the current sensor, the source also includes an AC current output.

As with every other component, a current sensor also has a behavior according to the temperature. A built-in light bulb is a heater for the sensor. With the rising temperature, the output drifts away. The temperature and its corresponding output can be measured with a thermometer and a multimeter. With the last housing, different current sensors based on magnetic fields are investigated for their intrinsic noise. The setup holds different sensors whose outputs are measured with an oscilloscope and compared to each other.

1 *A selection of the mounted racks and sensor modules.*

2 *Output of a sensor module to determine the step response of the sensor.*

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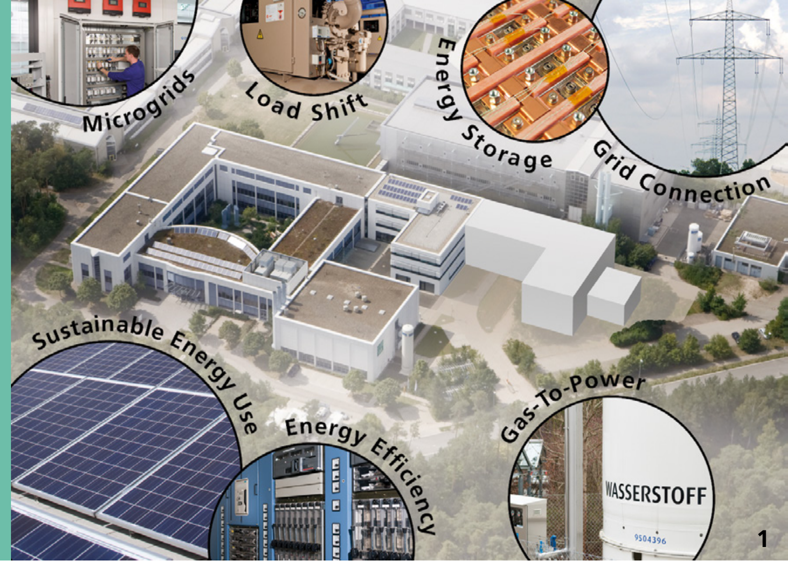
ENERGY TECHNOLOGIES: SEEDS – A PATH TO THE INDUSTRIAL “ENERGIEWENDE“



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SEEDs – Nucleuses for an Industrial Energy Transition

The basic idea of the project SEEDs is to immediately start reconstructing the energy supply for small and medium-sized companies (industrial level) by utilizing and further developing existing approaches and techniques. The goal is the research, development and implementation of a sustainable energy production, energy storage, energy supply and efficient energy use at an industrial level. In this connection, the focus is on the highest efficiency, cost effectiveness as well as the security of supply and stability autarchy.

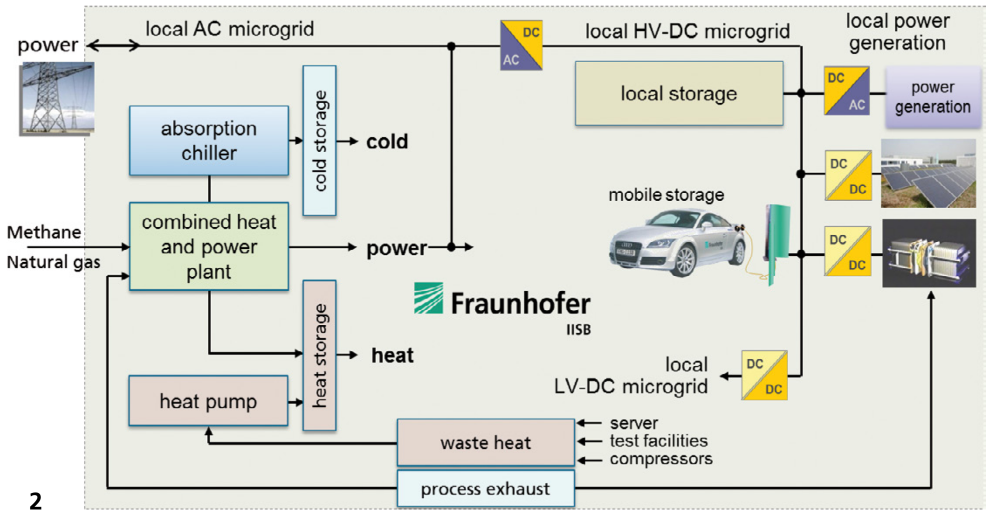
The areas covered in SEEDs are shown in Fig. 1: microgrids, energy storage, gas-to-power, grid connection, load shift, sustainable creation and use of energy, as well as energy efficiency. The whole chain of energy technology will therefore be investigated. Specific attention will be paid to an efficient interlinking of the different components of the energy system with power electronic systems and interfaces to set up a stable overall system with respect to control. These interfaces are a core competence of Fraunhofer IISB.

The research and development activities cover the demonstration of already existing solutions in an entire linked system, in addition to the development, evaluation and utilization of new technical solutions, with respect to introduction to market as well. In addition, basic research will be performed in specific areas for new technologies, approaches and solutions, and the technical feasibility will be considered as well.

The overall institute building of the Fraunhofer IISB serves as a research and demonstration platform. The requirements for different energies (heat, cold, and electricity), as well as the size, infrastructure and energy consumption of the IISB are comparable to those of a small and medium-sized company. IISB shows a high fluctuation of load, high peak loads and a substantial need for secondary energy due to a considerable amount of labs and equipment for semiconductor processing as well as manufacturing. A cleanroom is continuously operated, but a large number of labs and offices are also used. Therefore, the IISB platform covers office and home aspects as well as industrial and lab aspects, which means that nearly all facets of energy management and the energy sector are available. Production-related activities are continuously performed, but no direct production cycle will be disturbed for research and development. Therefore, this research and development platform seems to be ideal for applications such as research and demonstration activities. An overview of the topics and the planned components of the research and development platform is shown in Fig. 2.

In addition to Fraunhofer IISB, the Fraunhofer institutes IIS and ISC are also participating in the project. IIS will cover communication-related topics and ISC material aspects for electrical battery development.

The project SEEDs is funded by the Bavarian Ministry of Economic Affairs and Media, Energy and Technology in the framework of the Bavarian concept for research and development of technology for energy.



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1 *Fraunhofer IISB itself is used as a demonstration platform for energy research.*

2 *SEEDs – Overview of the research and demonstration platform.*

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Content

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Selected News

1 *Official opening event of the SEEDs energy research project on Juli 6, 2013 at Fraunhofer IISB in Erlangen with (from left to right) Head of the Institute Prof Lothar Frey, Bavarian State Secretary Katja Hessel, President of the University of Erlangen-Nuremberg Prof. Karl-Dieter Grueske and the Chancellor of the University Thomas Schöck. Image: Kurt Fuchs / Fraunhofer IISB*

SEEDs – launching the turnaround in industrial energy policy

On Friday, June 7, 2013 the Bavarian economics secretary Katja Hessel confirmed officially the funding agreement for the SEEDs energy research project with Fraunhofer IISB in Erlangen. Within the framework of SEEDs the implementation of sustainable energy production, storage and supply for units comparable in size to industrial plant will be researched and demonstrated according to the motto „launching the turnaround in industrial energy policy". The institute building of Fraunhofer IISB will serve as the research and demonstration platform.

The change-over to energy supply with a significant component of renewable energy sources requires an implementation for all sizes of users, from private households to large-scale industry. And especially for medium-sized industrial plant it is of considerable interest to find out how industrial plant can be operated in a way optimizing energy and costs on the basis of decentralized production as well as future possibilities of energy storage and recycling. The basic idea of the SEEDs project is the immediate launch of converting energy supply at an industrial level by the use and extension of existing seeds (SEEDs). The highest levels of efficiency, cost effectiveness and also the largest possible autonomy of supply and stability will be in the forefront.

The IISB institute building will serve as the first research and demonstration platform. The building's energy usage is comparable to that of a medium-sized industrial plant, with a considerable variability of load, peak loads and considerable secondary energy requirements because of the extensive laboratory and plant technology and also in particular a continuous clean room operation. The IISB has requirements for both office and industrial / laboratory usage and hence almost all facets of our energy sector. Workflows comparable to those of production are used regularly. Consequently the institute building is ideally suited as a research and development platform.

In SEEDs the total chain of energy technology is considered and used. Special emphasis is placed by the researchers on the efficient linking of the individual components and demonstrators by electronic interfaces to – at least partly – an autonomous complete system that is stable with respect to control technology.

In addition to Fraunhofer IISB, the Fraunhofer Institute IIS, and ISC, numerous Bavarian industrial partners also participate in SEEDs. The project is funded by the Bavarian Ministry of Economic

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Continuation: Selected News

Affairs and Media, Energy and Technology within the scope of the Bavarian Concept for Research and Technological Development in the Energy Sector.

Mobility in the Future – looking back to the special exhibition on electro-mobility

From June 19 to August 25, 2013 the special exhibition "Mobility in the Future – Understanding e-mobility" could be visited in the Museum for Industrial Culture in Nuremberg. This exhibition gave a graphic overview of the technical and historical background, the state of the development and the possibilities of electrical mobility. Together with the Museum of Industrial Culture, Fraunhofer IISB created a place in which technology came to life and could be touched and experienced.

Electric vehicles have been in existence for more than 130 years but for private transport they have up to now only been found in small numbers, with the internal combustion engine being dominant. The scarcity of fossil fuels, the threats presented by climate change and massive environmental problems – above all in conurbations and megacities – require us to rethink. Electrifying propulsion gives the chance to reduce the dependency on oil, to minimize emissions and also to redefine individual mobility. In the exhibition "Mobility in the Future" large numbers of visitors had the chance to inform themselves in an enjoyable way of this exciting field of development on the basis of facts and graphic exhibits.

A core component of "Mobility in the Future" was a travelling exhibition of the Fraunhofer System Research Group on Electromobility (FSEM), which explained on a number of interactive information stands the various aspects of electromobility – from new concept vehicles via battery technology to sustainable traffic development.

Emphasis was also placed on the vehicles and exhibits of firms and research establishments from the metropolitan region of Nuremberg and North Bavaria, for many developments and innovations concerning electromobility saw the light of day there. Exhibits of North Bavarian companies on the topics drive technology, energy storage and charging infrastructure confirmed that electromobility has long left its original niche and has now become very much a focus of interest of the automobile and supplier industry. Onboard network components, power electronic modules, motor interface models, charging columns and safety equipment reflected the impressive range of regional high-tech projects. Interesting electric vehicles – from historical bicycles, scooters, the first officially registered solar vehicle in Germany through to modern electric town vehicles

1 *The special exhibition „Mobility in the Future – understanding e-mobility" in the Museum of Industrial Culture in Nuremberg provided visitors with a clear overview of the technical and historical background, state of development and also the possibilities of electro-mobility. Image: Kurt Fuchs / Fraunhofer IISB*

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Continuation: Selected News

and sports cars – showed those attending the exhibition developments of the last few decades permitted for use on public highways.

Furthermore, a great number of interesting numbers and facts was presented on informative charts, e.g. regarding energy requirements, actual CO_2 emissions or the range of electric vehicles. Information on regional networks, training junior staff and on public projects rounded off the exhibition. Thanks to its comprehensible presentation technique "Mobility in the Future" provided an exciting trip to a sustainable mobile world – of course only electrically – to non-technicians, school students of all ages and other young people.

15th Annual IISB Conference – components for energy electronics

The 15th annual conference of the Fraunhofer IISB took place on 21 November 2013 in Erlangen. This time the conference theme was "Components for Energy Electronics". The latest developments in the production of microelectronic components for use in energy-efficient systems and the potential uses in energy electronics were presented at the event. The Hans-Georg-Waeber innovation prize of the Förderkreis für die Mikroelektronik e.V. (Microelectronics Support Group registered association) was awarded at the conference.

For over 25 years there has been a close cooperation of IISB with the University of Erlangen-Nuremberg in the field of microelectronics and nanoelectronics. In the business segments semiconductors, power electronics and energy an extremely wide research and development program is underway for basic materials for semiconductors, components and power electronic systems through to sustainable energy management. IISB has provided for a long time the service of producing customized components in its CMOS process line. After further development of this service the customer can now make use of "π-Fab" for prototype production.

These and other topics were described in detail in lectures by IISB staff members and representatives of cooperation partners, e.g. the topics monolithic attenuation components in trouble-free drive inverters, the integration of trench gates in planar topologies or the extended silicon process line for the production of SiC components.

Scientists at Fraunhofer IISB in Erlangen and the JENOPTIK Automatisierungstechnik GmbH in Jena were awarded the Georg-Waeber Innovation Prize 2013 of the Förderkreis für die Mikroelek-

1 *Dr. Anton Bauer, head of the Technology department, opened on November 21, 2013 the 2013 annual conference of Fraunhofer IISB.*

Content

Continuation: Selected News

1 *Participants of the DRIVE-E-Akademie 2013 in Dresden during an excursion. Image: Jörg Carstensen / BMBF*

tronik e.V. for their combined R&D efforts in developing a novel laser-based separation process for brittle materials.

Electromobility for students – DRIVE-E Academy and award of the students prize 2013

As is well known, enthusiasm and interest are aroused when you experience something yourself. The DRIVE-E Academy, a project of the Federal Ministry of Education and Research (BMBF) and the Fraunhofer Gesellschaft, provides the perfect platform for this. Within the framework of this outstanding event tomorrow's creative talents meet first-class experts in the field of electromobility: The former group will not only be informed and inspired but at the same time will make important contacts. Lectures accompanied by workshops and also stimulating excursions to renowned automobile manufacturers are the trademark of this exclusive event. In total the DRIVE-E Academy not only provides an excellent entry to the complex group of themes of electromobility but it is also a special experience. The climax each year is the award of the DRIVE-E students prize at which the motivation of talented young people and their outstanding work are honored.

As of 7 January 2013, the last date for applications, a total of 46 applications for the coveted prize had been received. Of this total, 21 were for category I (bachelor's thesis, project or other work during a bachelor's degree course) and 25 in the category II (master's or diploma thesis). The work was carried out within a range of subjects like business administration, chemistry, computer sciences, lightweight construction engineering and simulation, mechatronics, mechanical engineering or mechanical engineering together with other topics (e.g. energy technology), microtechnology, systems engineering, technical environmental protection, engineering and business administration as well as a number of different disciplines of electrical engineering and automobile technology. Applicants came from 10 technical universities or universities of applied sciences and 10 non-specialized universities from the whole of Germany – from Braunschweig to Dresden and from Kiel to Munich.

First prize in the category "master´s or diploma thesis" was awarded to Julian Timpner of Braunschweig Technical University for his master's thesis in the field of traffic and mobility concepts. With the title "Design, Implementation and Evaluation of Central Components for the V-Charge system", he developed a traffic concept deploying electric vehicles as feeders for public transport vehicles in combination with autonomous parking and an optimized charging strategy during parking. According to the jury this combination has the potential to be part of an extensive market launch of electric vehicles with additional comfort and safety functions.

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First prize in the category "bachelor's thesis, project or other work during a bachelor's degree course" was awarded to Stephan Leppler, whose work was an investigation of the costs of using conventional hybrid and battery-driven electric vehicles and consequently has the title "TCO (Total Cost of Ownership) comparison of newly registered conventional and (partly) electric vehicles from the user's point of view". According to the jury when explaining their decision, this work, which Stephan Leppler carried out at the Institute for Technical Environmental Protection of Berlin Technical University, makes an important contribution to establishing environmental friendly electric drives.

The Long Night of the Sciences 2013 – a glimpse behind the scenes of Fraunhofer IISB

On 19 October 2013 the triangle of cities Nuremberg / Fuerth / Erlangen sent out an invitation for the sixth time to "The Long Night of the Sciences". On this occasion Fraunhofer IISB opened its doors once again to give interested members of the public a glimpse behind the scenes.

Visitors at the location of the Institute in Erlangen were given information on the newest developments in nanoelectronics and electromobility. In the IISB department "Technology Simulation" the visitors could for example experience close up how the nanoelectronics of tomorrow already exists today, virtually.

The test center for electric vehicles showed interested visitors how components of electric and hybrid vehicles but also total vehicles can be measured and optimized. In addition to an exhibition of everything to do with electromobility the Bavarian Research Alliance for Electromobility (FORELMO) presented itself, and the company E-T-A, appearing as a guest, presented an electric vehicle and other highly interesting exhibits and gave specialist lectures on the topic electric safety and onboard power supply monitoring.

Extremely popular was the lecture "Electrotainment", in which the basics of electricity were explained in an entertaining and exciting manner using graphic and impressive experiments.

Particularly popular were also the tours of the large clean room hall of the Chair of Electron Devices (LEB). In this hall the visitors were given an insight into the highly developed technology and infrastructure required for manufacturing electronic components at the nanometer level.

1 *Bavarian State Secretary Bernd Sibler giving his expert opinion at the Fraunhofer IISB stand of an inductive charging station for electric vehicles at the opening of the Long Night of Science 2013 at the Energy Campus Nuremberg (EnCN). In the background (from left to right): Prof. Karl-Dieter Grüske (President of the University of Erlangen-Nuremberg), Prof. Michael Braun (President of the TH Nuremberg), Prof. Wolfgang Arlt (EnCN spokesman), Stefan Ditze (Fraunhofer IISB). Image: Kurt Fuchs / Fraunhofer IISB*

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1 *Prof. Martin März (on the left of the picture) in conversation with participants of the ECPE Students Day at the Fraunhofer IISB stand at PCIM Europe 2013 in Nuremberg.*

Measures for optimizing energy efficiency require comprehensive knowledge of the temporal distribution of energy flows, e.g. electrical energy, heat and cold air. Fraunhofer IISB gave a live demonstration of an energy monitoring system just recently implemented. Current values of consumption were shown and also loads at regular intervals for a day, a week or a month for electrical power, heat and cold as well as inputs into the Institute's own photovoltaic plant.

Furthermore, during the "Long Night", results of research in printed electronics could be seen. As an extension to silicon technology, electronic functions can be realized by printing processes on large areas or unusual surfaces. Examples of this range from plastic sheets with integrated touch or temperature sensors to the cost-effective production of large displays. In this area IISB is carrying out research on new materials and process techniques.

Without our noticing it, our everyday life is full of crystals. Consequently, a large exhibition was dedicated 100% to crystals as bespoke key materials for the semiconductor industry. The visitors to the exhibition were given a great deal of information on how these are produced and the marvelous properties they have.

But Fraunhofer IISB was not only represented in Erlangen. It presented its research activities also at the Energie Campus Nürnberg (EnCN). This presentation was focused on power electronic systems for the electrical grid of the future. This comprised all areas of energy transmission from modern high-tension DC transmission (HGÜ) to charging systems for electric vehicles. Using experiments and demonstrators for all aspects of power electronics the highly varied nature of this area of research was demonstrated.

PCIM Europe 2013 in Nuremberg – Fraunhofer IISB presents its innovations

From May 14 to 16, 2013 the annual PCIM Europe took place on the Nuremberg Exhibition Grounds. This is an international trade fair and conference for power electronics, intelligent drive technology, renewable energies and energy management. The "Power Electronic Systems" department of Fraunhofer IISB used the fair as an opportunity to display its newest work in the field of power electronics.

The highly interested industry experts were shown among other things highly efficient bidirectional charging equipment and battery modules for electric vehicles, drive solutions for electric vehicles with integrated drive inverters, novel assembly and joining technology like laser-sintered

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power modules and also solutions for DC grids, e.g. the so-called multiport converters. Moreover Fraunhofer IISB presented highly reliable and compact DC converters for applications in aeronautics and medical technology, super small and inductive chargeable battery modules for hearing aids and also technologies for the effective cooling of electronic power switches like double-sided sintered power modules using the sandwich form of construction. The main highlights on the IISB stand were a red electric sports car constructed completely from components developed at IISB and an inductive charging station as well as a demonstrator for the application center for DC grids. Also shown were measurement rigs for reliability tests on high-performance components.

The Fraunhofer IISB stand was well visited and proved to be an excellent platform in particular for the ambitious young scientists of Fraunhofer IISB for making themselves and their innovative developments known to the experts in the field concerned. In addition Fraunhofer IISB was also represented on the joint stand of the European Center for Power Electronics (ECPE), with posters of information for the Bavarian Research Alliance for Electromobility (FORELMO).

International expert meeting IWBNS 2013 discusses technologies and markets for bulk GaN

The market penetration of bulk GaN crystals is continuing. This is the conclusion of an international expert meeting organized by Fraunhofer IISB. More than 70 internationally renowned experts met during the 8th International Workshop on Bulk Nitride Semiconductors (IWBNS) from 30 September to 5 October 2013 at Kloster Seeon in order to discuss the current status and future direction of growing bulk nitride crystals. The workshop was organized by Fraunhofer IISB and enjoyed the patronage of the German Association of Crystal Growth DGKK.

Nitride semiconductors are a strong research focus worldwide, since wide band gap semiconductors such as GaN and AlN have turned out to be the best choice for power electronic and optoelectronic devices with enhanced power efficiency or optical performance. GaN LEDs are increasingly dominating global lighting, and electronic GaN devices are expected to achieve a substantial volume in the market soon. However, one of the key requirements for boosting the market share of nitride devices and helping to develop green technologies is the availability of cheap, high quality native substrates, which is expected to have a great impact on the further development of power electronic systems for high power applications and high brightness LEDs and high power laser diodes.

Fraunhofer IISB has more than a decade of experience in the field of bulk nitride semiconductors and is currently doing research on the HVPE growth of GaN crystals and on the growth of nitrides with the ammonothermal technique. The latter project is being carried out in close collaboration with the University of Erlangen-Nuremberg within the "Ammonothermalsynthesis" research group funded by the German Science Foundation DFG. Part of the research of Fraunhofer IISB additionally focuses on the correlation of the electrical performance of the devices with the quality of the substrates and epitaxial layers. It was therefore a great honor that Dr. Elke Meissner from Fraunhofer IISB was selected by an international steering committee to host the 8th IWBNS workshop.

1 *Group portrait of the participants of the 8th International Workshop on Bulk Nitride Semiconductors (IWBNS) 2013, organised by Fraunhofer IISB at Kloster Seeon in southern Bavaria. Image: James Edgar*

The IWBNS workshop is the only expert meeting in the world that is especially dedicated to the science and technology of the crystal growth of bulk nitrides. On the question of the number of participants, the 8th IWBNS workshop was the largest one ever held. More than seventy renowned international experts from ten nations in Asia, the United States, South America and Europe gathered for the first time in Germany at the beautiful, scenic location of Kloster Seeon in southern Bavaria.

It was an amazing meeting with an extremely high scientific level due to the outstanding contributions of the participants. The workshop covered the crystal growth and technology of GaN, AlN, InN and other binary nitrides. "The quality of the papers was the highest of the five of these meetings I have attended," said James Edgar from Kansas State University. Jan Weyher from the Polish Academy of Science commented, "It was a very stimulating workshop, perfectly organized."

The IWBNS has classic individual scientific spirit, intensity and character. It is designed to implement and increase an intense exchange of information that is as open as possible as well as deep scientific discussion and collaboration among academic, industrial, and government scientists regarding the challenges of growing high quality group III nitride crystals with a low concentration of structural defects and a controlled conductivity type. The highly concentrated program of the 8th IWBNS clearly demonstrated the great necessity for further intensive exchange among experts in this field in order to further promote the penetration of the wide band gap materials into the market for energy efficient LEDs and power devices.

The organizers of the 8th IWBNS workshop gratefully acknowledge the support of several organizations that helped to make the meeting successful and the generous support for the participation of young scientists by the German Association of Crystal Growth DGKK and the International Union of Crystallography IUCR.

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1 *Prof Martin März, Deputy Director of Fraunhofer IISB, has been appointed honorary professor of the University of Erlangen-Nuremberg in 2013. Image: Kurt Fuchs / Fraunhofer IISB.*

Martin März appointed as an honorary professor of the University of Erlangen-Nuremberg

Dr. Martin März, Deputy Director of Fraunhofer IISB in Erlangen has been appointed as an honorary professor of the University of Erlangen-Nuremberg. Martin März has been closely involved for years with education and training at the Friedrich-Alexander-University of Erlangen-Nuremberg (FAU), which since the founding of the Fraunhofer Institute has collaborated closely with the IISB.

In the future the collaboration will be even more intensive. Since 2006 Martin März has been holding lectures regularly on power electronics, automobile electronics and electromobility and in addition supervised numerous items of project work and other work carried out during bachelor degree courses as well as diploma, bachelor's and master's theses. As the responsible person for the BMBF-Fraunhofer young-academic support program for electromobility DRIVE-E, and in the FAU student project TechFak EcoCar and in the practical training for mechatronic systems he also makes a contribution to promoting young scientists and engineers.

Martin März, born 1962, worked after completing his studies of electrical engineering and, later, being awarded a Ph.D., five years in the semiconductor division of Siemens AG, later renamed Infineon Technologies AG. In April 2000 he moved to Fraunhofer-Gesellschaft in order to build up, at IISB, the department "Power Electronic Systems". In the meantime he belonged to the largest department of the Institute and has made an extremely significant contribution to the growth of Fraunhofer IISB. With Martin März as its head, the IISB in Erlangen operates large electronics and design laboratories, a test center for electric vehicles and also an application center for DC grids and highly efficient energy supply solutions. He is also responsible for the branch of the IISB in South Nuremberg, with its emphasis on industrial energy electronics, and the IISB working group at the Energie Campus Nürnberg (EnCN).

With his field of work Martin März is at the forefront of current developments. Modern power electronics is indispensable for the successful launch of electromobility and the conversion of energy supply and also for energy-efficient production plant and household appliances. Power electronic components and systems are used in order to distribute electrical energy and to convert to the form required in each case, e.g. from DC to AC or between the various voltage values. The technological challenge consists of keeping heat losses as low as possible and to work at the highest possible efficiency, thus saving energy. Questions of cost optimization, robustness, safety and reliability play a great role in this context as also do the aspects of cooling and reduction of volume and weight. The importance of mechatronic systems integration is growing, i.e. the

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integration of electronics directly where it is needed. Examples of this are the drive units of electric vehicles.

Martin März collaborates with numerous industry partners. These partners are located above all in the metropolitan region of Nuremberg, which is marked by a high density of power electronics, energy technology and automobile supplier companies. He is a sought after contact for regional and international industrial federations, for example in the Bavarian Cluster on Power Electronics, or the European Center for Power Electronics (ECPE). Furthermore, Martin März is a member of the Steering Committee of, and Priority Area Manager in, the Fraunhofer System Research Group on Electromobility (FSEM) and also Project Leader of the Fraunhofer Innovation Cluster "Electronics for Sustainable Energy Use", coordinated by the IISB. In addition to this, he actively participates in the National Platform for Electromobility and is a member in several scientific advisory boards and specialist committees.

DKT-2013 – Crystal experts from all over Germany as guests in Erlangen

Approximately 150 German experts from the business and academic worlds met from March 6 to 8, 2013 at the German Conference for Crystal Growth (DKT-2013) in order to present and discuss the newest most recent research results in producing crystals and thin crystalline layers with special physical properties. The development of new crystals or crystalline layers enables for example cheaper production and integration of renewable energy, new applications in information and communication technology, or innovative processes in production, inspection and medical technology. DKT-2013 enjoyed the patronage of the German Association for Crystal Growth (DGKK) and was organized jointly by the department of Materials for Electronics and Energy Technology (i-MEET) of the Friedrich-Alexander University Erlangen-Nuremberg and Fraunhofer IISB. At DKT-2013 the DGKK prize and the DGKK prize for young research scientists were awarded.

It was no accident that DKT-2013 was held in Erlangen. Research and development in the area of crystal-growing has a long tradition in the metropolitan region of Nuremberg and especially in Erlangen. Activities in this field commenced in the 1950s, when pioneer work was carried out at the Siemens research laboratory in the field of semiconductor technology. Since the 1970s much excellent scientific and technological work has been carried out on crystal-growing at the Friedrich-Alexander-University Erlangen-Nuremberg in the department for Electrical Engineering Materials of the Institute for Materials Science (currently the department i-MEET). In the 1990s the department "Crystal Growth" was founded at Fraunhofer IISB in order to carry out for German industry applied research in the field of development and optimizing of crystal-growing processes. The university activities led to two start-ups of companies in the metropolitan region which in the meantime are successful on the world market. Furthermore, a great number of international and national research prizes for the crystal experts of Fraunhofer IISB indicate the leading position of the metropolitan region of Nuremberg in the field of crystal-growing research.

1 *Group portrait of the participants of the German Conference for Crystal Growth DKT-2013.*

In addition to the presentation of the most recent research results in crystal-growing the DGKK prize and the DGKK young research scientist prize were awarded at DKT-2013. The DGKK prize was awarded to Professor Alois Krost of Magdeburg University for his outstanding scientific and technical work concerning the epitaxy of gallium nitride (GaN) on silicon. As a result of his pathfinding results it became possible to deposit fissure-free and comparatively defect-free layers with a thickness of a few micrometers on large-area silicon substrates. This was an important condition for the commercialization of the GaN-on-Si technology for LED production and the production of power electronic components. There were two winners of the young research scientist prize. Benjamin Reuters of the RWTH (Rheinland-Westfalian Technical University) Aachen was awarded the prize for his outstanding investigations concerning the production of quaternary nitride mixed crystal layers (AlGaInN). Benjamin Reuters optimized the growth parameters for the epitaxy of quaternary nitride mixed crystal layers (AlGaInN) with respect to layer tension and relaxation. The understanding he achieved of the issues involved is an important condition for designing new, more powerful quaternary component structures. The second winner of the young research scientist prize is Dr. Kaspar Dadzis of the corporation SolarWorld AG in Freiberg. Within the framework of his doctoral thesis – performed in close cooperation with Fraunhofer IISB – Dadzis applied simulation models in order to optimize, under the influence of magnetic fields, the growth conditions for directional crystallization of multicrystalline silicon for photovoltaics. With the understanding he achieved of the issues involved as the starting point, a crystal-growing plant was developed in which his theoretical results could be confirmed. His insights are important conditions for increasing further the crystal yield in the industrial production of silicon and in this way reducing production costs.

Served hot & cold – separating microchips by means of laser beams and water aerosols

Scientists at Fraunhofer IISB in Erlangen and JENOPTIK Automatisierungstechnik GmbH in Jena were awarded the Georg Waeber Innovation Prize 2013 of the Förderkreis für die Mikroelektronik e.V. for developing a novel, laser-based separation process for brittle materials. Among other things the process can be used in semiconductor production for separating integrated circuits. As representative of the support group, Knut Harmsen, head of the Erlangen branch of the Chamber of Industry and Commerce Nuremberg for Central Franconia, presented the award

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to the research team. The awards ceremony took place at the annual conference of Fraunhofer IISB on 21 November 2013. Dr. Matthias Koitzsch, Dirk Lewke and Dr. Martin Schellenberger of Fraunhofer IISB in Erlangen as well as Dr. Hans-Ulrich Zühlke of JENOPTIK Automatisierungstechnik GmbH in Jena developed with the "thermal laser beam separation" (TLS) an innovative process with which brittle materials can be separated in high quality and without any loss of material. The separation procedure is based on guiding a crack by means of thermally induced mechanical tension. At the same time the material surface is heated with a laser and then cooled using an aerosol. Using basic investigations as a starting point for understanding the process, the TLS principle was developed till it was ready for a market launch and implemented in prototype apparatus. The significant advantages of the novel process are the separation procedure without erosion, the high speed and the almost perfect separation edge.

The applications, which were determined during engineering development solely for semiconductor production, are extremely varied. A first area of application for thermal laser beam separation is separating integrated circuits (microchips) on a silicon basis. By means of the TLS a higher packing density was achieved on the semiconductor wafers, for example as a result of the quality of the separation edges, and also a higher breaking strength of the individual chips, which in total leads to a higher yield. In silicon carbide, a semiconductor material with a high potential in power electronics, TLS functions up to a 100 times faster than established separation procedures. Furthermore, TLS enables a subsequent size adaptation of wafers, which is, for example, of interest for research and experimental purposes.

"With the TLS separation process a domestic manufacturer of apparatus has an innovative and competitive technology at his disposal, which in important respects is significantly superior to the established separation processes. TLS has high potential and not only in the semiconductor industry", commented Dr. Martin Schellenberger, who at Fraunhofer IISB is responsible for the scientific planning coordination of apparatus and process development for the TLS separation process and also for widening its fields of application. Dr. Hans-Ulrich Zühlke, on behalf of JENOPTIK Automatisierungstechnik GmbH as project leader with responsibility for specifying the TLS apparatus and for coordinating the development work with Fraunhofer IISB and for the assembly of the first prototype apparatus sums up, "together with our colleagues from IISB we are extremely pleased at being awarded the innovation prize for microelectronics and in the name of all those involved we should like to thank the Förderkreis Mikroelektronik for the recognition of our work. Naturally, as industry partners, we are also pleased at the fact that the application of the TLS process is already being investigated by two renowned semiconductor manufacturers."

1 *The 2013 Microelectronics Innovation Prize awarded by Förderkreis für die Mikroelektronik e.V.: Dirk Lewke, Dr. Matthias Koitzsch, Dr. Martin Schellenberger of Fraunhofer IISB in Erlangen, Dr. Hans-Ulrich Zühlke of Jenoptik Automatisierungstechnik GmbH in Jena, and Knut Harmsen, head of the Erlangen branch of the Nuremberg Chamber of Industry for Central Franconia, at the award ceremony of the Microelectronics Innovation Prize within the framework of the Fraunhofer IISB annual conference of November 21, 2013.*

2 *Dr. Mathias Koitzsch in the Fraunhofer IISB clean-room laboratory with a 200 mm wafer cut out from a 300 mm wafer using thermal laser beam separation (TLS). By means of TLS, precise circular sections can be produced as well.*

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Guest Scientists

Belko, V.
November 19, 2013 – November 29, 2013
Russia
Belarusian State University, Minsk

Di Benedetto, L.
June 05, 2013 – December 10, 2013
Italy
University of Salerno
Junction termination for high voltage SiC diodes

Kangawa, Y.
April 24, 2013 – May 09, 2013
Japan
Kyushu University, Kasuga, Fukuoka
Characterization of AlGaN Crystals produced by solution growth

Li, S.
September 24, 2013 – September 27, 2013
China
Shanghai Institute of Optics and fine mechanics (SIOM)
Chinese Academy of Sciences

Ouennoughi, Z.
June 19, 2013 – July 05,2013
Algeria
University Sètif
Electrical characterization of MOS capacitors with different gate oxide on 4H-SiC

Ozden, B.
July 22, 2013 – July 27, 2013
Turkey
CrysMAS Training

Klunikowa, J.
July 01, 2013 – July 31, 2013
Russia
Southern Federal University, Tagaruag
Theoretical investigation of interaction of SiC particles

Chun
May 27, 2013 – June 14, 2013
Korea

Jung
May 27, 2013 – June 14, 2013
Korea

Rai, D.
July 16, 2013 – August 03, 2013
India

Sakari, S.
September 20, 2013 – October 30, 2013
Finland
Aalto University, Helsinki
Untersuchung der Mikrostruktur von GaN Kristallen

Veerapandian, S.
September 20, 2013 – November 30, 2013
India

Xia, C.
October 20, 2013 – October 19, 2014
China
Shanghai University
Ladungskompensationsbauelement in SiC

Xu, D.
March 1, 2013 – April 4, 2015
China
Shanghai Institute of Optics and fin Mechanics (SIOM)
Chinese Academy of Sciences

Patents

Burenkov, A.:
An interconnection network between semiconductor structures, integrated circuit and method for transmitting signals
5328144

Kampen, C.; Burenkov, A.:
Electric contacting of semiconductor components having low contact resistance
US 8,513, 714 B2

Knörr, M.; Schletz, A.:
Verfahren zum stoffschlüssigen Verbinden von elektronischen Bauelementen oder Kontaktelementen und Substraten
DE 10 2010 013 610 B4

Lorentz, V.; Berberich, S.; März, M.:
Apaparatus and method for sensing a current within a coil
US 8,498,089 B2

März, M.; Ryssel, H.; Pettinger, K.-H.; Heuberger, A.:
Energiespeichervorrichtung
DE 102 93 585 B4

Ryssel, H.; März, M.:
Bekleidungsstück mit induktiver Energieübertragung sowie induktive Verbindung
EP 2 133 890 B1

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Continuation: Patents

Tobisch, A.; Schellenberger, M.; Mattes, A.:
Verfahren und Vorrichtung zur ortsaufgelösten Neigungsmessung einer spiegelnden Oberfläche durch Beleuchtung mit einer Farbstruktur
DE 10 2012 025 551 B3

v. Dorp, J.; Erlbacher, T.; Frey, L.:
Elektrisches Überbrückungselement, insbesondere für Speicherzellen eines Energiespeichers
DE 10 2012 005 979 B4

Zenkner, A.; Billmann, M.; Malipaard, D.; Blösch, C.:
Leistungshalbleitermodul mit schichtweise aufgebauten isolierenden Seitenwänden
RU 2492548 C2

Participation in Committees

Bauer, A.J.
- Koordinator der VDE / VDI – Fachgruppe 1.2.4 „Heißprozesse“

Erdmann, A.
- Member of the Program Committee of the „Micro- and Nanoengineering Conference Europe (MNE) 2012“, Lyon, FRA, September 2012
- Member of the Program Committee of SPIE Advanced Lithography, San José, CA, USA, February 2012
- Co-Chair of the SPIE Optical Design Conference Europe, Barcelona, ESP, November 2012

Frey, L.
- Mitglied der Studienkommission Elektrotechnik, Elektronik und Informationstechnik
- Mitglied der Deutschen Physikalischen Gesellschaft
- Mitglied der Böhmischen Physikalischen Gesellschaft
- Member of the Excellence Cluster „Engineering of Advanced Materials“ (EAM) der Universität Erlangen-Nürnberg
- Mitglied der Erlangen Graduate School in Advanced Optical Technologies (SAOT)
- Mitglied des wissenschaftlichen Beirats des Leibnitz-Instituts für Innovative Mikroelektronik IHP Frankfurt/Oder
- Member of the Evaluation Panel (NT-L) of the Swedish Research Council
- Representative of the Fraunhofer Gesellschaft / Microelectronics Alliance at the European Semiconductor Industry Association (ESIA)
- Nationale Plattform Elektromobilität, AG1
- Wissenschaftlicher Beirat der NaMLab GmbH in Dresden
- Advisory Board, Res. Inst. for Tech. Phys. and Matl. Sci. (MFA), Budapest, HUN
- Kerngutachter in der Auswahlkommission „Kooperative Projekte“ der Fraunhofer Gesellschaft mit dem Max-Planck-Institut
- Wissenschaftlicher Beirat der Gesellschaft für Mikro- und Nanoelektronik GMe, Vienna, AUT

Friedrich, J.
- President der Deutschen Gesellschaft für Kristallwachstum und Kristallzüchtung e.V. (DGKK)
- Mitvorsitzender des DGKK-Arbeitskreises „Herstellung und Charakterisierung massiver Halbleiter“
- Councilor in the Executive Committee of the International Organization of Crystal Growth (IOCG)
- Program Co-Chair of the „International Conference on Crystal Growing“ (ICCG-17), Warsaw, POL
- Advisory Committee of International Workshop on Crystalline Silicon for Solar Cells
- Advisory Committee of International Workshop on Modeling of Crystal Growth
- Reviewer for Journal of Crystal Growth, Applied Physical Letters
- Co-Chair of 1st International Freiberg Conference on Electrochemical Storage Materials, ESTORM2013, Freiberg

Häublein, V.
- Mitglied der GMM-Fachgrppe 1.2.2
- Mitglied der ITG-Fachgruppe 8.1.1 „Ionenimplantation“

Jank, M.P.M.
- Working group on nanomaterials – European Semiconductor Industry Association (ESIA)
- VDE GMM Fachausschuss Gesamtprozesse (1.3) – Schwerpunkt Materialien für nichtflüchtige Speicher (1.3.6)
- Exzellenzcluster Engineering of Advanced Materials an der FAU Erlangen-Nürnberg
- Gutachter im Peer-Review-Verfahren für IEEE Electron Device Letters, Materials Chemistry and Physics, Miecroelectronic Engineering
- Mitglied Prüfungskommittee in einem Promotionsverfahren an der Universität Dunarea de Jos, Galati (Rumänien)

Leisegang, T.
- Anzeigenredakteur der Mitgliederzeitschrift „Mitteilungen“ der Deutschen Gesellschaft für Kristallographie e.V.
- Member of the organizing commitee of 21. Jahrestagung der Deutschen Gesellschaft für Kristallographie, Freiberg, March 19 – 22, 2013
- Chairmen of microsymposium „Along the Innovation Chain – from Minerals and Crystals via Natural Sciences to Functional Materials“ of 21. Jahrestagung der Deutschen Gesellschaft für Kristallographie, Freiberg, March 19 – 22, 2013

Content

Continuation: Participation in Committees

- Member of the organizing commitee of 1st International Freiberg Conference on Electrochemical Storage Materials, ESTORM2013, Freiberg, June 3 – 4, 2013
- Reviewer for Journal of Crystal Research and Technology and physica status solidi

Lorenz, J.
- Chairman of the Modeling and Simulation International Working Group (ITWG) of the ITRS (International Technology Roadmap for Semiconductors)
- Member of the Electrochemical Society
- Member of the Institute of Electrical and Electronics Engineers (IEEE)
- Member of the Technical Program Committee, SISPAD 2013, 3. – 5. September 2013, Glasgow, UK
- Member of the Technical Program Committee, ESSDERC 2013, 16. – 20. September 2013, Bucharest, Romania

März, M.
- Wissenschaftlicher Beirat „Bayerisches Cluster Leistungselektronik“
- Wissenschaftlicher Beirat „Conference on Integrated Power Systems“ (CIPS)
- Wissenschaftlicher Beirat „Conference on Power Conversion and Intelligent Motion“ (PCIM)
- Fachbeirat im „Forum Elektromobilität e.V.“
- DRIVE-E Akademie, Gutachterkreis und Programmkomitee

Meißner, E.
- Member of the International Steering Committee „International Workshop on Bulk Nitride Semiconductors“
- Member of the Publication Committee of the International Workshop on Bulk Nitride Semiconductors
- Chair, International Workshop on Bulk Nitride Semiconductors-VIII, Kloster Seeon, Germany 2013
- Co-Chair of the „International Summer School of Crystal Growth“ (ISSCG-15), Gdansk, Poland 2013
- Reviewer for Journal of Crystal Growth and Materials Chemistry and Physics

Pfeffer, M.
- Member of the „Factory Integration Working Group“ (FITWG) of the „International Technology Roadmap for Semiconductors“ (ITRS)
- Member of Semicon Europe Semiconductor Technology Programs Committee (STC)

Pfitzner, L.
- Honorarprofessor an der Universität Erlangen-Nürnberg, Fachbereich Elektrotechnik
- Chair of IPWGN Face-to-Face Meeting at ITRS Summer Meeting, Monterey,California, July 8
- Chairman of the Executive Committee and of the 4th International Conference on „450 mm – Status and Overview“ 2012, Dresden, Germany, October 9 – 10
- Member of the Program Committee ISSM 2012 (IEEE „International Symposium on Semiconductor Manufacturing“), Tokyo, Japan, October 15 – 17
- Chairman of the „Yield Enhancement Working Group“ (ITWG) of the ITRS (International Technology Roadmap for Semiconductors) Conference 2012, Tokyo, Japan, December 3 – 4
- Mitglied der VDE/VDI-Gesellschaft für Mikroelektronik, Mikro- und Feinwerktechnik, Fachbereich „Halbleitertechnologie und Halbleiterfertigung“, Leiter des Fachausschusses „Produktion und Fertigungsgeräte“
- Mitglied der VDE/VDI-Gesellschaft für Mikroelektronik, Mikro- und Feinwerktechnik, Fachbereich „Halbleitertechnologie und Halbleiterfertigung“, Leiter des Fachausschusses 1.1 „Geräte und Materialien“
- Co-Chair of the SEMI Task Force „Environmental Contamination Control“
- Co-Chair of the Standardization Committee „Equipment Automation Standards Committee“ of SEMI
- Member of the „Global Coordination Committee“ of SEMI
- Member of the „European Planning Group for 450 mm Technology“ (EEMI450)
- Mitglied des Strategischen Beirats des österreichischen Bundesministeriums für Verkehr, Innovation und Technologie (BMVIT) für die Initiative „Intelligente Produktion“

Pichler, P.
- Board of Delegates der European Materials Research Society

Roeder, G.
- Koordinator der VDE/VDI-GMM-Fachgruppe 1.2.3 „Abscheide- und Ätzverfahren“

Rommel, M.
- Koordinator der VDE/VDI-GMM-Fachgruppe 1.2.6 „Prozesskontrolle, Inspektion & Analytik“

Ryssel, H.
- International Committee of the Conference „Ion Implantation Technology“ (IIT). The conference takes place biannually alternatingly in Europe, the USA, and East Asia.
- Mitglied der Informationstechnischen Gesellschaft (ITG): Leiter des Fachausschusses 8.1 „Festkörpertechnologie“
- Mitglied der VDE/VDI Gesellschaft für Mikroelektronik, Mikro- und Feinwerktechnik (GMM)
- Leiter des Fachbereichs 1, „Mikro- und Nanoelektronik-Herstellung“, Leiter der Fachgruppe 1.2.2 „Ionenimplantation“
- Mitglied des Beirats der Bayerischen Kooperationsinitiative Elektronik / Mikrotechnologie (Bayerisches Staatsministerium für Wirtschaft, Verkehr und Technologie)
- Mitglied der Böhmischen Physikalischen Gesellschaft
- Life Fellow of the Institute of Electrical and Electronics Engineers (IEEE)

Content

Continuation: Participation in Committees

- Editorial Board of „Radiation Effects and Defects in Solids" Taylor & Francis Ltd., Abingdon, U.K.
- Member of the European SEMI Award Committee

Schellenberger, M.
- Leiter der europäischen SEMI PCS-Taskforce
- Mitglied im Programmkomitee der europäischen APCM-Konferenz
- Moderator im VDE/VDI-GMM-Fachausschuss 1.1 „Produktion und Fertigungsgeräte"

Smazinka, T.
- Mitarbeit im Normungsgremium der DKE / UK 767.3 – Hochfrequente Störgrößen
- Mitarbeit im Normungsgremium der DKE / GAK 767.13.18 – Elektromagnetische Verträglichkeit, Fahrzeuge – EMV Elektromobilität
- Mitglied im Arbeitskreis Elektromagnetische Verträglichkeit EMV des VDE-Bezirksverein Nordbayern e.V.

Conferences, Workshops, Fairs, and Exhibitions

Cluster NanoMAT – Sprechertreffen
Karlsruhe, GER, January 14, 2013

Catrene Workshop on: Power Devices Enabling Higher Energy Efficiency
Paris, FRA, January 22, 2013

Leistungselektronik-Kolloquium des Fraunhofer Innovationsclusters „Elektronik für nachhaltige Energienutzung"
Erlangen, GER, February 18, 2013
Extreme Ultraviolet (EUV) Lithography IV
San Jose, CA, USA, February 24 – 28, 2013

Optical Microlithography XXVI
San Jose CA, USA, February 26 – 28, 2013

Junge Deutsche Gesellschaft für Kristallzüchtung und Kristallwachstum (jDGKK-Seminar)
Erlangen, GER, March 5, 2013

Kurzlehrgang „Etablierte und fortgeschrittene Verfahren in der Druck- und Beschichtungstechnik" des Lehrstuhls für Strömungsmechanik (LSTM) der FAU Erlangen-Nürnberg
Erlangen, GER, March 4 – 7, 2013

DRIVE-E Akademie
Dresden, GER, March 4 – 8, 2013

German Conference of Crystal Growth (DKT2013)
Erlangen, GER, March 6 – 8, 2013

Successful Research & Innovation in Europe
Düsseldorf, GER, March 8, 2013

Viscom Technologieforum,
Hannover, GER, March 13 – 14, 2013

China Semiconductor Technology International Conference (CSTIC)
Shanghai, CHN, March 17 – 18, 2013

OTTI-Profiseminar Frequenzumrichter
Regensburg, GER, March 18, 2013

Jahrestagung der Deutschen Gesellschaft für Kristallographie (DGK2013)
Freiberg, GER, March 19 – 22, 2013

FCMN 2013
Gaithersburg, MD, USA, March 25 – 28, 2013

Kraftfahrzeugleistungselektronik
Friedrich-Alexander-University Erlangen-Nuremberg,
Summer Semester 2013

Cluster-Schulung, Cluster Leistungselektronik
Erlangen, GER, April 9, 2013

33. Treffen der Nutzergruppe Heißprozesse und RTP, Fraunhofer IISB
Erlangen, GER, April 10, 2013

Ionenimplantation Nutzertreffen
Erlangen, GER, April 11, 2013

International Conference on Thermal, Mechanical and Multi-Physics Simulation and Experiments in Microelectronics and Microsystems (EuroSimE)
Wroclaw, POL, April 14 – 17, 2013

13th European Advanced Process Control and Manufacturing Conference
Dresden, GER, April 15 – 17, 2013

ECPE Research, ECPE Network Symposium
Nuremberg, GER, April 18, 2013
Open Lecture FH Wiener Neustadt
Wien, AUT, April 18, 2013

Gemeinsames Kolloquium zur Halbleitertechnologie und Messtechnik
Erlangen, GER, April 22, 2013

Technical Conference – Electric & Electronic Systems in Hybrid and Electric Vehicles and Electrical Energy Management
Bamberg, GER, April 23 – 24

Smart sensors, actuators and MEMS VI
Grenoble, FRA, April 24 – 26, 2013

FutureCar Network
Kassel, GER, April 25, 2013

BMBF Workshop Leistungselektronik
Nuremberg, GER, May 13, 2013

Conference on Modeling Aspects in Optical Metrology
Munich, GER, May 13 – 14, 2013

rbz-Kolloquium, Robert Bosch Zentrum für Leistungselektronik
Reutlingen, GER, May 14, 2013

Content

Continuation: Conferences, Workshops, Fairs, and Exhibitions

Advanced Semiconductor Manufacturing Conference (ASMC)
Saratoga Springs, NY, USA, May 14 – 16, 2013

PCIM Europe
Nuremberg, GER, May 14 – 16, 2013

POINTS Spring School
Strasbourg, FRA, May 26, 2013

European Materials Research Society (Spring Meeting)
Strasbourg, FRA, May 27 – 31, 2013

International Conference on Electron, Ion, and Photon Beam Technology and Nanofabrication (EIPBN)
Nashville, TN, USA, May 28 – 31, 2013

Nanoforum 2013
Linz, AUT, May 30 – 31, 2013

Bescheidübergabe SEEDs
Erlangen, GER, June 7, 2013

International SiC Power Electronics Applications Workshop (ISiCPEAW)
Stockholm, SWE, June 9 – 11, 2013

Kolloquium zur Halbleitertechnologie und Messtechnik
Erlangen, GER, June 17, 2013

15. FET-Treffen des Bayerischen Clusters Druck und Printmedien
Ismaning, GER, June 19, 2013

ACUM2013
Mannheim,GER, June 19 – 21, 2013

2nd Annual World Congress of Emerging InfoTech-2013
Dalian, CHN, June 20 – 22, 2013

Bewegung Zukunft – eMobilität begreifen
Nuremberg, GER, June 19, 2013

Conference on Ph.D. Research in Microelectronics and Electronics (PRIME)
Villach, AUT, June 24 – 27, 2013

Conference of „Insulating Films on Semiconductors“ (INFOS)
Cracow, POL, June 25 – 28, 2013

ECPE Tutorial on Thermal Engineering
Erlangen, GER, June 27, 2013

ECPE Workshop Lifetime Modeling and Simulation
Düsseldorf, GER, July 3 – 4, 2013

Fraunhofertag „Mikroverkapselung und Partikelanwendungen“
Munich, GER, July 4, 2013

19th American Conference on Crystal Growth and Epitaxy
Keystone, CO, USA, July 21 – 26, 2013

15th International Summer School on Crystal Growth (ISSCG-15)
Gdansk, POL, August 4 – 10, 2013

17th International Conference on Crystal Growth and Epitaxy (ICCGE-17)
Warsaw, POL, August 11 – 16, 2013

European Aerosol Conference 2013
Prague, CZ, September 1 – 6, 2013

18th International Conference on Simulation of Semiconductor Processes and Devices, SISPAD
Glasgow, GBR, September 3 – 5, 2013

International Conference on Nanoscience and Technology (ICN+T 2013)
Paris, FRA, September 9 – 13, 2013

Anwendungen in der Mobilität
September 10, 2013

Vortragsreihe EnCN
Nuremberg, GER, September 11, 2013

International Conference on Micro and Nano Engineering (MNE)
London, GBR, September 16 – 19, 2013

43rd European Solid-State Device Research Conference (ESSDERC 2013)
Bucharest, ROM, September 16 – 20, 2013

International Workshop on Polycrystalline Growth of Si
Karlsruhe, GER, September 19 – 20, 2013

International Conference on Gettering and Defect Engineering in Semiconductor Technology (GADEST) 15
Oxford, GBR, September 22 – 27, 2013

Fachtagung Zuverlässigkeit und Entwurf
Dresden, GER, September 24 – 26, 2013

19th International Workshop on Thermal Investigations of ICs and Systems, THERMINIC 2013
Berlin, GER, September 25 – 27, 2013

11th Fraunhofer IISB Lithography Simulation Workshop
Hersbruck, GER, September 26 – 28, 2013

15th International Conference on Silicon Carbide and Related Materials (ICSCRM)
Miyazaki, JPN, September 29 – October 4, 2013

Architekturen und Systemtechnik für Elektromobilität
Friedrich-Alexander-University Erlangen-Nuremberg, Winter Semester 2012/2013

Cluster-Schulung Ansteuer- und Schutzschaltungen, Cluster Leistungselektronik
Erlangen, GER, October 1, 2013

European Symposium on Reliability of Electron Devices, Failure Physics and Analysis (ESREF) Arcachon. FRA, September 30 – October 4, 2013

Fab Manager Forum
Dresden, GER, October 8, 2013

SEMICON Europa 2013, 450 mm Conference
Dresden, GER, October 8 – 10, 2013

Kuratoriumssitzung
Erlangen, GER, October 10, 2013

Content

Continuation: Conferences, Workshops, Fairs, and Exhibitions

5. Mikrosystemtechnik-Kongress
Aachen, GER, October 14 – 16, 2013

5. Int. Kongress für Elektro- und Hybrid-Mobilität (eCarTec)
Munich, GER, October 16, 2013

DGKK Arbeitskreis – Herstellung und Charakterisierung von massiven Halbleiterkristallen
Erlangen, GER, October 16, 2013

Kooperationsforum Leistungselektronik
Nuremberg, GER, October 21, 2013

12th International Conference on Nanoimprint and Nanoprint Technology (NNT)
Barcelona, ESP, October 21 – 23, 2013

7th International Workshop on Crystalline Silicon Solar Cells (CSSC7)
Fukuoka, JPN, October 22 – 25, 2013

273. PTB-Seminar VUV and EUV Metrology
Berlin, GER, October 24 – 25, 2013

Electrochemical Society (ECS Meeting)
San Francisco, CA, USA, October 28 – 31, 2013

3rd International Electric Drives Production Conference (EDPC)
Nuremberg, GER, October 29 - 30, 2013

Workshop Schaltungstechnik für GaN-Bauelemente in der Leistungselektronik
Berlin, GER, November 4, 2013

50. Treffen der Nutzergruppe Ionenimplantation
Frankfurt/Oder, GER, November 7, 2013

IECON 2013
Vienna, AUT, November 10 – 13, 2013

ECPE Workshop Power Electronics Packaging
Baden-Dättwil, SUI, November 12 – 13, 2013

Energie Manager Seminar
Nuremberg, GER, November 18, 2013

Leistungselektronik-Kolloquium des Fraunhofer Innovations-clusters „Elektronik für nachhaltige Energienutzung“
Erlangen, GER, November 18, 2013

Fraunhofer Jahrestagung: Bauelemente für die Energieelektronik, Fraunhofer IISB
Erlangen, GER, November 21, 2013

1st Review Meeting of the EC project SUPERTHEME
Glasgow, UK, November 27, 2013

EU Brokerage Event on Kets in Horizon 2020
Strasbourg, FRA, November 29, 2013

Fachausschuss „Verfahrenstechnik“ der Deutschen Keramischen Gesellschaft (DKG)
Erlangen, GER, December 3, 2013

Instituts-Kolloquium des Robert Bosch Zentrum für Leistungselektronik - Integrierte Schaltungstechnik - Hochschule Reutlingen
Reutlingen, GER, December 3, 2013

1st STEEP Winter School
Leissigen, SUI, December 9 – 11, 2013

Workshop, GMM-Fachgruppe 1.2.3 (Abscheide- und Ätzverfahren)
Erlangen, GER, December 11, 2013

1st STEEP Industrial Day
Leissigen, SUI, December 12, 2013

Cluster Praxiskurs
Nurember. December 12, 2013

European-Indian Winter Academy
Guwahati, IND, December 13, 2013

Publications

Adelmann, B.; Hürner, A.; Schlegel, T.; Bauer, A.J.; Frey, L.; Hellmann, R.:
Laser alloying nickel on 4H-silicon carbide substrate to generate ohmic contacts
Journal of Laser Micro/Nanoengineering. Online journal 8, 1, 97-101, 2013
http://www.jlps.gr.jp/jlmn/index.php?action=laser archive vol
DOI: 10.2961/jlmn.2013.01.0019

Badr, E.; Pichler, P.; Schmidt, G.:
Extended model for platinum diffusion in silicon
Proceedings of the 9th Conference on Ph.D. Research in Microelectronics and Electronics PRIME 2013
New York, NY: IEEE, 253-256, 2013
DOI: 10.1109/PRIME.2013.6603162

Banzhaf,C.T.; Grieb,M.; Trautmann, A.; Bauer, A.J.; Frey, L.:
Characterization of Diverse Gate Oxides on 4H-SiC 3D Trench-MOS Structures
Materials Science Forum 740-742, 691, 2013
DOI: 10.4028/www.scientific.net/MSF.740-742.691

Banzhaf, C.T.; Grieb, M.; Trautmann, A.; Bauer, A.J.; Frey, L.:
Influence of Diverse Post-Trench Processes on the Electrical Performance of 4H-SiC MOS Structures
Materials Science Forum 778-780, 595, 2013
DOI: 10.4028/www.scientific.net/MSF.778-780.595

Content

Continuation: Publications

Banzhaf, C.T.; Grieb, M.; Trautmann, A.; Bauer, A.J.; Frey, L.:
Investigation of Trenched and High Temperature Annealed 4H-SiC
Materials Science Forum 778-780, 742, 2013
DOI: 10.4028/www.scientific.net/MSF.778-780.742

Baum, M.; Polster, S.; Jank, M.P.M.; Alexeev, I.; Frey, L.; Schmidt, M.:
Laser melting of nanoparticulate transparent conductive oxide thin films
Journal of Laser Micro/Nanoengineering. Online journal 8, 2, 144-148, 2013
DOI: 10.2961/jlmn.2013.02.0005

Dadzis, K.; Niemietz, K.; Pätzold, O.; Wunderwald, U.; Friedrich, J.:
Non-isothermal model experiments and numerical simulations for directional solidification of multicrystalline silicon in a traveling magnetic field
Journal of Crystal Growth 372, 145-156, 2013
DOI: 10.1016/j.jcrysgro.2013.02.030

Dadzis, K.; Vizman, D.; Friedrich, J.:
Unsteady coupled 3D calculations of melt flow, interface shape, and species transport for directional solidification of silicon in a traveling magnetic field
Journal of Crystal Growth 367, 77-87, 2013
DOI: 10.1016/j.jcrysgro.2012.12.135

Evanschitzky, P.; Shao, F.; Erdmann, A.:
Efficient simulation of extreme ultraviolet multilayer defects with rigorous data base approach
Journal of micro/nanolithography, MEMS and MOEMS 12, 2, Art. 021005, 12, 2013
DOI: 10.1117/1.JMM.12.2.021005

Fader, R.; Schömbs, U.; Verschuuren, M.:
Alignment Accuracy in a MA/BA8 GEN3 Using Substrate Conformal Imprint Lithography (SCIL),
SUSS Reports 1 / 2013, 2013

Fader, R.; Landwehr, J.; Rumler, M.; Rommel, M.; Bauer, A.J.; Frey, L.; Völkel, R.; Brehm, M.; Kraft, A.:
Functional epoxy polymer for direct nano-imprinting of micro-optical elements
Microelectronic engineering 110, 90-93, 2013
DOI: 10.1016/j.mee.2013.02.030

Fader, R.; Rommel, M.; Bauer, A.J.; Rumler, M.; Frey, L.; Verschuuren, M.A.; Laar, R.v.d.; Ji, R.; Schömbs, U.:
Accuracy of wafer level alignment with substrate conformal imprint lithography
Journal of vacuum science and technology B. Microelectronics and nanometer structures 31, 6, Art. 06FB02, 5, 2013
DOI: 10.1116/1.4824696

Fader, R.; Rumler, M.; Rommel, M.; Bauer, A.J.; Frey, L.; Brehm, M.; Kraft, A.; Reboud, V.; Landis, S.:
Life time of flexible PDMS stamps for UV-enhanced substrate conformal imprint lithography (SCIL)
International Conference on Micro and Nano Engineering (MNE), 2013

Filimon, R.; Grosch, J.; Teuber, E.; Jank, M.; Lorentz, V.; Wenger, M.; Giegerich, M.; März, M.; Frey, L.:
Innovative balancing, heating and temperature sensing element for automotive batteries
Electric & Electronic Systems in Hybrid Electric Vehicles and Electrical Energy Management – Technical Conference, Haus der Technik, Bamberg, 2013

Filimon, R.; Grosch, J.; Teuber, E.; Jank, M.; Lorentz, V.; Wenger, M.; Giegerich, M.; März, M.; Frey, L.:
Innovative balancing, heating and temperature sensing element for automotive batteries
Electric & Electronic Systems in Hybrid Electric Vehicles and Electrical Energy Management – Poster Presentation, Technical Conference, Haus der Technik
Bamberg, GER, April 23 – 24, 2013

Fisicaro, G.; Huet, K.; Negru, R.; Hackenberg, M.; Pichler, P.; Taleb, N.; La Magna, A.:
Anomalous impurity segregation and local bonding fluctuation in l-Si
Physical review letters 110, 11, Art. 117801, 5, 2013
DOI: 10.1103/PhysRevLett.110.117801

Fisicaro, G.; Pelaz, L.; Aboy, M.; Lopez, P.; Italia, M.; Huet, K.; Cristiano, F.;Essa, Z.; Yang, Q.; Bedel-Pereira, E.; Hackenberg, M.; Pichler, P.; Quillec, M.; Taleb, N.; La Magna, A.:
Dopant Dynamics and Defects Evolution in Implanted Silicon under Laser Irradiations: A Coupled Continuum and Kinetic Monte Carlo Approach
International Conference on Simulation of Semiconductor Processes and Devices SISPAD 2013, 33-36, Piscataway: IEEE, 2013
DOI: 10.1109/SISPAD.2013.6650567

Content

Continuation: Publications

Friedrich, J.; Stockmeier, L.; Müller, G.:
Constitutional supercooling in Czochralski growth of heavily doped silicon crystals
Acta physica Polonica. A, General physics, physics of condensed matter, optics and quantum electronics, atomic and molecular physics, applied physics 124, 2, 219-226, 2013
DOI: 10.12693/APhysPolA.124.219

Giegerich, M.; Koffel, S.; Filimon, R.; Grosch, J.L.; Fühner, T.; Wenger, M.M.; Gepp, M.; Lorentz, V.R.H.:
Electrothermal Modeling and Characterization of High Capacity Lithium-Ion Battery Systems for Mobile and Stationary Applications
IECON, 2013

Hackenberg, M.; Pichler, P.; Baudot, S.; Essa, Z.; Gro-Jean, M.; Tavernier, C.; Schamm-Chardon, S.:
Influence of La on the electrical properties of HfSiON: From diffusion to Vth shifts
Microelectronic engineering 109, 200-203, 2013
DOI: 10.1016/j.mee.2013.03.071

Hackenberg, M.; Rommel, M.; Rumler, M.; Lorenz, J.; Pichler, P.; Huet, K.; Negru, R.; Fisicaro, G.; La Magna, A.; Taleb, N.; Quillec, M.:
Melt Depth and Time Variations during Pulsed Laser Thermal Annealing with One and More Pulses
ESSDERC 2013, Piscataway: IEEE, 214-217, 2013

Häublein, V.; Temmel, G.; Mitlehner, H.; Rattmann, G.; Strenger, C.; Hürner, A.; Bauer, A.J.; Ryssel, H.; Frey, L.:
Comparative Study of n-LIGBT and n-LDMOS structures on 4H-SiC
Materials Science Forum 740-742, 887, 2013
DOI: 10.4028/www.scientific.net/MSF.740-742.887

Holfelder, I.; Beckhoff, B.; Fliegauf, R.; Honicke, P.; Nutsch, A.; Petrik, P.; Roeder, G.; Weser, J.:
Complementary methodologies for thin film characterization in one tool - A novel instrument for 450 mm wafers
Journal of analytical atomic spectrometry 28, 4, 549-557, 2013
DOI: 10.1039/c3ja30324a

Hürner, A.; Schlegl, T.; Adelmann, B.; Mitlehner, H.; Hellmann, R.; Bauer, A.J.; Frey, L.:
Alloying of Ohmic Contacts to n-type 4H-SiC via Laser Irradiation
Materials Science Forum 740-742 (2013) 773
DOI: 10.4028/www.scientific.net/MSF.740-742.773

Hürner, A.; Bonse, C.; Kallinger, B.; Mitlehner, H.; Erlbacher, T.; Häublein, V.; Bauer, A.J.; Frey, L.:
Temperature and Electrical Field Dependence of Ambipolar Mobility in n-Doped 4H-SiC
Materials Science Forum 778-780, 487, 2013
DOI: 10.4028/www.scientific.net/MSF.778-780.487

Hutzler, A.; Schletz, A.:
Statistical analysis of power cycling data
PCIM, 2013

Hutzler, A.; Schletz, A.; Tokarski, A.:
Extending the power cycling lifetime of SiC diodes (by increased cooling temperatures)
International SiC Power Electronics Applications Workshop (ISiCPEAW), 2013

Hutzler, A.; Tokarski, A.; Schletz, A.:
Extending the lifetime of power electronic assemblies by increased cooling temperatures
Microelectronics reliability 53, 9-11, 1774-1777
DOI: 10.1016/j.microrel.2013.07.029

Iglesias, V.; Martin-Martinez, J.; Porti, M.; Rodriguez, R.; Nafira, M.; Aymerich, X.; Erlbacher, T.; Rommel, M.; Murakami, K.; Bauer, A.J.; Frey, L.; Bersuker, G.:
Bimodal CAFM TDDB distributions in polycrystalline HfO2 gate stacks: The role of the interfacial layer and grain boundaries
Microelectronic engineering 109, 129-132, 2013
DOI: 10.1016/j.mee.2013.03.022

Joffe, C.; Ditze, S.; Rosskopf, A.:
A Novel Positioning Tolerant Inductive Power Transfer System,
ETEV, 2013

Jung, T.; Seebeck, J.; Friedrich, J.:
Combined global 2D-local 3D modeling of the industrial Czochralski silicon crystal growth process
Journal of Crystal Growth 368, 72-80,2013
DOI: 10.1016/j.jcrysgro.2013.01.026

Content

Continuation: Publications

Kallinger, B.; Berwian, P.; Friedrich, J.; Thomas, B.:
Step-controlled homoepitaxial growth of 4H-SiC on vicinal substrates
Journal of Crystal Growth 381, 127-133, 2013
DOI: 10.1016/j.jcrysgro.2013.07.024

Kallinger, B.; Berwian, P.; Friedrich, J.; Azizi, M.; Rommel, M.; Hecht, C.; Friedrichs, P.:
Influence of epilayer thickness and structural defects on the minority carrier lifetime in 4H-SiC
Clausthal-Zellerfeld: Trans Tech Publications, (Materials Science Forum 740/742), 633-636, 2013
DOI: 10.4028/www.scientific.net/MSF.740-742.633

Kallinger, B.; Berwian, P.; Friedrich, J.; Hecht, C.; Peters, D.; Friedrichs, P.; Thomas, B.:
SXRT investigations on electrically stressed 4H-SiC PiN diodes for 6.5 kV
Clausthal-Zellerfeld: Trans Tech Publications, (Materials Science Forum 740/742), 899-902, 2013
DOI: 10.4028/www.scientific.net/MSF.740-742.899

Kallinger, B.; Polster, S.; Berwian, P.; Friedrich, J.; Danilewsky, A.N.:
Experimental verification of the model by Klapper for 4H-SiC homoepitaxy on vicinal substrates
Journal of applied physics 114, 18, Art. 183507, 9, 2013
DOI: 10.1063/1.4829707

Kallinger, B.; Berwian, P.; Friedrich, J.; Rommel, M.; Azizi, M.; Hecht, C.; Friedrichs, P.:
Influence of Epilayer Thickness and Structural Defects on the Minority Carrier Lifetime in 4H-SiC,
Materials Science Forum 740-742, 633-636, 2013
Silicon Carbide and Related Materials 2012

Karzel, P.; Ackermann, M.; Gröner, L.; Reimann, C.; Zschorsch, M.; Meyer, S.; Hahn, G.:
Dependence of POCl3 Gettering and Hydrogen Passivation Efficacy on Grain Boundary Type in multicrystalline Silicon
Proceedings of 28th European Photovoltaic Solar Energy Conference and Exhibition, Paris, September 30 – October 4, 895-901, 2013

Kazantsev, D.; Ryssel, H.:
Apertureless SNOM imaging of the surface phonon polariton waves: What do we measure?,
Applied Physics A, Springer Berlin Heidelberg, 113, 27-30, 2013
DOI: 10.1007/s00339-013-7869-y

Kazantsev, D.V.; Ryssel, H.:
Scanning Head for the Apertureless near Field Optical Microscope,
Modern Instrumentation, 2, 33-40, 2013
DOI: 10.4236/mi.2013.22006

Kölpin, N.; Wegener, M.; Teuber, E.; Polster, S.; Frey, L.; Roosen, A.:
Conceptional design of nano-particulate ITO inks for inkjet printing of electron devices
Journal of Materials Science : JMS 48, 4, 1623-1631, 2013
DOI: 10.1007/s10853-012-6919-8

Lorenz, J.:
Technology Computer Aided Design
State-of-the-Art Electron Devices (ed. J. N. Burghartz), John Wiley & Sons Ltd, 97, 2013
ISBN 978-1-118-34726-3

März, M.; Eilers, D.; Gillner, A.; Schliwinski, H.-J.; Schneider-Ramelow, M.; Schubert, T.; Partsch, U.; Paschen, U.; Wilken, R.:
Leistungselektronik und elektronische Antriebstechnik
Buller, Ulrich; Hanselka, Holger; Fraunhofer Verbundprojekt Systemforschung Elektromobilität:
Fraunhofer-Systemforschung Elektromobilität. Aspekte der Fraunhofer-Systemforschung
Stuttgart: Fraunhofer Verlag, 34-41, 2013
ISBN: 3-8396-0410-9
ISBN: 978-3-8396-0410-6

Mortet, V.; Bedel-Pereira, E.; Bobo, J.F.; Cristiano, F.; Strenger, C.; Uhnevionak, V.; Burenkov, A.; Bauer, A.J.:
Hall effect characterization of 4H-SiC MOSFETs: Influence of nitrogen channel implantation
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Jauß, T.; Cröll, A.; Sorgenfrei,T.; Azizi, M.; Reimann, C.; Friedrich, J.; Hörstermann, H.; Kundin, J.; Böhm, J.; Emmerich, H.:
Behaviour of particle depots in molten silicon during float-zone growth
Poster Presentation, 3rd Meeting of jDGKK
Erlangen, GER, March 5 – 6, 2013

Jauß, T.; Cröll, A.; Sorgenfrei, T.; Azizi, M.; Reimann, C.; Friedrich, J.; Hörstermann, H.; Kundin, J.; Böhm, J.; Emmerich, H.:
The critical growth rate for particle incorporation during the directional solidification of solar silicon under microgravity
19th American Conference on Crystal Growth and Epitaxy
Keystone, CO, USA, July 21 – 26, 2013

Joffe, C.; Ditze, S.; Roßkopf, A.:
A novel positioning tolerant inductive power transfer system
3rd International Electric Drives Production Conference (EDPC)
Nuremberg, GER, October 29 – 30, 2013

Kallinger, B.:
Fehlpassung bei der Homo- und Heteroepitaxie
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Erlangen, GER, March 5, 2013

Kallinger, B.; Ehlers, C.; Berwian, P.; Rommel, M.; Friedrich, J.:
HCl assisted growth of thick 4H-SiC epilayers for bipolar devices
Poster Presentation, International Conference on Silicon Carbide and Related Materials
Miyazaki, JPN, September 29 – October 4, 2013

Kallinger, B.; Rommel, M.:
Carrier Lifetime Optimization in SiC-Epilayers
15. Jahrestagung des Fraunhofer IISB „Bauelemente für die Energieelektronik"
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Comparison of carrier lifetime measurements and mapping using time resolved photoluminescence and µ-PCD
Poster Presentation, International Conference on Silicon Carbide and Related Materials
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Kilian, D.; Polster, S.; Jank, M.; Frey, L.; Peukert, W.:
Flame Spray Pyrolysis (FSP) & Direct Deposition (DD) of amorphous Indium Zinc Oxide (IZO) nanoparticles – application as active layer in field effect transistors
European Aerosol Conference 2013
Prag, CZ, September 1 – 6, 2013

Knetzger, M.; Meißner, E.; Spiecker, E.; Knoke, I.:
Skalenübergreifende Charakterisierung dicker GaN-HVPE-Schichten mittels korrelativer Mikroskopie
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On an improved boron segregation calibration from a particularly sensitive power MOS process
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Strasbourg, FRA, May 27 – 31, 2013

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Koffel, S.; Pichler, P.; Lorenz, J.; Bisognin, G.; Napolitani, E.; De Salvador, D.:
On the Strain Induced by Arsenic into Silicon
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Bukarest, ROM, September 16 – 20 September, 2013

Koitzsch, M.; Lewke, D.; Schellenberger, M.; Pfitzner, L.; Ryssel, H.; Kolb, R.; Zühlke, H.-U.:
Improving electric behavior and simplifying production of Si-based diodes by using thermal laser separation
Advanced Semiconductor Manufacturing Conference (ASMC)
Saratoga Springs, NY, USA, May 14 – 16, 2013

Kraft, S.:
Sintern statt Löten - Motivation, Verarbeitung und Herausforderungen
Viscom Technologieforum,
Hannover, GER, March 13 – 14, 2013

Kraft, S.:
Test Data for Die Attach Lifetime Modeling
ECPE Workshop Lifetime Modeling and Simulation
Düsseldorf, GER, July 3 – 4, 2013

Kupka, I.; Reimann, C.; Seebeck, J.; Lehmann, T.; Wunderwald, U.; Friedrich, J.; Dadzis, K.; Kropfgans, F.; Sylla, L.:
Influencing the crystallization behaviour of multi crystalline silicon in a R&D furnace
7th International Workshop on Crystalline Silicon Solar Cells (CSSC7)
Fukuoka, JPN, October 22 – 25, 2013

Kupka, I.; Reimann, C.; Seebeck, J.; Lehmann, T.; Wunderwald, U.; Friedrich, J.; Dadzis, K.; Kropfgans, F.; Sylla, L.:
Influencing the crystallization behaviour of multi crystalline silicon in a R&D furnace
Poster Presentation, 17th International Conference on Crystal Growth and Epitaxy - ICCGE-17
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Kupka, I.; Reimann, C.; Lehmann, T.; Wunderwald, U.; Friedrich, J.; Kropfgans, F.; Sylla, L.:
Influencing the Initial Crystallization Behavior during Directional Solidification of Multicrystalline Silicon
DGKK Arbeitskreis – Herstellung und Charakterisierung von massiven Halbleiterkristallen
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Lehmann, T.; Meissner, E.; Zschorsch, Friedrich J.:
Korrelation zwischen Kornstruktur/-gefüge, Kristalldefekten und elektrischen Parametern von N- und P- dotierten mc-156x156mm² Siliziumwafern
Poster Presentation, Junge Deutsche Gesellschaft für Kristallwachstum und Kristallzüchtung (jDGKK)
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A way of statistical evaluation of different characteristics of the grain structure on the entire wafer area in multicrystalline silicon
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Lehmann, T.; Meissner, E.; Reimann, C.; Meyer S.; Seidl A.; Birkmann, B.; Friedrich J.:
Correlation Between Photoluminescence Imaging and Grain Orientation Maps for Multicrystalline Silicon Wafers
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Correlation Between Photoluminescence Imaging and Grain Orientation Maps for Multicrystalline Silicon Wafers
International Conference on Gettering and Defect Engineering in Semiconductor Technology (GADEST) 15
Oxford, GBR, September 22 – 27, 2013

Leisegang, T.:
Investigation of Rare Earth Compounds – Response and Properties of the Crystal Structure on Composition Variations
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Leisegang, T.:
X-ray Investigation of Rare Earth Compounds – The Response of the Crystal Structure on Composition Variations
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Freiberg, GER, March 19 – 22, 2013

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Lewke, D.; Schellenberger, M.; Pfitzner, L.; Fries, T.; Tröger, B.; Muehlig, A.; Riedel, F.; Bauer, S.; Wihr, H.:
Full wafer nanotopography analysis on rough surfaces using stitched white light interferometry images
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Lorenz, J.:
EC Project SUPERTHEME – Circuit Stability Under Process Variability and Electro-Thermal-Mechanical Coupling Workshop FP7 Variability and Reliability
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Poster Presentation, Ninth International Nanotechnology Conference on Communication and Cooperation
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Lorenz, J.:
Overview of SUPERTHEME project
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Simulation in Power Devices
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Lorenz, J.:
WP1 plans and progress in period, forecast for next period
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März, M.:
Basics on Heat Generation and Heat Transfer
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Erlangen, GER, June 27, 2013

März, M.:
Batterieladetechnik für Elektrofahrzeuge: schnell – sauber – kontaktlos
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Nuremberg, GER, October 21, 2013

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Bewegung Zukunft – eMobilität begreifen
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März, M.:
Brauchen wir eine System-Roadmap?
BMBF Workshop Leistungselektronik
Nuremberg, GER, May 13, 2013

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Halbleiterbauelemente – Eigenschaften, Ansteuerung, Schutz, Kühlung
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Regensburg, GER, March 18, 2013

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März, M.:
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März, M.:
Mobilität von morgen – Herausforderungen, Fakten, Perspektiven, Szenarien
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Störszenarien und ausgewählte Anwendungsprobleme
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Erlangen, GER, October 1, 2013

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System Integration in Automotive Power Electronics – Highlights & Milestones from 10 Years ECPE Research
ECPE Network Symposium
Nuremberg, GER, April 18, 2013

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Thermisches Management in der Leistungselektronik
Cluster-Schulung, Cluster Leistungselektronik
Erlangen, GER, April 9, 2013

März, M.; Eckardt B.:
Architekturen und Systemtechnik für Elektromobilität
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Eine ganzheitliche elektrische Antriebsstranglösung für Elektrofahrzeuge
5. Int. Kongress für Elektro- und Hybrid-Mobilität (eCarTec)
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Thermisches Management in der Leistungselektronik
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Meissner, E.:
Characterization (electrical, optical, structural, chemical)
15th International Summer School on Crystal Growth ISSCG-15
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Meissner, E.; Knetzger, M.; Friedrich, J.:
Insight into the microstructure of a GaN crystal from the atomic to centimeter scale
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Meissner, E.; Knetzger, M.; Friedrich, J.:
Insight into the microstructure of a GaN crystal from the atomic to centimeter scale
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Erlangen, GER, October 16, 2013

Meric, Z.; Weis, S.; Mehringer, C.; Jank, M.; Peukert, W.; Frey, L.:
Thin films made from Si, Ge and SiGe nanoparticles: Processing, annealing and electrical behavior
Poster Presentation, EAM Symposium des Exzellenzclusters Engineering of Advances Materials
Bad Staffelstein, GER, November 18, 2013

Oertel, S.; Jank, M.P.M.; Teuber, E.; Bauer, A.J.; Frey, L.:
High-mobility metal-oxide thin-film transistors by spray deposition of environmentally friendly precursors
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Oertel, S.; Jank, M.P.M.; Teuber, E.; Bauer, A.J.; Frey, L.:
Non-toxic mixed metal-oxide precursors for spray-deposition and printing of thin-film transistors
Poster Presentation, International Exhibition and Conference for the Printed Electronics Industry (LOPE-C)
Munich, GER, June 11 – 13, 2013

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Öchsner, R.:
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Öchsner, R.:
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Öchsner, R.:
Konzept und Auslegung einer Kraft-Wärme-Kälte-Kopplung mit Kältespeicher
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Öchsner, R.:
SEEDs – Aufbruch in die industrielle Energiewende
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Öchsner, R.:
SEEDs – Keimzellen für die Energiewende im Industriemaßstab
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Öchsner, R.:
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Erlangen, GER, October 10, 2013

Pfeffer, M.:
Technologie und Zukunft im internationalen Wettbewerb im Kontext der Halbleiterindustrie
Open Lecture FH Wiener Neustadt
Wien, AUT, April 18, 2013

Pfeffer, M.:
Energieeffizienz in der Halbleiterfertigung – Geräte- und Fabrikaspekte
Ionenimplantation Nutzertreffen
Erlangen, GER, April 11, 2013

Pfeffer, M.:
Semiconductor Euipment Assessment – An enabler for production ready 450 mm equipment
SEMICON Europa 2013, 450 mm Conference
Dresden, GER, October 10, 2013

Pfitzner, L.; Anger, S.; Koitzsch, M.; Schoepka,U.; Roeder, G.; Tobisch, A.; Schellenberger, M.; Pfeffer, M.:
Frontiers in Defect Detection
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Rauh, H.:
Einfluss der Umgebungsbedingungen auf die Reichweite von Elektrofahrzeugen
FutureCar Network
Kassel, April 25, 2013

Reimann, C.:
Challenges in material improvement and cost reduction for crystalline silicon for PV
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Influencing the as grown dislocation density in directionally solidified multicrystalline Silicon
Invited
7th International Workshop on Crystalline Silicon Solar Cells (CSSC7)
Fukuoka, JPN, October 22 – 25, 2013

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Richter, C.; Rommel, M.; Beuer, S.:
Manufacturing of Cantilever Probes with Sub-100nm Pt-Electrodes Integrated in a Sharp Tip for Scanning Electrochemical Microscopy
International Conference on Nanoscience and Technology (ICN+T 2013)
Paris, FRA, September 9 – 13, 2013

Roeder, G.; Schellenberger, M.; Pfitzner, L.; Winzer, S.; Jank, S.:
Virtual metrology for prediction of etch depth in a trench etch process
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Roeder, G.; Gumprecht, T; Schellenberger, M; Pfitzner, L.:
Thin film analytics with VUV reflectometry. 273. PTB-Seminar VUV and EUV Metrology
Berlin, GER, October 24 – 25, 2013

Rommel, M.:
Customized FIB machining of 3D micro- and nano structures,
1st STEEP Industrial Day
Leissigen, SUI, December 12, 2013

Rommel, M.:
Ion Beam Principles,
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Leissigen, SUI, December 9 – 11, 2013

Rosskopf, A.:
Methoden zur Dimensionsreduktion und zum Lösen von Multiskalenproblemen in elektrischen Systemen
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Mannheim,GER, June 19 – 21, 2013

Rumler, M.; Rusch, O.; Fader, R.; Haas, A.; Rommel, M.; Bauer, A.J.; Frey, L.; Brehm, M.; Kraft, A.:
Evaluation of UV-SCIL resists for structure transfer using plasma etching
Poster Presentation, International Conference on Nanoimprint & Nanoprint Technology (NNT)
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Ryssel, H.:
50 Jahre Nutzergruppe Ionenimplantation
50. Treffen der Nutzergruppe Ionenimplantation
Frankfurt/Oder, GER, November 7, 2013

Ryssel, H.:
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Guwahati, IND, December 13, 2013

Scharin, M.; Rommel, M.; Dirnecker, T.; Marhenke, J.; Rumler, M.; Herrmann, B.; Fader, R.; Frey, L.; Herrmann, M.:
Micromolding of micropatterned PDMS surfaces to define the adhesive behavior of human cells in vitro
Poster Presentation, Jahrestagung der Deutschen Gesellschaft für Biomaterialien
Erlangen, GER, September 26 – 28, 2013

Scharin, M.; Rommel, M.; Dirnecker, T.; Rumler, M.; Fader, R.; Bauer, A.J.; Frey, L.; Hermman, M.:
Surface modification of flexible plain and microstructured hard and soft PDMS-thin films by plasma treatment and layer deposition for improved usability for biomedical applications
Poster Presentation, International Congress NanoBioEurope (NBE)
Toulouse, FRA, June 10 – 12, 2013

Schellenberger, M.:
First Results from a Study about Common Needs of the German Semiconductor Industry
13th European Advanced Process Control and Manufacturing Conference
Dresden, GER, April 15 – 17, 2013

Schellenberger, M.:
Common Development Topics for Semiconductor Manufacturers and their Suppliers in Germany
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Schellenberger, M.:
Gemeinsame Entwicklungsthemen für Halbleiterhersteller und ihre Zulieferer in Deutschland
5. Mikrosystemtechnik-Kongress
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Schletz, A.:
Keramik für die mobile Leistungselektronik
DGM Roadmapping-Workshop: Hochleistungs-Keramik-Werkstoffe für zukünftige Anwendungen in der Mobilität
September 10, 2013

Schletz, A., Hutzler, A., Müller, N., Tokarski A.:
Design and Material Considerations for Extended Lifetime
ECPE Workshop Power Electronics Packaging
Baden-Dättwil, SUI, November 12 – 13, 2013

Schneider, V.; Reimann, C.; Friedrich, J.; Müller, M.:
Reusable crucible for directional solidification of silicon: Impact of crucible purity
German Conference of Crystal Growth (DKT2013)
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Schneider, V.; Reimann, C.; Friedrich, J.; Müller, M.:
Reusable crucible for directional solidification of silicon: Impact of crucible purity
Poster Presentation, 7th International Workshop on Crystalline Silicon Solar Cells (CSSC7)
Fukuoka, JPN, October 22 – 25, 2013

Schömbs, U.; Fader, R.; Verschuuren, M.:
Alignment accuracy in a mask aligner using substrate conformal imprint lithography (SCIL)
Poster Presentation, International Conference on Micro and Nano Engineering (MNE)
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Schöpka, U.; Roeder, G.; Mattes, A.; Schellenberger, M.; Pfeffer, M.; Pfitzner, L.; Scheibelhofer, P.:
Practical aspects of virtual metrology and predictive maintenance model development and optimization
Advanced Semiconductor Manufacturing Conference ASMC
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Seebeck, J.; Jung, T.; Friedrich, J.:
Numerical investigation on the control of the melt flow in directional solidification using magnetic fields induced by AC operated heaters
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Seebeck, J.; Zschorsch, M.; Jung, T.; Kupka, I.; Reimann, C.; Friedrich, J.; Kropfgans, F.; Sylla, L.:
Influencing the grain structure in G1 sized mc silicon at the initialization of the growth processexperimental and numerical investigations
International Workshop on Polycrystalline Growth of Si
Karlsruhe, GER, September 19 – 20, 2013

Seliger, B.; Popov, J.; Eckardt, B.; März, M.:
Isolated High Voltage DC/DC Converter for Auxiliary Power Supply in Commercial Vehicles
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Strenger, C.; Uhnevionak, V.; Burenkov, A.; Bauer, A.J.; Pichler, P.; Erlbacher, T.; Ryssel, H.; Frey, L.:
Influence of ion implantation in SiC on the channel mobility in lateral n-channel MOSFETs
Electrochemical Society (ECS Meeting)
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Stockmeier, L.; Zschorsch, M.; Friedrich, J.; Lehmann, L.:
Formation of dislocations in highly doped n-Type Czochralski silicon
Poster Presentation, International Summer School on Crystal Growth (ISSCG-15)
Gdansk, POL, August 4 – 10, 2013

Stockmeier, L.; Zschorsch, M.; Friedrich, J.; Lehmann, L.:
Formation of dislocations in highly doped n-Type Czochralski silicon
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Trempa, M.; Reimann, C.; Friedrich, J.:
Influence of artificial grain boundaries between seed plates on the defect development in quasi-mono-crystalline silicon ingots for photovoltaic application
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Trempa, M.; Reimann, C.; Friedrich, J.:
Influence of artificial grain boundaries between seed plates on the defect development in quasi-mono-crystalline silicon ingots for PV application
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Erlangen, GER, October 16, 2013

Uhnevionak, V.; Burenkov, A.; Pichler, P.:
On the calculation of hall factors for the characterization of electronic devices
Conference on Ph.D. Research in Microelectronics and Electronics (PRIME)
Villach, AUT, June 24 – 27, 2013

Uhnevionak, V.; Burenkov, A.; Strenger, C.; Bauer, A.J.; Pichler, P.:
On the temperature dependence of the hall factor in n-channel 4H-SiC MOSFETs
Symposium on Gallium Nitride (GaN) and Silicon Carbide (SiC) Power Technologies
San Francisco, CA, USA, October 28 – 31, 2013

Uhnevionak, U.; Burenkov, A.; Strenger, C.; Mortet, V.; Bedel-Peireira, E.; Cristiano, F.; Bauer, A.J.; Pichler, P.:
Hall factor calculation for the characterization of transport properties in n-channel 4H-SiC MOSFETs
International Conference on Silicon Carbide and Related Materials (ICSCRM) 15
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Verschuuren, M.; Fader, R.; Brakel, R.v.; Hurxkens, G.-J.:
In situ ATR monitoring of cross-link and diffusion behavior of thin-film epoxy and sol-gel based imprint resist
Poster Presentation, International Conference on Nanoimprint & Nanoprint Technology (NNT)
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Völlm, H.; Herrmann, J.; Maier, R.; Feili, D.; Häublein, V.; Ryssel, H.; Seidel, H.:
Simulation and design optimization of transparent heaters for spectroscopic micro cells
Smart sensors, actuators and MEMS VI
Grenoble, FRA, April 24 – 26, 2013

Wright, A.; Koffel, S.; Pichler, P.; Enichlmair, H.; Minixhofer, R.; Wachmann, E.:
On the thermo-mechanical modelling of a ball bonding process with ultrasonic softening
International Conference on Thermal, Mechanical and Multi-Physics Simulation and Experiments in Microelectronics and Microsystems (EuroSimE)
Wroclaw, POL, April 14 – 17, 2013

Yang, C.; Wang, X.; Li, S.; Erdmann, A.:
Source mask optimization using real-coded genetic algorithms
Optical microlithography XXVI
San Jose, CA, USA, February 24 – 28, 2013

Xu, D.; Li, S.; Wang, X.; Führer, T.; Erdmann, A.:
Defect parameters retrieval based on optical projection images
Conference on Modeling Aspects in Optical Metrology
Munich, GER, May 13 – 14, 2013

Xu, D.; Li, S.; Wang, X.; Erdmann, A.:
Defect inspection and detection using optical image projection
China Semiconductor Technology International Conference (CSTIC)
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Zeltner, S.:
Leistungselektronik in DC-Netzen für Gebäude
Leistungselektronik-Kolloquium des Fraunhofer Innovationsclusters „Elektronik für nachhaltige Energienutzung“
Erlangen, GER, February 18, 2013

Zeltner, S.:
Leistungselektronische Systeme einfach modular betreiben
Leistungselektronik-Kolloquium des Fraunhofer Innovationsclusters „Elektronik für nachhaltige Energienutzung“
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Reutlingen, GER, December 3, 2013

PhD Theses

Azizi, M.:
Eisenverunreinigungen in multikristallinem Silizium: Gerichtete Erstarrung und Analyse der strukturellen und elektrischen Eigenschaften

Führer, T.:
Künstliche Evolution für die Optimierung von lithographischen Prozessbedingungen

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Koitzsch, M.:
Thermisches Laserstrahlseparieren spröder Werkstoffe – Optimierung von Rissinitiierung und Rissausbreitung am Beispiel von Silicium

Laven, J.:
Untersuchung und Modellierung von Dotierungsprofilen in Silicium erzeugt durch hochenergetische Protonenimplantationen

Trempa, M.:
Gerichtete Erstarrung von einkristallinen Siliciumkristallen nach dem VGF-Verfahren für die Anwendung in der Photovoltaik

Weinreich, W.:
Herstellung und Charakterisierung ultradünner ZrO2-basierter Schichten als Isolatoren in Metall-Isolator-Metall Kondensatoren

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Integration eines E-Learning-Konzepts in das Lehrangebot des Lehrstuhls für Elektronische Bauelemente

Chahine, C.:
Characterization and Optimization of a Lithography Stepper

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Han, Y.:
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Kramer, R.:
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Landwehr, J.:
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Vogel, S.:
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Bachelor Theses

Bonse, C.:
Untersuchung unipolarer Eigenschaften von n-dotiertem 4H-SiC

Clemmer, G.:
Herstellung und Charakterisierung implantierter Randfeldbegrenzungen für PiN-Dioden auf 4H-SiC

Goblirsch, P.:
Strukturelle und elektrische Eigenschaften von einkristallinem Siliciummaterial nach einer Temperaturbehandlung

Hemmer, J.:
Verfahren zur Detektion der Spulenposition eines induktiven Ladesystems für Elektro- und Hybridfahrzeuge

Hofmann, H.:
Entwicklung und Untersuchung einer intelligenten Kühlkreislauf-Steuereinheit für ein Elektrofahrzeug

Gosses, K.:
Aufbau und Inbetriebnahme eines Testsystems für eine Asynchronmaschine

Gül, S.:
Aufbau einer energetischen Simulationsumgebung zur Darstellung von thermischen und elektrischen Energieflüssen in Produktionsumgebungen mit elektrischen Antrieben

Hölzl, M.:
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Kästner, P.:
Entwicklung eines EMV-Filters für die Versorgungs- und Signalleitungen eines Gleichspannungswandlers für Elektrofahrzeuge

Koschmieder, M.:
Entwicklung einer hochpräzisen Batterieüberwachung für Li-Ionen Batteriesysteme in automobilen Anwendungen

Krapf, M.:
Entwicklung eines Batterie Management Systems für ein Elektrofahrzeug

Mundt, M.:
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Niebauer, M.:
Modifizierung von Polypropylenfolien mittels Ionenimplantation zur Erhöhung der Zuverlässigkeit in Dünnfilmkondensatoren

Ohlendorf, M.:
Entwicklung einer Ansteuerelektronik für Hochleistungs-LED

Marhenke, J.:
Herstellung, Modifikation und Charaktiериserung von PDMS-Folien

Rusch, O.:
Bewertung der Plasmaätzeigenschaften von Lacken für die substratkonforme Imprintlithographie (SCIL)

Sacher, A.:
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